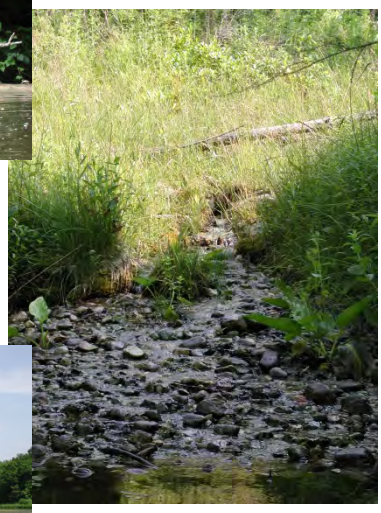
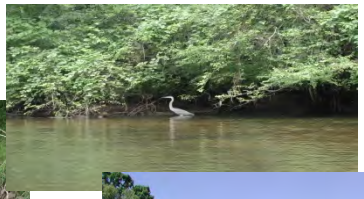
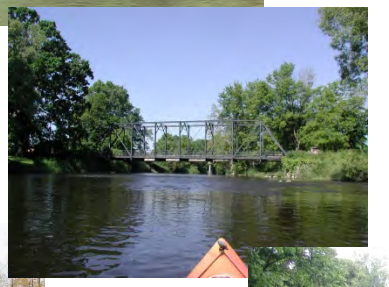
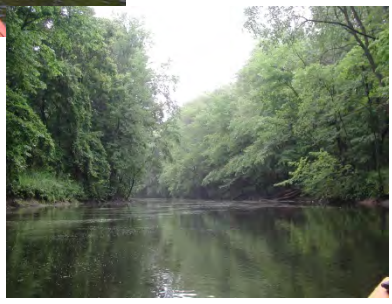


Thornapple River Watershed Management Plan







June, 2015

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1 EXECUTIVE SUMMARY

The Thornapple River Watershed (TRW) is the largest subbasin of the Lower Grand River Watershed, and is located in the southwestern portion of Lower Michigan. The Thornapple River Watershed planning area extends from Potterville, Michigan, westward to the western portion of Barry County, then north to its confluence with the Grand River in Ada. The planning area covers all of the Thornapple River Watershed's subwatersheds, excepting the Coldwater River Watershed, which has its own management plan. Draining approximately 422,545 acres, the TRW planning area includes 24 subwatersheds and nine designated trout streams.

The TRW is located in a primarily rural portion of southwest Michigan, with 52.1% of land use devoted to agriculture, and 38.7% comprised of forestland and open space. Urbanizing areas include the M-37 corridor north of Middleville and the M-69 corridor between Potterville and Charlotte. The Thornapple River and its many lakes provide recreation for local residents and tourists alike and are important features in both the rural and urbanizing communities.

Concerns over the visible signs of water quality decline throughout the TRW, most evident as sediment build-up and increasing weed and algae growth in these recreational areas, inspired the formation of the Thornapple River Watershed Council (TRWC) in 1994, and the Thornapple River Watershed Steering Committee (TRWSC) in 2004. Working in concert, these two groups determined the need to investigate sources contributing to decreasing water quality and to build a group of stakeholders interested in improving the water resource. The TRWSC has led the watershed planning process, while the TRWC continues to lead the effort to increase citizen awareness and involvement in watershed issues.

In assessing current watershed conditions, it was discovered that the most critical issues in the TRW are the least visible. Well-water testing indicates that in certain areas, groundwater, which provides the only source of drinking water throughout the watershed, is contaminated with high levels of nitrate, with levels exceeding state water quality standards in approximately 30% of wells in these contaminated areas. Sources of contamination include historic and current agricultural practices, sewage systems and lawn fertilization.

In 2012, the MDEQ Integrated Report placed a requirement for total maximum daily load limits for mercury and PCB levels in surface water and fish tissue for the Thornapple River Watershed. Levels of pollution in the TRW have not required additional fish advisories beyond the existing statewide cautions.

In the 2008 Integrated Report, eleven of the TRW's tributaries were noted as not attaining the designated surface water use of supporting aquatic and other wildlife due to channelization. Since that time, MDEQ has removed channelization or stream alteration as a cause for non-attainment for many streams, but the condition of these streams has not improved. Streams in much of the upper and middle portions of the TRW were historically channelized for agricultural purposes and are currently maintained as drains. Channelization affects the ability of at least two of the watershed's designated trout streams to support a coldwater fishery.

Past MDEQ data indicates that nutrient loading is plaguing some of the TRW's major recreational lakes, with two attaining mesotrophic levels, three at eutrophic levels and one at the stage of hypereutrophication. High sediment and nutrient levels are evident in most areas of the TRW, with chemical weed control programs on the rise for residential lakes and portions of the river's mainstem. Primary sources of sediment and nutrient loading in the TRW are agricultural, with a lesser degree of input from residential sources including lawn maintenance and failing septic systems.

Goals of the TRW Management Plan are based on assessing and prioritizing uses, pollutants, sources and causes. Addressing the four impaired stream reaches in the watershed is the first goal of the TRW Plan. Improving degraded areas, those where issues have been identified through monitoring and assessment, constitutes the second goal of the plan. The importance of protecting and enhancing high quality water resources in the TRW is expressed in the third goal. Further study of areas within the watershed where insufficient information makes it unclear if stream reaches or river miles are meeting state water quality standards is the fourth goal of the plan. Recognizing that any changes that take place to improve water quality begin with raising awareness about issues and impacts, educational elements are infused into each goal of the TRW Plan and are represented as Goal 5.

Specific areas for implementing BMP's have been determined by pollutant load estimates, documented non-point source contributions and conditions that indicate high risk for pollutant loading. These areas are identified first on a subwatershed scale, with additional data locating some site-specific points of contributions. Additional focus has been placed on preserving high-quality waterbodies and the natural areas which sustain them.

The TRW Management Plan's Information and Education Strategy outlines needed information delivery, target audiences and audience-specific messages to raise awareness, develop positive attitudes and encourage action regarding water quality improvement. The strong local and regional partnerships developed through the planning process will assist in the delivery of these messages throughout the TRW.

Resources needed to implement the TRW Management Plan and measure its accomplishments, including monitoring components, technical assistance, educational outreach, evaluation programs and partnership development, are identified in the plan. The total estimated cost for implementing the plan over ten years is $17,382,678. Implementing all of the proposed elements to the Thornapple River Watershed Management Plan will include the services of a watershed coordinator for education, outreach, grant management and implementation oversight; education and outreach programs and publications; watershed monitoring and management measures. Funding to undertake the elements of the management plan may come from a combination of sources listed in Section 8.1. Similarly, support and in-kind assistance will be requested from project partners such as those listed in Section 8.1 and others that are interested in supporting this plan's goals.

Citizens interested in learning more about the Thornapple River Watershed, this management plan, watershed activities and partner organizations may contact:

Barry Conservation District
1611 S. Hanover, Suite 105
Hastings, MI 49058
(269) 948-8056 x 3
joanne.barnard@mi.nacdnet.net

2 INTRODUCTION

In 1966, U.S. Secretary of the Interior Steward L. Udall, along with state and federal officials, embarked on a boat tour of the Thornapple River near Nashville, Michigan. A local paper reported of his post-tour speech:

He was heartened and glad to see the concern of the people of this community for the river. He added that the Thornapple River could have a great future for people who plan ahead. He said that the river was much cleaner than the Kalamazoo and people here should not fail to take full advantage of its recreational facilities[1.]

Though populations, economics and other trends have changed in the last half century, Udall's words still ring true today. The Thornapple River Watershed has remained remarkably rural, preserving many of the fishing and recreational resources recognized so long ago, and just as importantly, community concern and regard for the watershed has not diminished.

The Thornapple River Watershed, or TRW, is a major subbasin of the Grand River Watershed in southern Lower Michigan. The TRW comprises not only the Thornapple River, but all of the land that drains into the river, its lakes, streams and wetlands and supports its groundwater resources. The TRW's surface and groundwater are the sources of drinking water, irrigation, energy, industrial water supplies, recreation and wildlife habitat within the watershed. Good water quality is essential to each of these uses. Through cooperation and management, the TRW can be sustained and improved as a clean water resource for generations to come.

2.1 Document Overview

The purpose of the Thornapple River Watershed Management Plan is to raise awareness of specific issues threatening the watershed resource and to provide guidance and encourage collaboration in addressing water quality problems. The TRW Management Plan describes the watershed's natural features (Section 2), reviews current and future conditions which have impacts on the watershed's natural resources (Section 3) and prioritizes designated and desired uses within the watershed. An assessment of existing monitoring and resource data as well as non-point and point-source pollutants, leads to an identification of pollutant loads, sources and causes as well as critical areas for load reduction and natural resource protection (Section 5). Watershed goals, objectives and strategies are outlined in Section 6, along with targets for strategy implementation. Existing and needed resources for plan implementation are identified in Section 7, with implementation plans and an overall needs assessment expressed in Section 8.

2.2 Watershed Management Plan Purpose and Process

The largely rural landscape of the TRW has been mainly beneficial to water quality. The TRW has little history of the industrial pollutants which plague neighboring watersheds. Generations of agricultural cultivation have altered the landscape in many ways, but large tracts of open space, intact wetland complexes and naturally meandering streams are still characteristic of the watershed region. The development boom of the 1990's and early 2000's, which brought population increases of up to 45% in some watershed communities, prioritized the need for planning and sound management strategies to protect the TRW's natural resources. The TRW Management Plan is intended to guide decision-making

1Nashville Area Centennial Inc. 1969. Nashville, Michigan, 1869-1969. Nashville, Mich., p. 23:

on individual, organizational, educational and governmental levels, to inspire collaboration across jurisdictional boundaries, and to provide information and resources needed to enhance and preserve water quality and related natural resources in the Thornapple River Watershed.

This management plan was created through the Thornapple River Water Management Plan Project, which was funded through grants from the National Fish and Wildlife Foundation and the Michigan Department of Environmental Quality. The Barry Conservation District has worked in collaboration with partnering agencies, organizations and individuals from throughout the watershed region. As the Thornapple River Watershed Steering Committee, these partners provided professional services, expertise and the valuable commitment of time to develop management strategies for the TRW. The recommendations and conclusions in this document are based on the best available data for determining current environmental conditions and future impacts. A full list of steering committee members and their responsibilities is found in Appendix 1.

3 WATERSHED DESCRIPTION

The Thornapple River Watershed is a major subbasin of the Grand River Watershed, which flows into Lake Michigan. The Grand River Watershed is the second largest drainage system in the State of Michigan and comprises 13% of the entire Lake Michigan drainage basin, with a drainage area of 5,572 square miles[2]. The TRW plan area drains approximately 700 square miles of predominately agricultural lands in the five counties of Eaton, Barry, Kent, Ionia and Allegan. The main channel of the Thornapple is 78 miles long, originating in northeastern Eaton County. The river flows in a westerly direction to the village of Middleville in northwest Barry County, at which point it flows north to its confluence with the Grand River near the town of Ada in south-central Kent County.

3.1 Physical and Natural Features

3.1.1 Watershed Boundaries

The Thornapple River Watershed Management Plan covers the Thornapple River, excluding the Coldwater River subwatershed, which has an approved watershed management plan [Figure 3.1.1-A]. For purposes of the TRW Management Plan, the watershed has been divided into 24 subwatersheds corresponding with major tributaries and river divisions. These subwatersheds are listed below in Figure 3.1.1 with reference numbers utilized in this plan and hydrologic unit codes.

2 USACE, Detroit District, Grand River Sediment Transport Modeling Study, May, 2007.

Figure 3.1.1.A Thornapple River Location Map

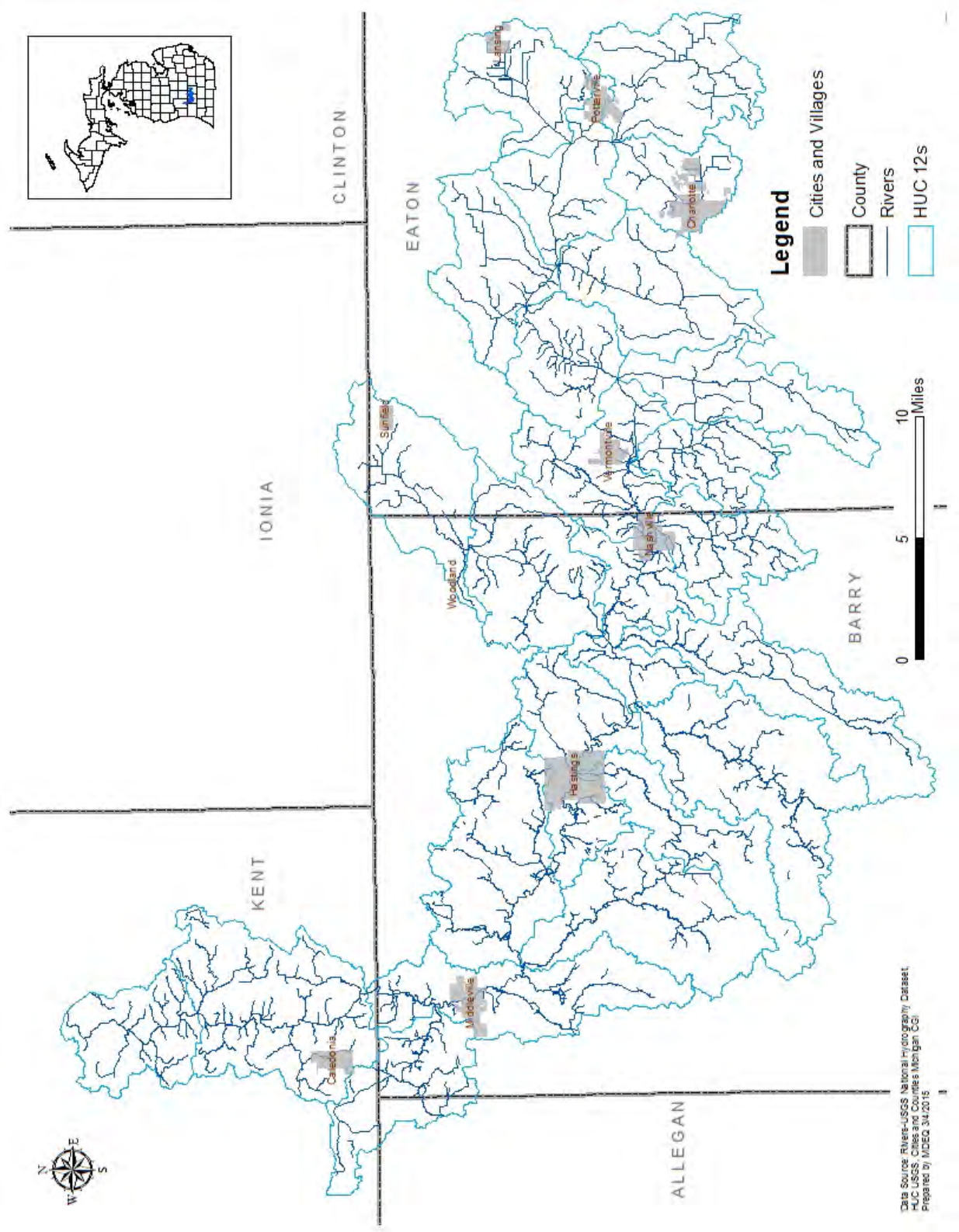
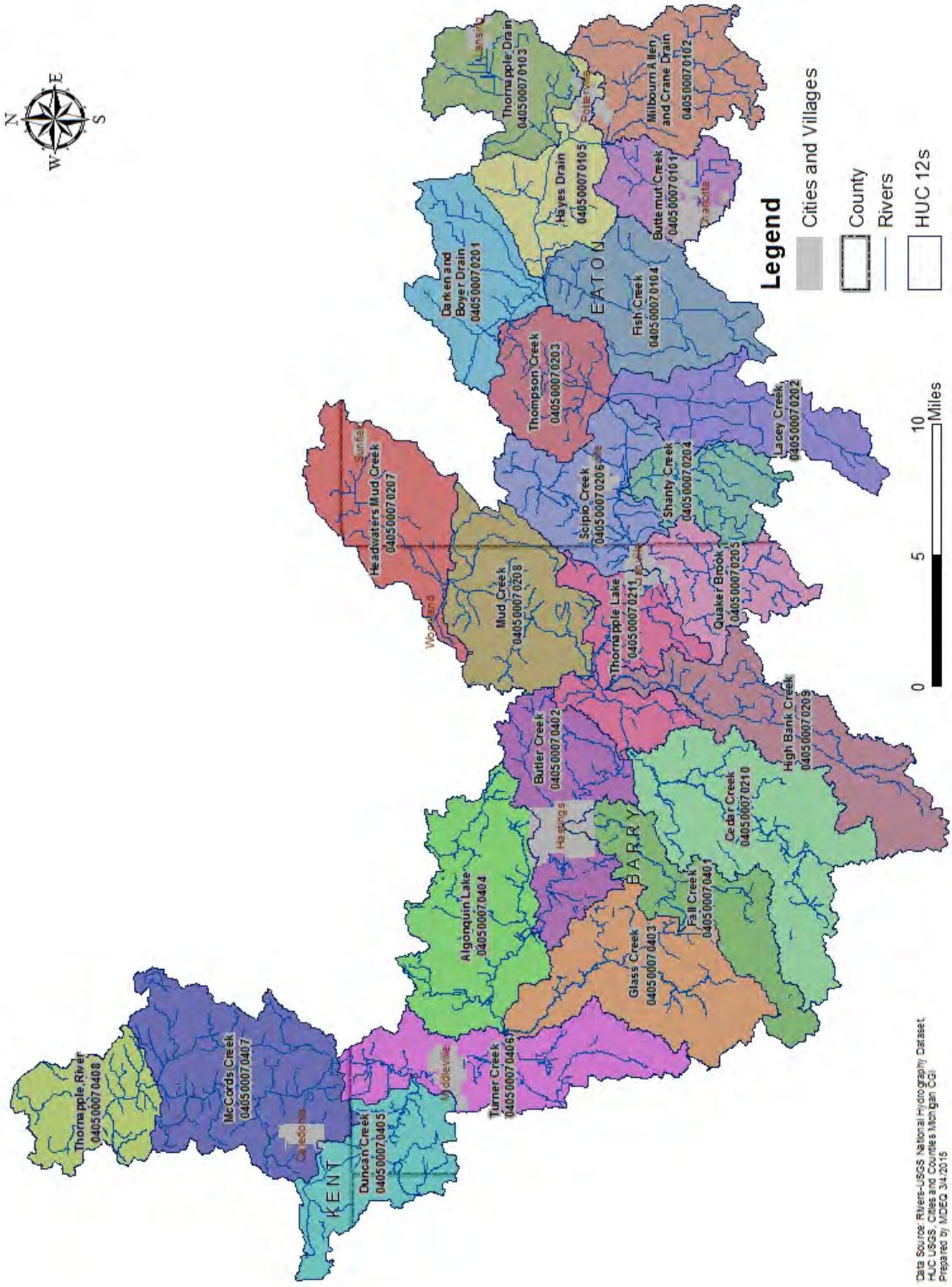


Figure 3.1.1 Subwatersheds of the Thornapple River Watershed

REFERENCE #	HYDROLOGIC UNIT CODE (HUC)	SUBWATERSHED
1	040500070101	Butternut Creek
2	040500070102	Milbourn, Allen & Crane Drain
3	040500070103	Thornapple Drain
4	040500070104	Fish Creek - Little Thornapple River
5	040500070105	Hayes Drain - Thornapple River
6	040500070201	Darken & Boyer Drain – Thornapple River
7	040500070202	Lacey Creek
8	040500070203	Thompson Creek - Thornapple River
9	040500070204	Shanty Brook
10	040700050205	Quaker Brook
11	040500070206	Scipio Creek – Thornapple River
12	040500070207	Headwaters Mud Creek
13	040500070208	Mud Creek
14	040500070209	High Bank Creek
15	040500070210	Cedar Creek
16	040500070211	Thornapple Lake - Thornapple River
17	040500070401	Fall Creek
18	040500070402	Butler Creek - Thornapple River
19	040500070403	Glass Creek
20	040500070404	Algonquin Lake – Thornapple River
21	040500070405	Duncan Creek
22	040500070406	Turner Creek – Thornapple River
23	040500070407	McCords Creek – Thornapple River
24	040500070408	Thornapple River @ Mouth

Figure 3.1.1.B - Subwatersheds



3.1.2 Hydrology

The MDEQ's "Thornapple River Watershed Flashiness Report[3]" analyzed data from the three USGS gages in the watershed - located at Quaker Brook near Nashville (#04117000), on the Thornapple River near Hastings (#04117500) and on the Thornapple River near Caledonia (#04118000) - for periods between 1945 and 2005. Flashiness rankings for all three gages were in the lower middle quartile, with only one gage indicating a trend toward increasing flashiness. The report notes that "the increasing flashiness trend of that gage, USGS #04118000 - Thornapple River near Caledonia, appears to be the result of the operation of a power plant" (Fongers, 10). The full report on flashiness in the TRW can be found in Appendix 2.

Figure 3.1.2 Thornapple River Watershed Flashiness Results

Gage Number and Description	Total Drainage Area (sq. mi.)	Quartile Rank	Flashiness Trend
4117000: Quaker Brook near Nashville	8	lower middle	
4117500: Thornapple River near Hastings	410	lower middle	
4118000: Thornapple River near Caledonia	795	lower middle	more flashy

The document recommends that "although the flow regime appears to be currently stable, it is possible that the Thornapple River's morphology continues to adapt to past hydrologic changes. There may also be some local channel instabilities in more sensitive headwater streams due to nearby land use transitions or other local causes. Flow increases due to projected urbanization may be of concern if not properly managed, however" (Fongers, 17).

Issues affecting increased flow within the TRW include channelization, increasing impervious surface area, storm water management and culvert size and placement. Hydrology is also affected by increased development, which creates increased impervious surface area and runoff potential.

Seasonal flooding is a regular issue in the TRW, especially in the middle and lower reaches of the watershed. Roads, homes and businesses are annually impacted by flood waters. Current drain and storm water systems, designed to quickly move water away from fields and developed areas, increase the impact of seasonal floods. Wetland loss and development within floodplain and wetland areas have also contributed to flood impacts.

3.1.3 Climate and Precipitation

The general weather conditions over the thirty year period from 1971-2000 in the watershed area are taken from an average of data from weather stations in Charlotte in Eaton County, Hastings in Barry County and the Kent County Airport and compiled by the Midwestern Regional Climate Center. These points approximate the headwaters, center point and mouth of the Thornapple River. The mean annual

3 Fongers, D. July 3, 2008. "Thornapple River Watershed Flashiness Report." Michigan Department of Environmental Quality.

temperature for the watershed area is 47.2°F, with January averaging 22.1 F and July 70.7 F. Overall precipitation averages 35.57 inches per year, with mean snowfall calculated at 58.8 inches.

3.1.4 Surface Water Resources

The TRW's surface waters are an important part of the recreational economy of the region. The TRW contains over 250 lakes totaling approximately 14,000 acres. Many of the larger lakes support seasonal residential communities and provide access for boating, water sports and fishing. Thornapple Lake, a natural lake formed from inlets that include the Thornapple River, High Bank Creek and Mud Creek, is approximately 409 acres and reaches depths up to 30 feet. Other major recreational lakes include Middle, Leach, Carter and Algonquin Lakes on Sand Creek; Wall Lake at the origin of Cedar Creek; the Jones, Wilkinson, Cloverdale and Long Lake chain comprising the headwaters of Fall Creek; Guernsey Lake at the origin of Glass Creek; the Fine, Mill, Long and Bristol Lake chain at the headwaters of High Bank Creek; Duncan Lake on Duncan Creek and Campau Lake on McCords Creek.

The hundreds of smaller, less developed lakes sustain the rural quality of life sought by so many beyond the outskirts of larger cities like Grand Rapids, Lansing and Kalamazoo, providing fertile hunting, wildlife viewing and general outdoor enjoyment. According to *Michigan's Wildlife Action Plan* (MDNR, 2005), 65% of lakes in the region are in fair or good condition. The remainder is classified as degraded or very degraded. Lake conditions are often adversely affected by residential development and recreational use.

The Thornapple River itself is a critical feature of many TRW communities. The cities and villages that sprang up along the river in the early 1800's still thrive in this region, and the river provides a scenic corridor for parks and recreation through each community. In addition to its real estate and recreational value, the river also provides hydroelectric power and industrial and agricultural water resources to local communities.

The hundreds of miles of tributaries in the TRW sustain the region's agricultural economy and also provide an important fishery resource for the state. Both cold and warm-water fisheries are present in the TRW. Some of the major tributaries of the Thornapple are Butternut Creek, Fish Creek, Mud Creek, Quaker Brook, High Bank Creek, Cedar Creek, Fall Creek, Glass Creek and Duncan Creek. Each subwatershed's major tributaries, lakes and impoundments are listed in Section 5.

3.1.5 Groundwater Resources

All drinking water in the Thornapple River Watershed is supplied by groundwater sources. Public water supplies are limited to cities and villages, with rural water supplied by onsite wells. This dependence on groundwater resources makes the protection and maintenance of groundwater recharge areas a high priority for watershed management.

There are five wellhead protection areas (WHPA's) in the Thornapple Watershed, one each in Hastings, Nashville and Vermontville, and two around the wells in the Village of Middleville. In each of these areas, abandoned wells and other potential groundwater contamination sources were cataloged and either closed or placed on an observation schedule.

Groundwater recharge, the amount of precipitation infiltrating through the ground to the water table aquifer, varies significantly in the watershed. According to the Michigan Groundwater Mapping Project

Database, the lowest levels of recharge, less than 6 inches per year, occur in the eastern portion of the watershed, from Potterville to Vermontville in Eaton County. This area coincides with the area of highest agricultural drainage and wetland loss in the watershed. The Glass Creek subwatershed and the southern half of the Turner Creek subwatershed show recharge from 12 to 22 inches per year. The rest of the watershed generally ranges between 7 to 11 inches of recharge annually[4]. Areas with higher recharge levels are likely to be more susceptible to contamination by surface pollutant absorption.

Impacts to the groundwater are distributed throughout the watershed. Contaminants such as nitrate (as nitrogen) are more prevalent is some areas. The drinking water in the TRW is provided by multiple aquifers including glacial drift and bedrock aquifers with varying levels of confinement, if any. The Barry-Eaton District Health Department reported that in Barry and Eaton Counties there are at least four hundred fifty-six (456) sites with nitrate levels in the drinking water above five (5) parts per million (fifty percent of the EPA's Drinking Water Standards maximum contaminant level of ten (10) parts per million). Sources of nitrate include agricultural practices, sewage systems and lawn fertilization. The highest concentrations of nitrate contamination have been located in the following subwatersheds: Turner Creek, High Bank Creek, Algonquin Lake, Cedar Creek and Quaker Brook.

Protecting groundwater recharge areas is important not only to drinking water quality, but to surface water quality as well. Surface water in the TRW is a combination of precipitation and groundwater discharge. The average annual mean baseflow, or amount of groundwater discharged from an aquifer into a watercourse as calculated in the National Hydrography Dataset for Michigan, indicates that the Thornapple River, from its confluence with the Little Thornapple River in Eaton County to its confluence with the Coldwater River, receives groundwater at a rate of 50 – 500 cubic feet per second (cfs) as an annual average. Beyond the Coldwater River, that rate increases to above 500 cfs, due to the predominance of groundwater-fed cold water streams in the Coldwater River subwatershed. Groundwater baseflow is gauged at 20-50 cfs in Mud Creek, High Bank Creek, Cedar Creek and Glass Creek.

The trout streams within the Thornapple River Watershed project area are groundwater dependent and include Quaker Brook, Buckson Creek, Upper High Banks Creek, Cedar Creek, Glass Creek, Hill Creek, Turner and Bassett Creeks, and Cascade Creek. These important fisheries as well as the main channel of the Thornapple rely on clean and uncontaminated groundwater to sustain their ecosystems. Those areas where high recharge and high base flow (or groundwater dependent streams) overlap are of special concern in terms of groundwater protection. These key areas include Glass, Hill, Turner, Bassett and Upper Cedar Creek, as well as the main stem of the Thornapple River from Caledonia to its confluence with the Grand River.

3.1.6 Floodplains

Floodplains flank rivers and streams, providing storage areas for high waters and thereby reducing the impact of floods. Floodplain wetlands function to store and filter excess nutrients and sediment, improving water quality. Fish and other aquatic wildlife utilize these areas for spawning, rearing and food sources. Floodplains are an important part of river and stream ecosystems, but they are also a diminishing part, as developers capitalize on waterfront areas for development.

4 Michigan Groundwater Mapping Project Database. http://gwmap.rsgis.msu.edu

The floodplain of the Thornapple River is a nearly continuous band of bottomland hardwoods in its lower reaches and a combination of woodland, pastureland, cropland and urbanized areas in its upper reaches. Topography has been the determining factor in floodplain development along the Thornapple, with the high-banked portions, where flooding poses little threat, developed for agricultural or residential uses, and the lowlands, with their seasonal inundation, mostly undeveloped.

The "Floodplain Management Study: Thornapple River – Eaton, Barry and Ionia Counties, Michigan[5]" was completed by the U.S. Department of Agriculture, Natural Resources Conservation Service in 2004. The study, which covers the area from the river's headwaters outside Potterville to the River Road bridge just outside Hastings, was undertaken to assist in land use planning in the increasingly developing tri-county area. Aside from this portion of the river's main reach, the study includes Mud Creek, a tributary which extends from Ionia County through portions of Eaton and Barry Counties. Within the 44-mile study of the river's main reach, there were 157 homes potentially within the 100-year floodplain. Management recommendations within the plan include: restricting building or other development in floodplains; minimizing or decreasing changes in upland runoff and erosion with measures such as tree plantings, permanent vegetative cover and on-site storm water storage; preservation of open space within the floodplain and surrounding uplands; and development and/or updating of floodplain protection and zoning ordinances based on 100 year floodplain delineations.

The Barry County Master Plan of 2005 outlines a corridor of "Rural Conservation" zoning along the main reach of the Thornapple River within Barry County which provides for protection through required setbacks and maintenance of existing native vegetation in this sensitive area. Similar protection is afforded through the City of Hastings' Riparian Protection Ordinance, passed in 2008. These municipalities provide models of floodplain protection for the TRW.

Hydric soil conditions make most remaining natural floodplain regions unsuitable for modern development. Further development in these areas is limited due to local zoning and health department ordinances as well as current State wetland laws. Existing homes, roads, bridges and other infrastructure within the Thornapple River Watershed's flood plains risk costly flood damage and also alter the natural flow and storage patterns of the watershed. Septic systems in these areas pose surface water contamination risks. Wells located in flood plains also risk contamination during high water periods.

Land management in flood plains is an issue of concern in the Thornapple River Watershed. Cattle grazing, private off-road vehicle trails, unpermitted filling and dumping, draining and ditching are key management problems that need to be addressed through outreach and education in order to protect this valuable part of the watershed ecosystem.

3.1.7 Dams

Dams alter the flow of rivers and streams, create barriers for fish passage, retain sediment and potentially concentrate toxic chemicals and substances. Impoundments or ponds often form upstream of river barriers. A dam impoundment's ability to store floodwaters affects stream hydrology by reducing flood volume and velocity downstream of the barrier, then prolonging elevated discharge rates

5 U.S. Department of Agriculture Natural Resources Conservation Service. June 30, 2004. Floodplain Management Study: Thornapple River – Eaton, Barry and Ionia Counties, Michigan. East Lansing, Michigan.

as the floodwaters are more slowly released. The disruption of natural flow alterations can result in channel narrowing, aggradation or degradation in the downstream channel.

There are at least 25 small dams on tributaries of the Thornapple River[6], many historically constructed for small milling operations or for cattle watering facilities. Most are currently non-operational, providing impounded ponds used for private fishing areas. According to the DEQ, their structural conditions range from minor to major hazards. One such dam, the Maple Hill Dam on Butternut Creek near downtown Charlotte, was removed in 2009. When possible, it is recommended that these non-operational small dams be removed to return tributaries to their natural flow conditions.

There are five dams on the mainstream of the Thornapple: Irving, Middleville, LaBarge (in Alaska), Cascade and Ada. All are currently operating to produce hydroelectric power. A sixth dam, the Nashville Dam just west of M-66 in Nashville, was removed in 2009. Formerly utilized for milling, the dam did not produce hydroelectric power. The dam's 60 acre impoundment was drained and now provides floodplain habitat along the river corridor.

The Irving Dam, one of three operated by Commonwealth Power Company, is located in section 31 of Irving Township, in Barry County. The dam consists of two flow control dams above McCann Road, upstream of a power dam. The mean elevation of the impoundment is 741 feet, with a 32 acre impoundment. Portage from McCann Road to a DNR launch site off of Irving Road is required for boat passage.

The Middleville Dam, also operated by Commonwealth, is located in downtown Middleville in Thornapple Township sections 23 and 26, in Barry County. The mean elevation of the Middleville Dam is 724 feet. The dam measures 16 feet in height, with a 35 acre mill pond. Boaters can use two village boat launches to make the short portage across State Road.

The LaBarge Dam, operated by Commonwealth, is located in Caledonia Township, section 22, in Kent County, near the 84th Street crossing. The 32 foot LaBarge Dam's mean elevation is 692 feet, with a 100 acre mill pond. There are no public access sites above the impoundment, so non-motorized boaters should not attempt passage between 108th Street and 84th Street.

The Cascade Dam is owned by Cascade Township and operated by STS Hydropower and generates 1.4 megawatts of electric power. It is located in Cascade Township, section 16. This 32 foot dam impounds 270 acres with a mean elevation of 665 feet.

The Ada Dam in Ada Township is owned by the Thornapple Association and operated by STS Hydropower. The Thornapple Association is an association of approximately 230 homeowners with riparian property between the Cascade and Ada dams. This dam generates 1.6 megawatts of electric power. The mean elevation of the impoundment is 632 feet.

These operational dams are overseen by FERC, the Federal Energy Regulatory Commission. It is recommended that local units of government in the dam areas actively communicate with FERC and dam operators on issues of safety and water quality concerns.

6 Wessel, Paul T., P.E. MDEQ Dam Safety Program. Personal communication. Oct. 2, 2008.

Impoundments upstream of each of the operational dams are characterized by eutrophication and sediment build-up. The operational dams on the Thornapple River also do not utilize fish ladders to permit fish passage. These and the smaller dams in the watershed also create fish passage barriers, which over time can limit the number and quality of fish species in their reaches. Such considerations warrant regular monitoring of water quality and aquatic species in these areas. When possible, non-operational dams in the TRW should be removed.

3.1.8 Topography and Elevation

The topography of the TRW subbasin is relatively flat, with average elevations between 750 and 850 feet. Areas of minimal elevation change contain quantities of poorly drained soils. The middle portion of the TRW includes extensive and numerous wetlands and a number of lakes.

3.1.9 Geology and Soils

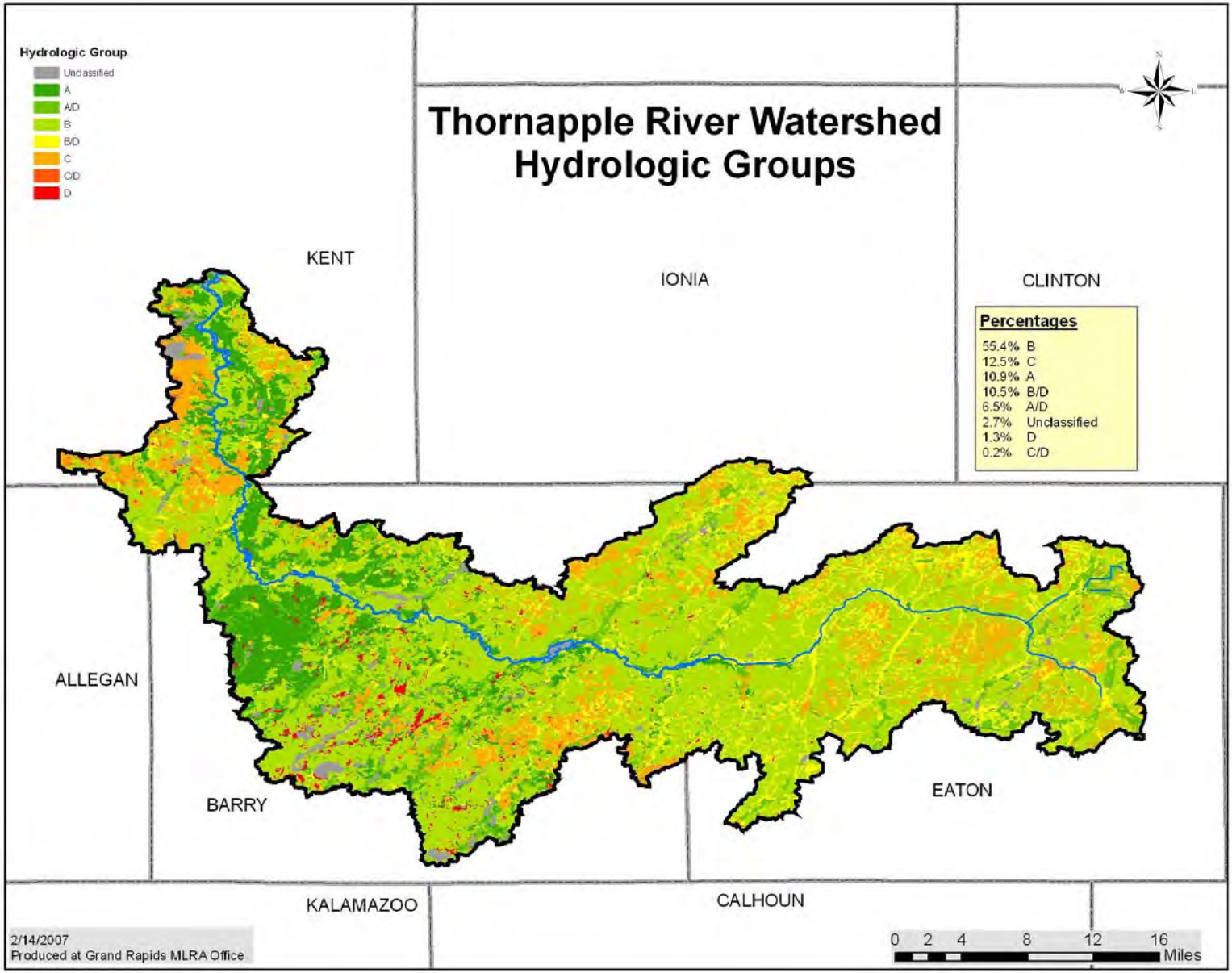
The soils within the TRW are principally derived from glacial till and outwash deposits. Soil textures and drainage class vary widely. Soils in the northeast quarter of the watershed are dominated by nearly level to gently rolling loamy soils with perched seasonal high water tables. If drained, these soils are well suited to row and forage crops. The primary land use in this part of the watershed is agriculture, and most of the area is drained through tile or channel structures. The remainder of the watershed is dominantly nearly level to rolling sandy and loamy well drained soils well suited to agriculture, forestry and recreation. The western half of the watershed is principally forested. Figure 3.1.9-A shows the distribution and list the percentages of each hydrologic soil group within the Thornapple River Watershed. From this information it can be determined that the majority of the watershed has soils with moderate or higher infiltration rates and medium or lower runoff potential. About 11% of the watershed has high to very high runoff potential under natural conditions. Critical runoff areas with correspondence to low infiltration rates include the subwatersheds of High Bank Creek, Cedar Creek, McCords Creek, Duncan Creek and areas in Fall Creek, Glass Creek, and Quaker Brook.

3.1.10 Vegetation

According to presettlement vegetation data[7], beech-sugar maple forest covered the Thornapple River watershed's landscape from the headwaters to what is now M-37 highway, and also in its northwest quadrant. Oak-hickory forest dominated from the headwaters of Cedar Creek to Turner Creek (Hastings to Middleville), then followed the river's east bank up to its confluence with the Grand River. Riparian corridors of mixed hardwood or mixed conifer swamp buffered the river and many of its tributaries from the headwaters to Thornapple Lake and throughout the Cedar and Fall Creek subwatersheds. Areas of mixed oak savannah, sometimes bordering emergent marshes, dotted the landscape from Hastings to Ada. Significant wet prairies existed around Black Creek at State Road and along Glass Creek at Gun Lake Road.

7 Comer, P. J. and D. A. Albert, 1997. "Vegetation circa 1800 of Allegan, Barry, Eaton, Ionia and Kent Counties." Michigan Natural Features Inventory.

Figure 3.1.9.A Hydrologic Soil Groups



Land cover data from IFMAP (Interface for Metadata Access Points) for the watershed indicates that nearly all of the presettlement beech-sugar maple forest area has given way to row and forage crops. Significant portions of the former oak-hickory forest, with the exception of Caledonia Township, are still populated with deciduous or mixed trees and shrubs. This is partly due to the protection provided by the Barry and Middleville State Game Areas, and partly due to the extensive wetland areas in the southwest portion of the watershed. Corridors of bottomland hardwoods still flank much of the river and its tributaries, but some of the species diversity and natural communities, such as oak barrens and oak savannahs, have been lost due to land conversion. The Michigan Natural Features Inventory data for the Thornapple River Watershed indicates the presence of dry-mesic southern forest, mesic southern forest, southern floodplain forest, wet prairie, hillside prairie and prairie fen communities in subwatersheds in the lower reaches of the Thornapple River Watershed. Each of these natural communities is considered of ecological importance.

Existing areas of diverse and high quality vegetation and habitat within the TRW are one of its most important resources.

3.1.11 Exotic and Invasive Species

Invasive plant and animal species can also affect human activity and natural processes. Exotic species are classes of plants or animals that are introduced into a "foreign" environment, and often these new varieties can have negative impacts on the native environment. There are many invasives in the TRW, and new species seem to plague the area annually. Examples of some of the more destructive species affecting water quality are found below. An up-to-date list of invasive species in Michigan, maintained by the Michigan Department of Natural Resources, can be found at http://www.michigan.gov/dnr/0,4570,7-153-10370_59996---,00.html .

Emerald Ash Borer (Agrilus planipennis Fairmaire) is an exotic beetle that has killed more than 10 million ash trees in Michigan since 2002. Smaller than a penny, the beetle lives throughout its larval stage in the cambium layer (between the bark and wood) of ash trees, voraciously destroying the trees' ability to carry water and nutrients to its leaves and branches. Once infested, a tree has little, if any chance of survival. The ash borer infests new trees annually, when adults leave their nursery trees to find new ones for the next year's brood. Beetles and larvae are also transported in cut wood. All of Lower Michigan is now in a quarantine to help stop the movement of the Emerald Ash Borer (EAB). There are no current methods to control or eradicate the species. The almost certain loss of all ash trees in Lower Michigan will change the nature of the hardwood and deciduous forests of the region, including the forested floodplains of the TRW, which are home to extensive ash stands.

Purple Loosestrife (Lythrum salicaria) is an invasive plant species transported to North America from Europe. The plant aggressively invades wetlands, lakes and rivers, choking out native vegetation critical to wildlife. The attractive purple flower may at first be welcomed by riparian landowners, but the plant's dense growth and resistance to eradication measures soon impairs shoreline access and blocks drainage systems. Purple loosestrife is present in many wetlands in the Thornapple River Watershed as well as along portions of its streams, creeks and the river. Seeds travel through waterways, exponentially increasing growth each season. Large-scale eradication is difficult at best, and current science suggests that the introduction of natural "enemies" in the form of Galerucella beetles, may be the only practical method to fight the spread of this invasive plant.

Zebra Mussels were most likely introduced to Michigan's Great Lakes through ballast water discharged from ships. The small, striped or solid colored mussels are characteristically clustered together in a fist-sized group and often found on beaches and shores. Zebra mussels feed on plankton, microscopic organisms that are part of the native ecosystem. Because the zebra mussels eat so much and multiply so quickly, they rob food sources from other, native species, disrupting the natural food chain. Zebra mussels travel easily from lake to lake, attaching themselves to boats, weeds and other surfaces. Their larvae, microscopic in size, can also be transported in live wells and bilges. Zebra mussels are present in the Thornapple River downstream of the Cascade Dam and are likely infesting many recreational lakes in the watershed. Boaters are encouraged to inspect their crafts before transporting them from place to place, to flush all water intake areas and to dry crafts for at least 48 hours before transporting them to uninfested waters.[8]

Eurasian Watermilfoil is an aquatic plant species commonly recognized as the "fish tank plant." Its presence was first documented in the U.S. in the 1940's and has now spread throughout North America. This harmless-looking plant, like other invasive species, takes over whole riverbeds and shallow lake areas, displacing native plants and the ecosystems they support. Eurasian watermilfoil can regenerate from very small plant pieces. When boat motors chop the weeds, they float to new locations and take root. Eurasian watermilfoil is present throughout the river and lakes of the Thornapple watershed. Many lakes are using chemical treatments which reduce milfoil and other aquatic plants. Boaters can slow the movement of this weedy invader by cleaning crafts and trailers before transporting them to a new location. There are currently no strategies for eradication of this species.

3.1.12 Wildlife

Wildlife species within the Thornapple River Watershed are typical of those found throughout the Southwest Michigan region. The area supports a large population of white-tailed deer. Coyote populations are present in rural areas, and one car-bear collision in the Thornapple Lake subwatershed in 2008 indicates the potential for isolated black bear locations within the watershed. Small mammals range from nuisance species like moles, woodchucks and raccoons to flying squirrels and species of bats. The watershed is home to a significant bird population which includes bald eagles, sandhill cranes, wild turkeys, blue and green herons, ring-necked pheasants, ruffed grouse, several raptor species, and an array of songbirds. Reptile and amphibian populations are most evident in the floodlplain and wetland areas of the TRW, where several species of turtles, salamanders, frogs, toads and snakes can be regularly seen.

3.1.13 Protected Species

According to the Michigan Natural Features Inventory[9], there are 71 plant and animal species considered endangered, threatened, or of special concern within the Thornapple River watershed. These important species and communities have been located in subwatersheds from the headwaters to the mouth of the watershed, indicating the ecological richness and diversity of the entire region. Endangered species include the Indiana Bat and Mitchell's Satyr butterfly (state and federal listed), the King Rail and Three-staff Underwing (state listed) and the Prairie Fringed Orchid (state - endangered, federal – threatened). The Bald Eagle is listed as threatened on the state and federal levels, but its federal listing may soon expire. Conversely, the Eastern Massasauga rattlesnake is being considered for

8 Michigan Sea Grant Website, www.miseagrant.umich.edu.
9 Michigan Natural Features Inventory Website, January 2007.

federal listing and is a state species of special concern. In addition to the listed species, there are nine natural communities, which are significant vegetative, geological or other features, within the watershed, including prairie fens, great blue heron rookeries and mesic southern forest. Subwatershed listings of the watershed's threatened, endangered and special concern species is included in Section 5.

The forested floodplain of the Thornapple River is a known location for the Indiana bat, which utilizes the area for summer nursery colonies. The loose bark of some floodplain trees, including silver maple, provides shelter for the colonies. Food sources include insect populations of wet and moist-soil areas. The bat is a seasonal resident, returning to caves in the Ohio Valley for the winter.

The king rail, a large, long-billed marsh bird, is also a seasonal resident, appearing in mid-April, then returning to its southern range in September. King rails favor large expanses of cattail, sedge or shrub marshes for cover and breeding, and they nest on clumps or tussocks above the water. Drainage, dredging and filling of wetlands has limited the rail's habitat in Michigan.

The Mitchell's Satyr is understood to require a very specific habitat for summer breeding. Calcareous (peat soil) wetlands, including wet prairies and prairie fens bordered by shrubs or forests, usually of the tamarack or red cedar type, as well as the presence of springs and Carex stricta - upright sedge - all seem to be necessary to host this rare species. Wetland alteration, both drainage and incursions that introduce exotic plant species, have been blamed for the decline of the Mitchell's Satyr.

The Massasauga rattlesnake, native to the Midwest but now found almost exclusively in Michigan, is a species on the decline due to habitat fragmentation and loss. The Massasauga hibernates through winter in wetland areas, and then moves upland during temperate months. Much like the several turtle species of concern in the watershed, the Massasauga may migrate over a mile between locations and therefore suffers when roadways and homes separate its winter and summer habitats. Michigan's only rattler, the Massasauga can be distinguished from other snakes by its triangular-shaped head, vertical pupils and audible rattle. Though venomous, this rattler is not aggressive, preferring to blend into the background rather than strike. It is illegal in Michigan to collect or harm this species without an authorizing permit.

The prairie fringed orchid, which in its southern range thrives in mesic and wet mesic prairies, has also suffered from floodplain conversion and stream channelization. Other threats are encroachment of shrubs into grassland areas, and the spread of invasive species, especially purple loosestrife, which compete with the orchid for precious open habitat. This tall (up to three feet), single-stemmed plant produces a full head of cream to yellow orchid-shaped blossoms in late June to early July. The prairie fringed orchid requires a moist soil for germination. To survive water level variation, the orchid casts its seeds landward during high water and shoreward during drought. Tubers often lie dormant in dry or saturated soils, so colonies may be unknowingly destroyed by streambank disturbance or shoreland conversion.

The common plight of the Thornapple River Watershed's special species and communities is land conversion. The clearing of forests, draining of wetlands and development of prairies for agricultural, residential and commercial uses have drastically altered the watershed's landscape. Only small fragments of critical habitat area now exist for these species. Good water quality and the environmental factors which sustain it are important to the protection of these significant, though diminishing, species and ecosystems. Only through changes in current land use management practices will these wildlife resources continue to exist in this region.

3.1.14 Sensitive Areas

The Michigan Natural Features Inventory (MNFI), which catalogs existing data on rare and declining species and habitats and collects data through on the ground surveys in its biotic database, publishes occurrence data by township for the State of Michigan. Occurrences are sightings or records of threatened, endangered and special concern species as well as high-quality natural communities[10]. County occurrence maps indicate the highest occurrences (16-20) in section 10 of Cascade Township, above 28th St., and relatively significant occurrences (over 11 per township section) in sections immediately surrounding it. Similar counts of over 11 occurrences are found in areas of the Barry State Game area including sections 3, 26 and 27 of Yankee Springs Township –around Shaw, Hall and Deep Lake, and in section 1 of Orangeville Township.

The MNFI conducted a *Potential Conservation Areas Analysis for Barry County* in 2006, and a *Potential Conservation Areas Analysis for Clinton, Eaton and Ingham Counties* in 2009. These studies coupled the above-mentioned biotic data with 2006 land cover data, Michigan presettlement vegetation data circa 1800 and the Michigan Geographic Framework 2006 base layers. Potential conservation areas ranked in the analysis were those with significant total size, core area (total size less a 300-foot buffer), stream corridor, connectivity with other habitat areas, restoration potential of surrounding areas, vegetation quality and occurrence data. Each potential conservation area was scored based on the above criteria and ranked as low, medium, high or highest priority for conservation. These ranked areas provide a more specific indication of sensitive areas for the Barry and Eaton County portions of the Thornapple River Watershed.

The *Potential Conservation Areas Analysis for Barry County* determined that the highest ranking county areas are in the Glass Creek and Turner Creek subwatersheds within and around the Barry State Game Area, the Fall Creek subwatershed between Schulz and West Quimby Roads, portions of the Cedar Creek subwatershed, Mud Creek and Thornapple Lake subwatersheds and the Algonquin Lake subwatershed in the Middleville State Game Area. Areas of lesser significance are abundant through the watershed area.

Potential conservation area rankings for Eaton County find the highest ranking areas along the floodplains and riparian corridors in the county's northwest corner. These include corridors along Scipio Creek, the Thornapple River at Thornapple Lake, and Thompson Creek. Additional important conservation areas are found around the chain of lakes at the Headwaters - Mud Creek, along the King Drain in the Milbourn Drain subwatershed, and along the Little Thornapple River.

3.2 Land Use and Land Cover

According to the most recent IFMAP land cover data, land use within the watershed is 52.1% agricultural production, 25.8% forested, 12.9% other non-production vegetation, 3.3 % paved road or airport, 2.1% low to high density urban, 1.5% water and 1.5% wetland. This data indicates the largely rural nature of the TRW and emphasizes the relative levels of impact on water quality from agricultural sources, wetland loss and urbanization. Land use percentages by subwatershed, expressed in Section 5, show the highest percentage of impervious surface and built area in the Thornapple River at Mouth subwatershed, in the areas of Cascade and Ada. Other highly developed areas are found in the Butternut Creek subwatershed in Charlotte and the Butler Creek subwatershed in Hastings. The highest

10 Michigan Natural Features Inventory. Number of Occurrences per PLSS Section Maps for Allegan, Barry, Eaton, Ionia and Kent Counties. www.http://web4.msue.msu.edu/mnfi

levels of agricultural use are found in the upper reaches of the TRW, and the highest levels of forested acres are found in the subwatersheds extending through the Barry and Middleville State Game Areas. Wetland percentages are highest in the southern Barry County portion of the TRW, and surface water percentages are highest at the Thornapple River subwatershed, where several tributaries drain into Thornapple Lake.

3.2.1 Open Space

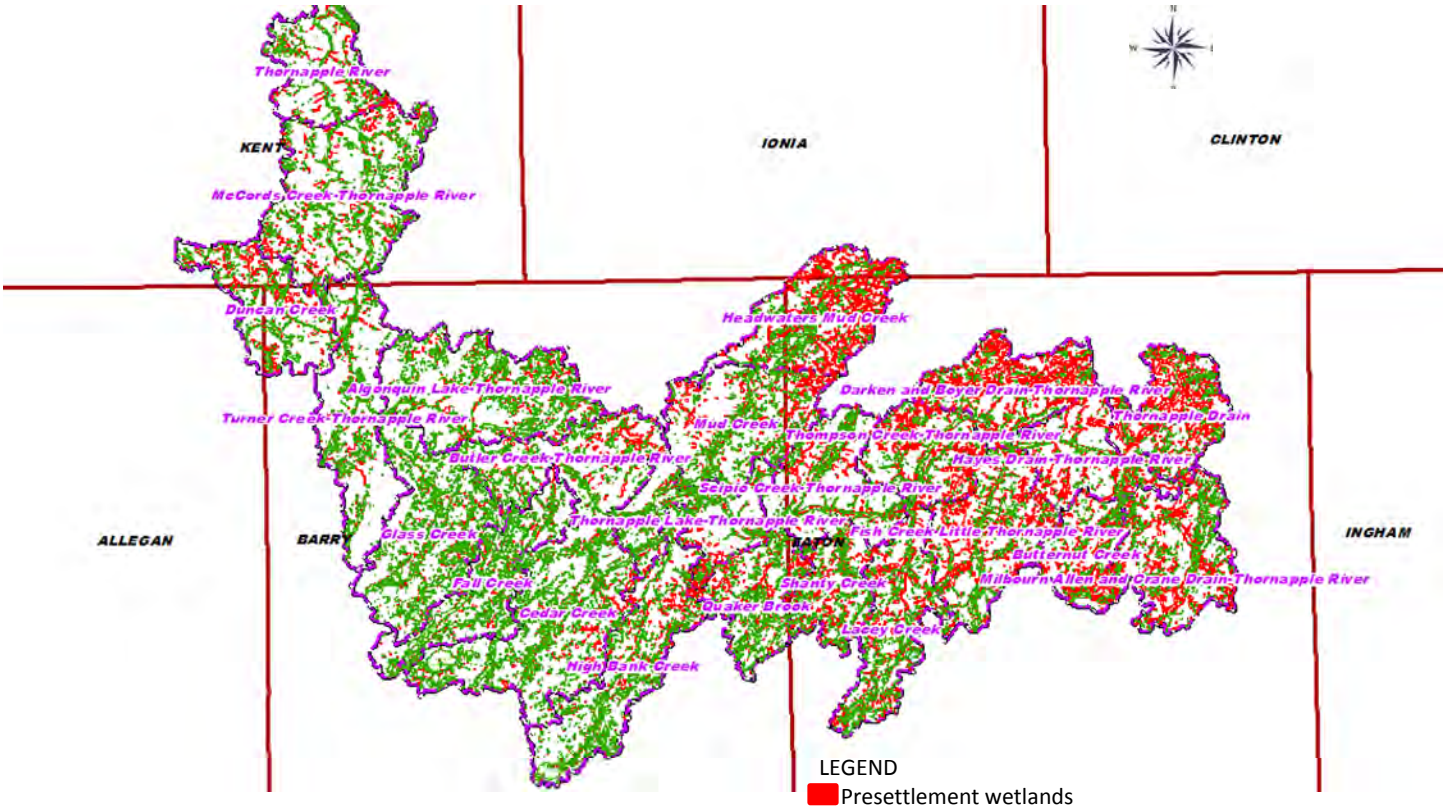
Within the TRW, 38.7% of land use is forested or other non-productive vegetation, with an additional 1.5% wetlands, providing ample open space areas. A large portion of forested acreage is owing to the three state game areas within the TRW and other portions are made up of floodplain areas and small, private woodlots. Within the TRW, approximately 3000 acres of open space have been protected through land conservancy conservation easements 1,200 of which have been protected through the Barry State Game Area Planning Project. The project is slated to conserve another 800 acres around the Barry State Game Area by 2015. Plans are needed to protect open space in and around urbanizing areas of the TRW to maintain the region's rural character. In addition, forest and open space management plans are needed for private lands to encourage best management practices for water quality and to improve wildlife habitat value.

3.2.2 Wetlands

Wetlands are characterized by water saturation in the root zone, or above the soil surface for a certain amount of time during the year. Wetlands play a critical role in regulating the movement of water within watersheds. They store precipitation and surface water and slowly release the water in associated water resources, ground water and the atmosphere. They help maintain the level of the water table and serve as filters for sediments and organic matter. Without wetlands, water quality decreases, areas become more prone to flash flooding, and habitat for specialized plants and animals is reduced.

Figure 3.2.2.1 Wetland Loss

Wetland Loss in the Thornapple River Watershed



LEGEND
Presettlement wetlands
Wetlands as of 2005
Source: Landscape Level Wetland Functional Assessment for the Thornapple River Less Coldwater River. MDEQ 2012
Scale 1:444,500

A comparison of wetlands from the 1800's to 2005 indicates that wetland loss was most significant in the Thornapple's headwaters, especially within the Thornapple Drain, Butternut Creek and Headwaters Mud Creek subwatersheds in Eaton County, and in the Quaker Brook and Algonquin Lake subwatersheds in Barry County. State data indicates that approximately 50% of wetlands in Michigan have been drained or altered for the purposes of agriculture and development[11]. Historic drain systems still support active agricultural operations on over 50% of land within the Thornapple River Watershed, and as farms are sold for development, these same lands are further modified to support subdivisions

Present-day land cover data indicates that the majority of the watershed is agricultural, with wooded wetland corridors still evident, though much narrower, along the river and many tributaries. Scattered patches of primarily hardwood swamp merge into thicker stands as the river moves westerly, and then thin again around the developing Grand Rapids suburbs. Emergent wetlands are common, especially along the corridors of creeks to the south of the Thornapple River and in the Scipio and Mud Creek

11 Michigan Department of Environmental Quality Website, March 2007.

subwatersheds to the north. In the southern portion of Barry County, significant tracts of swamp and marshland are still present.

The USACE Grand River Sediment Transport Modeling Study[12] indicates that the subwatersheds of Scipio Creek, Cedar Creek and Thornapple Lake are comprised of 10-12% wetlands. The developed subwatersheds of the Thornapple River, McCords Creek and Butternut Creek, along with the drained subwatersheds of Fish Creek, Lacey Creek and Shanty Brook contain only 0-3% wetlands. The remaining subwatersheds range from 4-9% wetlands.

3.2.3 Forested Areas

In pre-settlement times, nearly the entire watershed was covered in forest. Most has now given way to cropland and development. One quarter of the watershed remains forested, due largely to the protection of the Barry State Game Area and Yankee Springs Recreation Area southwest of the river in Barry County and the Middleville State Game Area just to its north. These areas, comprising approximately 22,000 acres, are managed by the Michigan Department of Natural Resources. Additional forested acreage corresponds with riparian corridors along streams and the river which are predominately lowland forest areas. Other vegetated areas, including shrub lands, herbaceous open land and low density forests are found in similar areas within the watershed.

Forests provide important habitat for many wildlife species. Along rivers and streams, forests provide cover, bank stabilization and filtration. Most private forest land within the TRW exists in small fragments. Landowner education about the importance of forest management, the value of forest corridors to game species and the emerging market for biomass may help to encourage the cultivation of larger, connected forest corridors throughout the watershed.

3.2.4 Agricultural Lands

Agriculture, the predominant land use within the TRW, includes row crops (26.7%), forage crops (25%) and orchards and nurseries (0.4%), according to IFMAP data. Corn, soybeans, hay and wheat are the major crops in the watershed area. The area supports a large number of livestock operations, including large dairies, mainly in the Kent and Barry County portions, along with several cattle ranches, hog farms and poultry farms. Significant orchards are located at the river's headwaters in Eaton County north of Potterville and also west of Eaton Rapids.

According to the USDA's farmland classifications, most of the watershed in Eaton and Ionia Counties is considered prime farmland if drained. Historic channelization of streams occurred throughout these areas and in the areas of Barry County that are similarly represented. Despite development, these areas are nearly all still in agricultural production, thus drain maintenance will likely continue to be necessary in these areas. Nearly all prime farmland and farmland of importance is currently in production in the watershed.

3.2.5 Mining

The TRW supports a small number of private sand and gravel mining pits as well as a few mid-sized operations used by local road commissions. There are no hard-rock mining or stream-gravel mining operations in the TRW.

12 USACE, Detroit District. May, 2007. Grand River Sediment Transport Modeling Study.

3.2.6 Fisheries

While the TRW's waters provide a substantial sport-fishery resource, there are no commercial fishing operations within the watershed. Information on the status of the fishery can be found in Section 4.2.3.2 below.

3.2.7 Recreation

Outdoor recreation is an important part of the TRW economy. Two state game areas and the Yankee Springs Recreation Area within the watershed provide forested recreation lands for hunting, hiking, cross-country skiing, horseback riding and a variety of other outdoor pursuits. Ample lakes and streams attract fishermen, boaters, and other water sports enthusiasts. The Thornapple River in Barry County supports two commercial canoe and kayak liveries and sees heavy use throughout the summer. Trail systems including the North Country Trail and the Paul Henry Thornapple Trail bring hikers from many states to the area. The TRW also boasts two Audubon Sanctuaries, four K-12 camps, the Pierce Cedar Creek Institute - an environmental education center, several golf courses and over a dozen private campgrounds.

3.2.8 Developed Areas

Major population centers within the watershed include Potterville, Charlotte, Nashville, Hastings, Middleville, Caledonia, Cascade, Southeast Grand Rapids and Ada. Potterville and Charlotte, along the I-69 corridor, continue to grow and industrialize as the urban area of Lansing pushes outward. While Vermontville, Nashville and Hastings face little development pressure, further north along the M-37 corridor, Middleville, Caledonia and the greater Grand Rapids region experienced 30-40% growth rates between 1990 and 2000, with little population change throughout the watershed region between 2000 and 2010. Urban or built acres and percentages of impervious surface correspond to rank the highest four areas of development in the subwatersheds of: Thornapple River, Butternut Creek, Thornapple Lake and McCords Creek. Impervious surface is greater in the Thornapple Drain subwatershed but urban and built areas are higher in the Thornapple Lake subwatershed. It is important that communities continue to support ordinances which promote smart growth and low impact development planning throughout the watershed region.

3.2.9 Transportation

The TRW is flanked by I-69 to the east, I-96 to the north, and US-131 to the west but is not centrally traversed by a freeway. The lack of a major transportation corridor in the central region of the TRW has kept industrialization and development to a minimum in the area. Main north-south arteries, M-37 and M-50, support the larger cities and towns of the watershed, with M-43 and M-79 as the key east-west routes. The City of Charlotte, near I-69, has seen increasing industrialization along the freeway corridor and along the rail line that serves the Lansing industries. The Kent County portion of the TRW, where M-37 and I-96 now meet, has seen major growth in industrial, commercial and residential development.

Continued development of the M-37 corridor and proposed new development of transportation corridors connecting the rural counties of Allegan, Barry and Eaton must be carefully planned to protect the TRW's resources. Collaborative efforts, such as the M-37 Corridor Group and the Barry Area Joint Planning Committee provide models for cross-jurisdictional cooperation in planning.

3.2.10 Political Boundaries

The TRW extends into portions of five counties in southwest Michigan: Eaton, Ionia, Barry, Allegan and Kent. Within the watershed, the Barry, Middleville, and Tamarack State Game Areas are the property of the State of Michigan and are managed by the Michigan Department of Natural Resources (MDNR). Fewer than 100 acres of the Barry State Game Area (BSGA) are technically deeded to the Federal Government but are managed as a part of the BSGA by the MDNR. There are no tribal lands within the TRW.

3.2.11 Relevant Authorities

Laws and ordinances providing for the management and protection of lands and waters within the TRW derive from federal, state, county and local units of government. In Michigan, state agencies such as the Michigan Department of Environmental Quality work to enforce federal and state environmental protection laws. The MDEQ is the state's permitting authority for inland lakes and streams, wetlands, NPDES, CAFOs, soil erosion and sedimentation control, and storm water management. The Michigan Department of Natural Resources manages fish and wildlife issues and controls state parks and game areas. County and municipal authorities may develop additional layers of protection through ordinances and land use regulations. Townships may act individually or in concert with other townships or a county to develop and enforce local ordinances.

Road Commissions and Drain Commissions, which function at the county level, also exercise authority over watershed resources. Road commissions plan and execute road development and maintenance projects. Road installation may impact drainage patterns within the watershed. Roads that cross over surface waters and wetlands may require the installation of culverts or bridges which may alter stream hydrology or wetland function. Bridge and culvert conditions, including size, depth and debris impaction, affect stream hydrology. Methods for road grading, repairs, and snow and ice removal can vary in their impact on water quality. Drain commissioners have authority to maintain or alter a large percentage of the watershed's tributaries, which are functioning as drains within agricultural and developed lands. It is important for both road and drain commissions to keep current regarding best management practices for water quality.

Local Health Departments exercise control over aspects of groundwater through permitting programs for well and septic system installation. The Barry-Eaton District Health Department is the oversight agency for an onsite well and septic system inspection program under its Time of Sale or Transfer (TOST) ordinance. Properties in Barry and Eaton Counties that are sold or transfer ownership must have these systems reviewed for functionality by a licensed inspector.

Soil erosion permitting, through Part 91, Soil Erosion and Sedimentation Control (SESC) is administered and enforced by MDEQ for the state as well as by various county and local government units. Counties are mandated to designate a County Enforcing Agency, and municipalities can elect to designate Municipal Enforcing Agencies (MEAs). Both CEAs and MEAs review soil erosion and sediment control plans, issue permits and review compliance with Part 91, taking enforcement actions when necessary. CEAs for counties within the Thornapple River Watershed are as follows:

Allegan – Allegan County Health Department
Barry – Barry County Planning Office
Eaton – Eaton County Drain Commission
Ionia – Ionia County Drain Commission

Kent – Kent County Road Commission

Kent County also has MEAs in Grand Rapids, Kentwood and the Department of Public Works with jurisdiction over areas of the TRW.

3.2.12 Future Land Use Considerations

Though areas in the middle and upper TRW regions experienced considerable growth in the 1990's and early 2000's, the recession that followed considerably slowed development. Government deficits, home foreclosure rates, unemployment, and stagnant construction markets minimized most land use changes for the next decade.

If political projections of continued economic improvement hold true, existing build-out models suggest that the same areas that saw over 25% population growth in the 2000 census could face the same impact in the next 10 to 15 years. In addition, previously less affected transportation corridors, specifically M-37 south of Middleville, M-79 between Charlotte and Hastings, and M-6 above Caledonia will experience increased urbanization.

Major impacts of projected development will be seen on the main stem of the Thornapple River, which is central to existing urbanized areas. Careful consideration is needed to protect the integrity of existing wetland and floodplain areas along the river's main stem in order to maintain current hydrology and water quality. Cooperative planning efforts between cities, villages and increasingly urbanizing townships along these corridors are necessary to combat sprawl, consolidate infrastructure needs and share infrastructure resources. The extension of the City of Hastings municipal sewer system to Middle and Leach Lakes and the collaborative efforts between Barry County and the Village of Middleville in developing the Paul Henry Thornapple Trail are good examples of such cooperation. Smart growth initiatives, already taking hold in Kent and Barry Counties, need further support throughout the watershed, especially at the village and township levels of government.

Secondary impacts of growth trends may affect recreational lakes in the vicinity of these areas, which provide attractive seasonal, retirement and year-round residences on the fringe of urban centers. Planning efforts must not only include the needs of growing lake communities, but also provide reasonable limits to population density in these areas. Old, seasonal lakefront cottages on these lakes have been expanded into family homes, sometimes exceeding the capacity or lifespan of their water and sewer systems. Homes on small lots have little space to replace these systems, making the need for municipal systems a compelling one. Like the river corridor, the push for lakeshore development threatens existing wetland and open space areas critical to water quality and flood storage. When these resources diminish, lake residents are prone to employ chemical weed management practices to treat the effects of nutrient loading.

National Agricultural Statistics Service data indicates that agricultural uses remained steady during the recession, with livestock, crop production and dairy production numbers showing little change in the past decade. Peak prices for corn and hay in the past few years have meant a reduction in agricultural "set aside" acres as lands are returned to production. Farming on highly erodible land as well as minimization or removal of stream buffers and windbreaks means an increase in runoff potential in the watershed. The 2012 drought has resulted in an increase in irrigation from both surface and ground water sources. A new state tax incentive has also supported more field tiling throughout the watershed. Both practices will likely impact the watershed by increasing nutrient-laden runoff in agricultural areas.

3.3 Demographic Characteristics

Figure 3.3 represents demographic characteristics for the three main counties in the TRW. Data are derived from the U.S. Census Bureau – State and County Quick Facts, found at http://quickfacts.census.gov/qfd/states/26000.html. Information regarding populations, age, race, education commuting patterns, economic conditions, employment, and commuting times are included and compared to State of Michigan data from the same period.

Data indicate that post-recession, population growth is minimal, with rural Barry County still experiencing declines. Smaller populations in the TRW region correspond with less racial diversity as well as smaller percentages of persons with higher education. Both median household income and median home values exceeded statewide statistics. Population distribution, in persons per square mile, is indicative of the economic basis of agriculture in the upper and middle watershed region, versus industry in the lower region.

Figure 3.3 Demographic Characteristics of the TRW Region

Characteristic	Barry County	Eaton County	Kent County	Michigan
Population 2012 estimate	58,990	108,008	614,462	9,883,360
Population % change 2010-2012	-0.3%	0.2%	2.0%	0.0%
Persons under 18 years, 2012	23.5%	22.3%	25.7%	22.9%
Persons over 65 years, 2012	15.9%	15.2%	11.6%	14.5%
White persons, 2012	97.3%	88.6%	83.7%	80.1%
Black persons, 2012	0.5%	6.8%	10.3%	14.3%
American Indian and Alaska Native persons, 2012	0.5%	0.5%	0.7%	0.7%
Asian persons 2012	0.4%	1.8%	2.5%	2.6%
Native Hawaiian and Other Pacific Islander, 2012	0.0%	0.0%	0.1%	0.0%
Persons of Hispanic or Latino origin, 2012	2.4%	5.0%	9.9%	4.6%
High school graduates age 25+, 2007-2011	90.6%	93.0%	88.6%	88.4%
Bachelor's degree or higher age 25+, 2007-2011	16.9%	24.6%	30.3%	25.3%
Homeownership rate, 2007-2011	84.7%	74.2%	71%	73.5%
Median home value, 2007-2011	$142,800	$147,900	$145,300	$137,300
Median household income, 2007-2011	$52,061	$54,170	$50,801	$48,669
Persons below poverty, 2007-2011	10.1%	9.7%	14.8%	15.7%
Persons per square mile, 2010	107.0	187.3	711.5	174.8
Mean travel time to work (minutes), 2007-2011	26.7	22.1	20.7	23.9

4 WATER QUALITY CRITERIA AND DATA SOURCES

4.1 Water Quality Standards

4.1.1 Designated Uses and Water Quality Standards

Designated and desired uses in the TRW are comprised of uses established by the State of Michigan. Designated uses are recognized uses of water established by state and federal water quality guidelines. According to Michigan's Public Act 451, all waters of the state are designated for the following uses: agriculture, industrial water supply, navigation, warm water fishery, other indigenous aquatic life and wildlife, partial body contact recreation, and total body contact recreation between May 1 and October 31. Certain waterbodies are designated by the state for use as cold water fisheries.

The Michigan Department of Environmental Quality (MDEQ) develops water quality standards for the Great Lakes and connecting waters and all surface waters of the state through its Water Resources Protection Act. These standards are generally intended to guide discharge permitting and as such, standards which are numerically based often reflect allowable levels of change. Other standards, such as those for physical characteristics, are less specific in nature. A general summary of Michigan's Water Quality Standards appears in table form below. Additional information including specific numeric criteria and exceptions can be found at www.michigan.gov/deq. Water Quality Standards listed in Figure 4.1.1 are derived from the Department of Environmental Quality's Part 4 – Water Quality Standards rules of 2006 and the 2012 Integrated Report. Listed criteria are those which apply to waters of the Thornapple River Watershed.

Figure 4.1.1 – Designated Uses and Water Quality Standards

Designated Use and Application	Water Quality Standards
Agriculture – all TRW waters	The MDEQ does not conduct specific assessments to evaluate support of the agriculture designated use. This use is assumed to be supported unless there is site-specific information indicating otherwise.
Navigation – all TRW waters	The MDEQ does not conduct specific assessments to evaluate support of the agriculture designated use. This use is assumed to be supported unless there is site-specific information indicating otherwise.
Industrial water supply – all TRW waters	The MDEQ does not conduct specific assessments to evaluate support of the industrial water supply designated use. This use is assumed to be supported unless there is site-specific information indicating otherwise.
Warm water fishery – all TRW waters except those listed in Table 4.1.1B	In all other waters, except for inland lakes as prescribed by R 323.1065 and inland waters designated as protecting coldwater fish, a minimum of 5 milligrams per liter of dissolved oxygen shall be maintained. [R323.1064 (1)]
	For all warm water inland lakes during stratification, a minimum dissolved oxygen concentration of 5 milligrams per liter shall be maintained throughout the epilimnion. At all other times, dissolved oxygen concentrations greater than 5 milligrams per liter shall be maintained. For all inland warmwater tributaries, a minimum of 5 milligrams per liter of dissolved oxygen shall be maintained. [R323.1065]
	Inland lakes shall not receive a heat load which would:

Designated Use and Application	Water Quality Standards
	(a) Increase the temperature of the thermocline or hypolimnion or decrease the volume thereof. (b) Increase the temperature of the receiving waters at the edge of the mixing zone more than 3 degrees Fahrenheit above the existing natural water temperature. (c) Increase the temperature of the receiving waters at the edge of the mixing zone to temperatures greater than the following monthly maximum temperatures: (J-45, F-45, M-50, A-60, M-70, J-75, J-80, A-85, S-80, 0-70, N-60, D-50) [R323.1072]
	Rivers, streams, and impoundments naturally capable of supporting warmwater fish shall not receive a heat load which would warm the receiving water at the edge of the mixing zone more than 5 degrees Fahrenheit above the existing natural water temperature. [R323.1075 (2)]
	Rivers, streams, and impoundments naturally capable of supporting warm water fish shall not receive a heat load which would warm the receiving water at the edge of the mixing zone more than 5 degrees Fahrenheit above the existing natural water temperature or to temperatures greater than the following monthly maximum temperatures: (J-41, F-40, M-50, A-63, M-76, J-84, J-85, A-85, S-79, 0-68, N-55, D-43) [R323.1075 (3, 3b)]
	Using MDEQ Procedure 51, warm water fish communities are scored with metrics that rate water bodies from excellent (+5 to +10) to poor (-10 to -5). Fish ratings from -4 to +4 are considered acceptable. [2012 IR 4.5.2.1]
Other indigenous aquatic life and wildlife – all TRW waters	Water column toxic substance concentrations are compared to Wildlife, Aquatic Maximum and Final Chronic Values as expressed in R 323.1057. [2012 IR 4.6.1.1]
	Ambient water column nutrient concentrations are used in conjunction with biological indicators to determine support of the other indigenous aquatic life and wildlife designated use per R 323.1060 using best professional judgement since Michigan does not have numeric standards for ambient concentrations of plant nutrients. [2012 IR 4.6.1.2]
	Physical characteristics addressed in R323.1050 are assessed by best professional judgment in conjunction with other assessment types. [IR 2012 4.6.1.3]
	In addition to chemical and physical assessment types, Michigan uses rapid bioassessment of macroinvertebrate communities in wadeable streams and rivers (generally P51; MDEQ, 1990) to determine support for the other indigenous aquatic life and wildlife designated use. Using P51, macroinvertebrate communities are scored with metrics that rate water bodies from excellent (+5 to +9) to poor (-5 to -9). Macroinvertebrate ratings from -4 to +4 are considered acceptable. [2012 IR 4.6.2.1]
	For inland lakes, Carlson's trophic status index (TSI) in conjunction with aquatic macrophyte surveys, are considered to determine designated use support. [2012 IR 4.6.1.2]

Designated Use and Application	Water Quality Standards
	Site-specific visual observation of bacteria, algae, macrophytes, and fungi may be used to make a support determination for the other indigenous aquatic life and wildlife designated use. [2012 IR 4.6.2.2]
Partial body contact recreation – all TRW waters	All surface waters of the state protected for partial body contact recreation shall not contain more than a maximum of 1,000 E. coli per 100 milliliters. Compliance shall be based on the geometric mean of 3 or more samples, taken during the same sampling event, at representative locations within a defined sampling area. [R323.1062 (2)]
Fish consumption – all TRW waters	Site-specific water column and fish tissue data are used together to determine fish consumption designated use support. Ambient water column mercury concentrations are compared to the HNV (nondrinking water) WQS (1.8 nanograms per liter [ng/L]); fish tissue mercury concentrations in edible portions are compared to Michigan's fish tissue value for mercury (0.35 milligrams per kilogram [mg/kg]). [2012 IR 4.8.1.1]
	To determine fish consumption designated use support for PCBs, the ambient water column PCB concentration is compared to the Human Cancer Value (HCV) (0.026 ng/L) as expressed in R 323.1057. [2012 IR 4.8.2.1]
	For contaminants other than mercury, a water body is considered to not support the fish consumption designated use if the Michigan Department of Community Health has issued a site-specific fish consumption advisory for that water body. [2012 IR 4.8.2.1]
Total body contact recreation – all TRW waters from May 1 to October 31	All surface waters of the state protected for total body contact recreation shall not contain more than 130 Escherichia coli (E. coli) per 100 milliliters, as a 30-day geometric mean. Compliance shall be based on the geometric mean of all individual samples taken during 5 or more sampling events representatively spread over a 30-day period. Each sampling event shall consist of 3 or more samples taken at representative locations within a defined sampling area. At no time shall the surface waters of the state protected for total body contact recreation contain more than a maximum of 300 E. coli per 100 milliliters. Compliance shall be based on the geometric mean of 3 or more samples taken during the same sampling event at representative locations within a defined sampling area. [R323.1062 (1)]
Cold water fishery – TRW waters listed in Table 4.1.2	Except for inland lakes as prescribed in R 323.1065, a minimum of 7 milligrams per liter of dissolved oxygen shall be maintained at all times in all inland waters designated by these rules to be protected for coldwater fish. [R323.1064 (1)]
	The following standards for dissolved oxygen apply to the lakes designated for coldwater fish in R 323.1100(4) and (6): (a) In stratified coldwater lakes which have dissolved oxygen concentrations less than 7 milligrams per liter in the upper half of the hypolimnion, a minimum of 7 milligrams per liter dissolved oxygen shall be maintained throughout the epilimnion and upper 1/3 of the thermocline during stratification. Lakes capable of sustaining oxygen

Designated Use and Application	Water Quality Standards
	throughout the hypolimnion shall maintain oxygen throughout the hypolimnion. At all other times, dissolved oxygen concentrations greater than 7 milligrams per liter shall be maintained. (b) Except for lakes described in subdivision (c) of this subrule, in stratified coldwater lakes which have dissolved oxygen concentrations greater than 7 milligrams per liter in the upper half of the hypolimnion, a minimum of 7 milligrams per liter of dissolved oxygen shall be maintained in the epilimnion, thermocline, and upper half of the hypolimnion. Lakes capable of sustaining oxygen throughout the hypolimnion shall maintain oxygen throughout the hypolimnion. At all other times, dissolved oxygen concentrations greater than 7 milligrams per liter shall be maintained. (c) In stratified coldwater lakes which have dissolved oxygen concentrations greater than 7 milligrams per liter throughout the hypolimnion, a minimum of 7 milligrams per liter shall be maintained throughout the lake. (d) In unstratified coldwater lakes, a minimum of 7 milligrams per liter of dissolved oxygen shall be maintained throughout the lake. (2) For all other inland lakes not specified in subrule (1) of this rule, during stratification, a minimum dissolved oxygen concentration of 5 milligrams per liter shall be maintained throughout the epilimnion. At all other times, dissolved oxygen concentrations greater than 5 milligrams per liter shall be maintained. [R323.1065 (1)]
	(1) Rivers, streams, and impoundments naturally capable of supporting coldwater fish shall not receive a heat load which would do either of the following: (a) Increase the temperature of the receiving waters at the edge of the mixing zone more than 2 degrees Fahrenheit above the existing natural water temperature. (b) Increase the temperature of the receiving waters at the edge of the mixing zone to temperatures greater than the following monthly maximum temperatures: (J-38, F-38, M-43, A-54, M-65, J-68, J-68, A-68, S-63, 0-56, N-48, D-40). [R323.1075 (1)]
	Fish communities collected from designated coldwater streams using P51 are determined to support the coldwater fishery designated use if the relative abundance of salmonids is equal to or greater than 1%. [2012 IR 4.5.2.1]
All Uses – all TRW waters	The surface waters of the state shall not have any of the following physical properties in unnatural quantities which are or may become injurious to any designated use: (a) Turbidity. (b) Color. (c) Oil films. (d) Floating solids. (e) Foams. (f) Settleable solids.

Designated Use and Application	Water Quality Standards
	(g) Suspended solids. (h) Deposits. [R323.1050]
	The addition of any dissolved solids shall not exceed concentrations which are or may become injurious to any designated use. [R323.1051]
	The hydrogen ion concentration expressed as pH shall be maintained within the range of 6.5 to 9.0 S.U. in all surface waters of the state, except for those waters where the background pH lies outside the range of 6.5 to 9.0 S.U. [R323.1053]
	The surface waters of the state shall contain no taste-producing or odor-producing substances in concentrations which impair or may impair their use for a public, industrial, or agricultural water supply source or which impair the palatability of fish as measured by test procedures approved by the department. [R323.1055]
	Toxic substances shall not be present in the surface waters of the state at levels that are or may become injurious to the public health, safety, or welfare, plant and animal life, or the designated uses of the waters. [R323.1057]
	The control and regulation of radioactive substances discharged to the waters of the state shall be pursuant to the criteria, standards, or requirements prescribed by the United States nuclear regulatory commission in 10 C.F.R. §20.1 et seq. and by the United States environmental protection agency. [R323.1058]
	(1) Consistent with Great Lakes protection, phosphorus which is or may readily become available as a plant nutrient shall be controlled from point source discharges to achieve 1 milligram per liter of total phosphorus as a maximum monthly average effluent concentration unless other limits, either higher or lower, are deemed necessary and appropriate by the department. (2) In addition to the protection provided under subrule (1) of this rule, nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the surface waters of the state. [R323.1060]

4.1.2 Cold Water Fisheries

Certain waterbodies, listed by the Department of Natural Resources as Designated Trout Streams, are also protected as cold water fisheries. Figure 4.1.2 lists the designated trout streams in the Thornapple River Watershed. Unless noted in the "Boundaries" column, the entire stream and its tributaries are included. A boundary designation indicates the downstream limit of the designation.

Figure 4.1.2 – Designated Trout Streams

Tributary	Subwatershed	Boundaries	Supporting Designated Use
Quaker Brook	Quaker Brook		Insufficient Information
Buckson Creek	Thornapple Lake		Yes
High Banks Creek	High Banks Creek	Lawrence Road	Yes
Cedar Creek	Cedar Creek		Yes
Glass Creek	Glass Creek		Yes
Hill Creek	Turner Creek		Yes
Turner Creek	Turner Creek	Confluence with Baker Creek	Yes
Bassett Creek	Turner Creek	Confluence with Thornapple River	Yes
Schoolhouse (Cascade) Creek	Thornapple River	Wood and Walden Lakes	Yes

4.1.3 Antidegradation Policies

The Michigan Department of Environmental Quality also provides a rule for antidegradation (Rule 98) within its Water Resources Protection Act (Michigan's Public Act 451). This rule is applicable to actions or activities which may result in new or increased pollutant loading to the state's surface waters where regulatory authority exists. Rule 98 states that "for all waters, the level of water quality necessary to protect existing uses shall be maintained and protected. Where designated uses of the water body are not attained, there shall be no lowering of the water quality with respect to the pollutant or pollutants that are causing the nonattainment"[13]. Similarly, if water quality standards are exceeded in a water body, that water is deemed high quality and that level of quality shall be maintained unless change is necessitated by a social or economic development need. Similar to the water quality standards above, the antidegradation policy applies only to permitted point-source discharges.

4.1.4 Desired Uses

Designated uses are confined to ways surface water is utilized, while desired uses take into account the land and water resources within the watershed and suggest the interests and concerns of watershed residents. The Thornapple River Watershed Steering Committee solicited public input to develop a list of desired uses for the TRW. Unlike statewide designated uses, these are not limited to surface water but include aspects of the watershed that are linked to overall water quality. Desired uses in the TRW are:

1. Groundwater resource
2. Education and interpretation
3. Other recreation
4. Riparian corridor resource
5. Wetland resource
6. Critical natural area resource
7. Renewable energy resource

13 Water Resources Protection: Michigan Department of Environmental Quality – Water Bureau. R 323.1098 (2).

The TRWSC evaluated both designated and desired uses in relation to the TRW in order to determine their relevance and ranking. Ranking is based on the need for protection of these uses from the threat of impairment. In some cases, desired uses supported designated uses. For example, wetland and riparian corridor resources ultimately improve fisheries and other indigenous aquatic life and wildlife. In these cases, the designated use was given precedence. The following list prioritizes designated and desired uses and explains their significance in the TRW:

Prioritized Designated and Desired Uses in the Thornapple River Watershed

1. Groundwater resource: In the TRW, all drinking water, as well as all commercial and domestic water needs are supplied by groundwater sources, making groundwater protection imperative for the region.
2. Warm water and cold water fishery: Use of the TRW as a warm water and cold water fishery is of high importance. According to MDNR fish stocking records, many lakes and streams in the TRW are regularly stocked with sport fishing species. The waters of the TRW attract anglers from throughout the state, supporting recreational tourism important to the regional economy. Additionally, Thornapple Lake provides one of two state sources for muskellunge stock. With nine tributaries of the TRW project area designated by the MDNR as trout streams, protection of the cold water fishery is also critical in the watershed.
3. Other indigenous aquatic life and wildlife: The number of threatened, endangered and special concern species in the TRW, coupled with the amount of sensitive areas within the floodplains and wetlands of the TRW make this use a high priority.
4. Partial body contact recreation: This use is defined by Michigan law as involving some direct bodily contact with the water, and encompasses activities like fishing, wading, hunting and dry boating. Since some level of contact is involved in nearly every water sport, and as the TRW is a valuable recreation area, this use is important throughout the watershed.
5. Total body contact recreation: This use involves immersion, such as occurs with swimming, where there is a risk of ingesting water. This use is less frequent than partial body contact, but given the number of lakes in the TRW and the potential for illness from ingesting contaminated waters, this use ranks equally with partial body contact recreation in the TRW.
6. Navigation: Navigation in the TRW is limited to recreational motorized and non-motorized boating. Navigation on the many public and private lakes as well as the main river channel and some larger streams is a significant asset to TRW residents and tourists alike. For this reason, navigation is considered an important use in the TRW.
7. Wetland resource: Within the TRW there is a strong grass-roots movement for wetland restoration and protection. Though approximately 50% of wetland resources have been lost statewide, there are still significant, unaltered wetland areas in the TRW, as expressed in Figure 3.2.2.1 from the Landscape Level Wetland Functional Assessment for the Thornapple River Watershed. Several properties in these important wetland complexes have been preserved, and in other areas restored through the assistance of the U.S. Fish and Wildlife Service, the USDA-NRCS's Wetland Reserve Program and non-profit land conservancies. Thanks to groups like the Southwest Michigan Land Conservancy, Pierce Cedar Creek Institute, the Thornapple River Watershed Council and the region's conservation districts, many citizens have been made aware of the importance of wetlands to ecosystem health and water quality. The quality of the TRW's wetlands and the concurrence of citizen groups make wetland resource protection a strongly desired use in the TRW.

8. Critical natural area resource: In addition to riparian corridors and wetlands, open space preservation, especially of critical natural areas, has been a pursuit supported by many throughout the TRW. Within the TRW over 4000 acres of open space have been preserved by private landowners through land conservancies. More than 1000 additional acres are held by nonprofit conservation entities. This and programs such as the Barry State Game Area (BSGA) Conservation Planning Project, which seeks to protect approximately 5000 acres of inholdings and surrounding critical natural areas contiguous to the BSGA, suggest the high level of interest in protecting critical areas in the TRW.
9. Riparian corridor resource: Land cover maps and Potential Conservation Area analyses both indicate that the TRW's riparian corridors provide some of the only remaining areas of unaltered vegetation and habitat. For ecosystem and water quality protection, preservation and improvement of riparian corridors in the TRW is a strongly supported use.
10. Education and interpretation: Public input expressed the desire to use the watershed as "a natural laboratory," where learners of all ages could explore and gain new insight into ecosystems and watershed functions. Similarly, the Thornapple River, as an historic navigation route, offers a pathway for exploration into early Native American and European settlements in the TRW.
11. Renewable energy resource: There are five hydroelectric dams on the main stem of the Thornapple River. In the current energy climate, maintenance of this important energy resource is also of importance in the TRW.
12. Other recreation: Citizens in the TRW placed importance on creating watershed-based recreational opportunities beyond partial and total body contact options, including ice skating, bird watching, wildlife viewing, linear trails within riparian corridors and riparian mini-parks.
13. Agriculture: According to the 2007 Census of Agriculture, within the three main TRW counties, Barry, Eaton and Kent, there are 428,339 acres of cropland. Of these acres, 13,619, or just over 3%, are irrigated. Due to the limited use of surface water resources in agriculture, this designated use was not perceived to be threatened or impaired.
14. Industrial water supply: Though there are pockets of industry within the larger cities and villages of the TRW, it is not a heavily industrialized region. Only 48 NPDES permits are issued within the TRW, and these include municipal wastewater treatment plants, airports and CAFOs. The limited use of surface water for industrial water supply indicates that this designated use is not a high priority in the TRW.

4.2 Available Monitoring and Resource Data

Several methods were used to determine current conditions in the Thornapple River Watershed. They include the Water Quality and Pollution Control in Michigan Integrated Reports published from 2004 - 2014 by the Michigan Department of Environmental Quality, biological surveys of the Thornapple River and its tributaries published by the DEQ from 1991 – 2009, road-stream crossing surveys and river surveys conducted by Thornapple River Watershed Steering Committee members, benthic macroinvertebrate monitoring conducted by the Thornapple River Stream Team and soil, land use, land cover and other mapping data provided by IFMAP, USDA-NRCS, MDNR and Barry County Land Information Services.

4.2.1 Water Quality Data

Water quality data used to assess conditions in the TRW includes studies conducted by the Michigan Department of Environmental Quality (MDEQ) and local health departments.

4.2.1.1 Impairments and Total Maximum Daily Load Schedules

Total maximum daily load (TMDL) studies are required when it is determined that a lake or stream is impaired, meaning it does not meet Michigan's Water Quality Standards for designated uses. Designated uses for all Michigan lakes and streams include total and/or partial body contact recreation, navigation, industrial water supply, agriculture, warm or cold water fishery, other indigenous aquatic life and wildlife and fish consumption. Once a lake or stream is determined to need a TMDL, a date is set for its completion, and a level of acceptable daily loading is determined for the water body. The load level includes all point source discharges, non-point source discharges and a margin of reserve. TMDL's are generally developed by the MDEQ in partnership with local communities, watershed councils and landowners.

Fish Consumption – All Waters: The MDEQ's most recent *Water Quality and Pollution Control in Michigan Integrated Report* (IR 2014), nearly all rivers and streams assessed within the Thornapple River Watershed were determined to be not supporting designated uses for fish consumption. These determinations were based on water column toxic substance concentrations, as well as fish tissue mercury and PCB concentrations. TMDL's are scheduled for 2014 but have not been published at this time.

The IR's water chemistry data indicates that statewide, PCBs in the water column exceeded the 0.026 ng/L water quality standard with 100% frequency. The likely sources for PCB's in Michigan's waters are atmospheric deposition and historical sediment contamination. Elevated levels of mercury in the water column also commonly exceeded the water quality standard of 1.3 ng/L. As part of the statewide study, one location in the Thornapple River Watershed Management area was sampled for PCB in the water column and three locations were sampled for mercury in the water column. Atmospheric deposition and local sources are cited as potential pollutant causes.

Other Indigenous Aquatic Life and Wildlife – Church Creek; Little Thornapple River; Trout Creek: The 2014 IR indicates that streams in three subwatersheds in the Thornapple River Watershed Management area are not supporting other indigenous aquatic life and wildlife. An unnamed tributary (Church Creek) in the Milbourn, Allen & Crane Drain subwatershed is listed as not supporting for unknown reasons. A TMDL is scheduled for 2025. The Little Thornapple River in the Fish Creek subwatershed is not supporting this use due to anthropogenic substrate and other flow regime alterations, or modifications made to waterways and maintenance activities carried out by county drain commissioners in streams designated as agricultural drains. No TMDL is currently scheduled for this stream. An unnamed tributary (Trout Creek) in the Thornapple River subwatershed is not supporting this use due to the presence bacterial slimes. A TMDL is scheduled for 2016, and revision of the NPDES permit for the Gerald R. Ford Airport will redirect de-icing fluids from this stream through a filtration system and into the Thornapple River, reducing the pollutant load to Trout Creek.

Seventeen other locations within the TRW have insufficient information regarding support of the other indigenous aquatic life and wildlife use. Future studies will determine whether conditions improve or decline and whether TMDLs will need to be scheduled for these locations, which are identified by subwatershed in Section 5.

Warm Water Fisheries – Mud Creek: The 2014 IR indicates that
Mud Creek, Hagar Creek and Gravel Brook in the Mud Creek subwatershed were not meeting their use as a warm water fishery due to other anthropogenic substrate alterations and other flow regime alterations. . Mud Creek and its tributaries are classified as county drains and carry runoff from largely agricultural areas. These drains are regularly maintained with dredging, woody debris removal and straightening. No TMDL is currenly scheduled for this impaired area.

Two other locations within the TRW have insufficient information regarding the standard for warm water fisheries. In addition, three locations have insufficient information regarding their cold water fishery status. Future studies are needed to determine whether these water bodies support their fishery status.

Figure 4.2.1 below represents waterbodies listed as impaired in the 2014 Integrated Report, excluding those impaired for fish consumption.

4.2.1.2 Coldwater River TMDLs

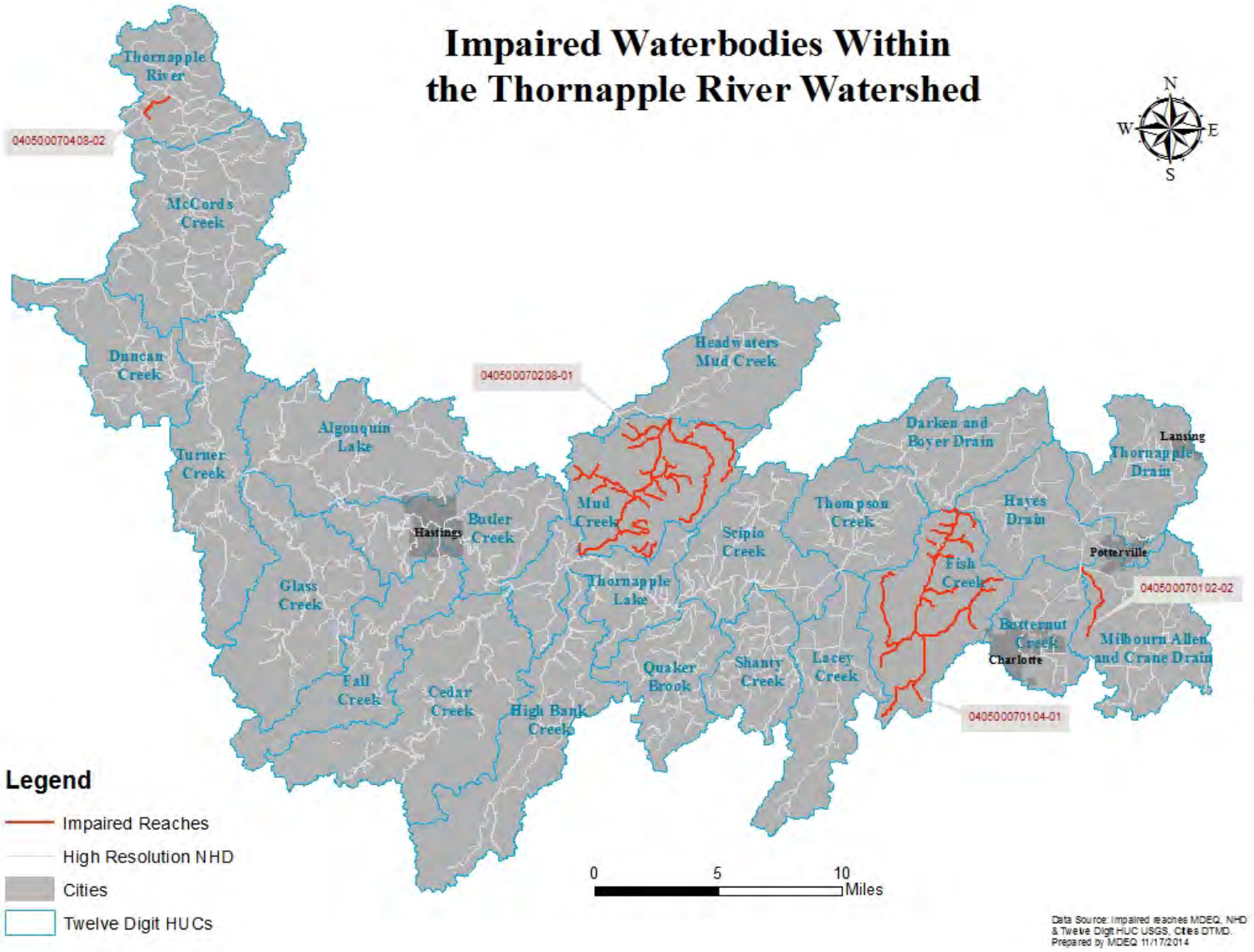
The Coldwater River and its tributaries constitute a major subbasin of the Thornapple River Watershed. Due to nonpoint source pollutant issues which have plagued this coldwater fishery for over a decade, a watershed management plan was developed in 2004, with a TMDL for E. coli completed in 2005 for the main stem of the Coldwater and one tributary, Bear Creek. As these waters flow into the TRW, they carry with them the threat of E. coli contamination in areas downstream of their confluence. Additional TMDL's for mercury and PCB's are scheduled for the main stem and all tributaries of the Coldwater in 2011 and 2010 respectively. The Barry Conservation District and Thornapple River Watershed Steering Committee are working in concert with the Coldwater River Watershed Council and the MDEQ on management plan implementation and share the goal of eliminating E. coli impairments and other threats to this important fishery.

4.2.1.3 Nitrate Areas

The Barry-Eaton District Health Department (BEDHD) has undertaken mapping of wells with nitrate levels exceeding EPA standards. The BEDHD study reports that there are at least four hundred fifty-six (456) sites with nitrate levels in the drinking water above five (5) parts per million (fifty percent of the EPA's Drinking Water Standards maximum contaminant level of ten (10) parts per million). Approximately 20% of these wells exceeded EPA maximum contaminant levels. Sources of nitrate include historic and current agricultural practices, sewage systems and lawn fertilization.

The highest concentrated areas of nitrate contamination have been located in the following subwatersheds: Turner Creek, Duncan Creek, High Bank Creek, Algonquin Lake, Fall and Butler Creeks. A nitrate contamination area covers a large portion of the Turner Creek subwatershed, extending from Cherry Valley Road northeast to 108th Street. This area includes the lower reaches of the Duncan Creek subwatershed. A large nitrate area surrounding Duncan Lake has also been identified. An extensive portion of Johnstown Township, along Banfield Road, M-37 and the connecting area of Bristol Road has been identified as a major nitrate area. This portion of the High Bank Creek subwatershed also includes residential wells around Mill, Little Mill and Bristol lakes. The affected areas in the Algonquin Lake subwatershed extend outward from the intersection of N. Solomon Road and W. State Road in Irving Township and east of the intersection of M-37 and McCann Road in Rutland Township.

Figure 4.2.1. Impaired Waterbodies within the Thornapple River Watershed



4.2.1.4 Lake Trophic Status

Trophic status, determined by Carlson's trophic status index of Secchi depth, total phosphorus concentration and chlorophyll *a* concentration, indicates the level of nutrient loading in lakes. The most recent DEQ trophic status data for lakes in the Thornapple River Watershed is from the 2004 *MDEQ Integrated Report*. Fine Lake and Leach Lake are listed as mesotrophic, indicating moderate nutrient loads. Carter Lake, Clear Lake and Duncan Lake are eutrophic, with high levels of nutrients evident. Thornapple Lake has reached hypereutrophic status, indicating excessive nutrient loading. Comments in the 2004 *IR* include 1990's Fisheries Division reports of frequent fish kills after spawning in Thornapple Lake. The Cascade Impoundment and Duncan Lake are currently being monitored through the Cooperative Lakes Monitoring Program. Its 2013 Annual Summary Report indicates that both of these locations are eutrophic[14].

4.2.2 Flow Data

There are three U.S. Geological Survey stations located within the TRW. The station on Quaker Brook, a tributary of the Thornapple south of Nashville, (USGS Gage 04117000) has been recording since 1955. A station at the historic McKeown Road bridge, on the mainstem of the Thornapple, southeast of Hastings, (USGS Gage 04117500) has been recording since 1945. The third station, located on the Thornapple River near Caledonia, (USGS Gage 04118000) has been active since 1952. Flow data from these gages has been analyzed in the DEQ's 2008 *Thornapple River Watershed Flashiness Report*, found in Appendix 2 of this plan. Daily and historic data can also be accessed through the USGS website at http://waterdata.usgs.gov/nwis/uv/?site_no=04117500&PARAmeter_cd=00065,00060,00062,72020

4.2.3 Biological Data

In addition to the biological data provided in the MDEQ Water Quality Standards surveys cited above, benthic macroinvertebrate monitoring has been conducted on selected TRW streams by the Thornapple River Watershed Stream Team since fall, 2006. Tables of biological surveys by subwatershed are provided in Section 5.

4.2.3.1 Benthic Macroinvertebrates

Benthic macroinvertebrate sampling was conducted in selected streams throughout the Thornapple River Watershed from 2006 to 2008 by the Thornapple River Watershed Stream Team. Funding from the Michigan Department of Environmental Quality, administered by the Great Lakes Commission through Michigan Water Quality Corps (MiCorps) provided training, administration and support for the program. All data collected through spring, 2010 is available for review at www.micorps.net. Results of these sampling events are listed by subwatershed in Section 5.

4.2.3.2 Fish

The Thornapple River mainstem, its tributaries, and the inland lakes within the watershed support diverse fish communities and collectively represent 16 families and 81 species of fish. The river mainstem provides recreational fishing for largemouth bass, smallmouth bass, northern pike, northern

14 Michigan Clean Water Corps. 2013. Cooperative Lakes Monitoring Program Annual Summary Report 2013. www.micorps.net/documents/CLMPFinalreport13.pdf

muskellunge, channel catfish, flathead catfish, yellow perch, walleye, and several species of sunfish. Although the mainstem is too warm to support coldwater species, several tributaries are classed as cold or cold-transitional (Zorn et al. 2008)[15] and provide habitat for several coldwater species including brook trout, rainbow trout, and brown trout. Inland lakes within the watershed range in size from 4 to 560 acres and support warmwater fish assemblages typically dominated by sunfish species. Four lakes within the watershed are considered coldwater lakes, three of which support populations of cisco, a state-threatened species.

The majority of the waters within the Thornapple River watershed are managed for native self-sustaining species. Active fisheries management conducted by the MDNR Fisheries Division on the Thornapple River mainstem includes the stocking of walleye and muskellunge. The northern muskellunge residing in Thornapple Lake were used as broodstock and annual egg-takes from this population are used to support northern muskellunge management throughout the State of Michigan until 2012, when MNDR switched from the northern to great lakes strain. Fisheries management of Thornapple River tributaries is limited to those waters that support trout fisheries. Although limited recruitment of brown trout and brook trout has been documented in some of these waters, these levels of natural reproduction are not sufficient to support good recreational fisheries. Trout populations are supplemented with annual stockings in High Banks Creek, Cedar Creek, Glass Creek, Tyler Creek, and the Coldwater River. Fish community management in the inland lakes within the watershed is primarily directed at sustaining populations of native fish through habitat protection. Limited stocking of walleye is conducted by individual lake associations by permit from the MDNR Fisheries Division.

Several species of fish in the Thornapple River watershed have been identified in the Michigan Wildlife Action Plan as Species of Greatest Conservation Need (SGCN)[16]. These species include: spotted gar, striped shiner, river chub, bigmouth shiner, lake chubsucker, spotted sucker, river redhorse, black redhorse, golden redhorse, brown bullhead, tadpole madtom, grass pickerel, cisco, starhead topminnow, and barred fantail darter. The species are identified as SGCN primarily based on evidence that their populations are in decline or sufficient population information is lacking. Threats associated with these declines include altered hydrologic regimes and sediment loads, stream dredging and channelization, habitat fragmentation from dam construction and poorly constructed road-stream crossings, nutrient enrichment, and degraded water quality associated with stormwater discharges and runoff.

4.2.4 Stream Survey Data

Road-stream crossing surveys were conducted in 2006-2007 by members of the Thornapple River Watershed Steering Committee to assist in determining current conditions in the Thornapple River Watershed. Surveys were conducted on approximately 30% of crossings in each subwatershed, with sites selected to represent minor tributaries when possible and major tributaries beyond junctions with minor tributaries to gain an understanding of pollutant source origination.

15 Zorn, T. G., P. W. Seelbach, E. S. Rutherford, T. C. Wills, S.-T. Cheng, and M. J. Wiley. 2008. A regional-scale habitat suitability model to assess the effects of flow reduction on fish assemblages in Michigan streams. Michigan Department of Natural Resources, Fisheries Research Report 2009, Ann Arbor.

16 Eagle, A.C., E.M. Hay-Chmielewski, K.T. Cleveland, A.L. Derosier, M.E. Herbert, and R.A. Rustem, eds. 2005. Michigan's Wildlife Action Plan. Michigan Department of Natural Resources. Lansing, Michigan. 1592 pp. http://www.michigan.gov/dnrwildlifeactionplan

The Road-Stream Crossing Survey is a visual assessment of stream conditions and watershed characteristics. Given the extensive scope of the Thornapple River Watershed Management Plan, such a survey provides a general indication of problem areas within the watershed. Trained assessors documented stream conditions following the guidelines of the MiCorps Volunteer Stream Monitoring Procedures[17]. Assessors photographed upstream, downstream, roads, culverts and bridges and conducted physical habitat inventories, potential sources inventories and site summary information. Complete records of these inventories can be found at www.micorps.net.

Road-stream crossing survey data for the TRW is critical in identifying specific locations of non-point source pollution. Data on road-stream crossing structure conditions pinpoints subwatersheds with the highest needs for structural repair as well as specific culverts or bridges contributing to sedimentation, flow alteration and fish passage barriers, found in Appendix 3 of this report.

17 Latimore, Jo. 2006. MiCorps Volunteer Stream Monitoring Procedures. MiCorps. www.micorps.net.

5 WATER QUALITY CONDITIONS, CAUSES AND SOURCES

Section 5 provides specific information on the conditions in each of the 24 subwatersheds of the Thornapple River watershed. Land use and other characteristics and features provide an overview each subwatershed. Point source contributions and data from monitoring activities in each subwatershed, as well as use support information from the 2014 Integrated Report are provided to identify impairments and/or degradations. Biological surveys of the Thornapple River Watershed are conducted approximately every five years by the MDEQ Water Resources Division Surface Water Assessment Section. Surveys include macroinvertebrate community, habitat and occasionally fish community. Biological surveys are included for each subwatershed where data is available. Recommendations for improving water quality are drawn from the identified issues, and specific locations identified for water quality improvement are listed along with the BMPs needed to reduce pollutant loads. Specific load reductions for each practice identified for each location in Section 5 are provided in Appendicies 4 and 5.

5.1 Subwatershed: Butternut Creek HUC: 040500070101

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
10015	11.04%	48.98%	0.00%	9.76%	17.37%	20.79%	0.13%	2.97%	100%

Land use in the Butternut Creek subwatershed is increasingly urbanizing, with continuing development along the I-69 corridor and its intersection with M-50 (Clinton Trail). The subwatershed includes the northeast corner of downtown Charlotte, where retail development flanks Lansing Road, with some small industry mixed in. Within the last two decades, development in the subwatershed has included two hotels and several “big box” stores on the city’s outskirts. The county office complex, a golf course and a large cemetery are also found within the subwatershed, with the latter two located on the banks of Butternut Creek. Core area development in the city and along the highway corridors gives way to large-lot residential, then to farmland in the outer portions of the subwatershed. Major agricultural production includes The Country Mill orchard on Otto Road, and corn-beans-wheat rotations on tillable acres, generally in areas classified as prime farmland if drained. Presettlement vegetation consisted of beech-sugar maple forest in the uplands, with mixed conifer swamp in the headwaters area and mixed hardwood swamp along the creek’s floodplain. Significant wetland loss occurred in the region bordered by M-50 to the south and Packard Highway to the north, an area now drained and utilized by the Charlotte Airport, commercial shopping centers and subdivisions. Additional wetland loss is evident along the creek in the area of the railroad line above Charlotte.

Soils: B,C, B/D mainly low and very low runoff potential

Protected Areas: Protection of 162 acres including a gravel pit pond, located just south of Packard Highway, is being pursued by the City of Charlotte. The Charlotte Country Club, airport and Maple Hill cemetery have all participated in improvements to riparian and instream areas on Butternut Creek, including the removal of the Maple Hill Dam in 2009.

Special Features: No special features or listed species are cataloged in the Michigan Natural Features Inventory for this subwatershed.

Hydrologic Features:

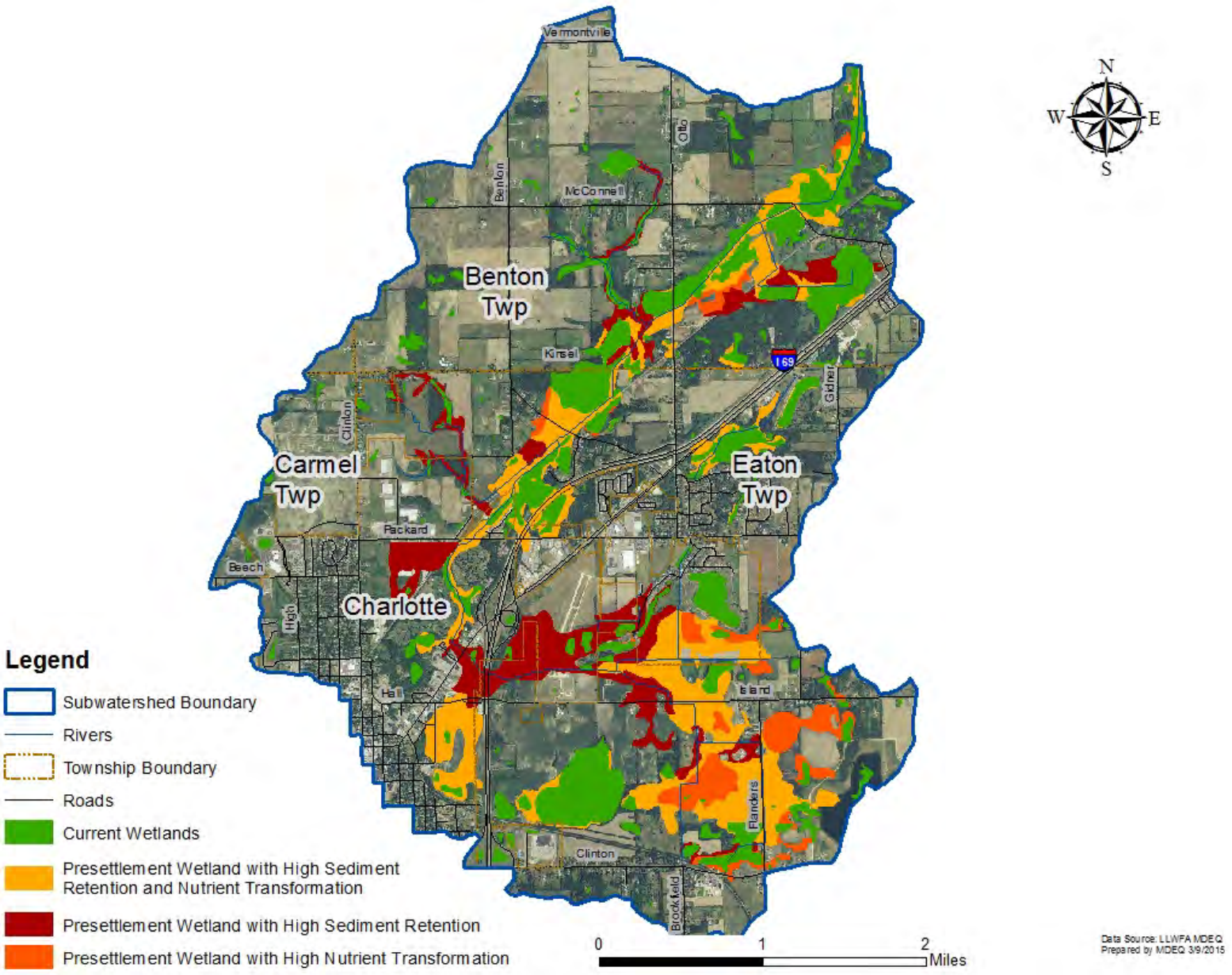
Tributaries: unnamed
Drains: Robinson Drain; Clafin Drain; Quantrell Drain
Lakes: Manmade lakes in subdivisions; manmade gravel pit lake
Dams: none

Water Temperature Classification: Butternut Creek and its small tributaries are classified as warm transitional streams. The Butternut Creek mainstem, including its headwaters area, is mostly drained and channelized, creating higher water temperatures due to decreased groundwater input and lack of canopy.

Point Source Contributions: The following facilities are permitted to discharge into the waters of the Butternut Creek subwatershed:

Facility Name	Permit Number	Latitude	Longitude	Permitted Discharge (Max)
Linn Products Inc-Charlotte	MIS510673	42.58404	-84.83414	
LL Johnson Lumber Mfg	MIS510563	42.5736	-84.8386	Stormwater
Potterville WWTP	MIG580413	42.625	-84.74333	Lagoons
R E Davis Motor Sales	MIS510325	42.596666	-84.791666	Stormwater
Kamps Pallets-Charlotte	MIS510680	42.60937	-84.75115	Stormwater
St Regis Culvert Inc	MIS510321	42.5694	-84.8336	Stormwater

Figure 5.1.A - Butternut Creek Wetland Restoration Potential



Environmental Contamination Sites: The Butternut Creek subwatershed contains 14 active LUST sites and 33 brownfield sites. The tables below provide location data from MDEQ databases.

Active Leaking Underground Storage Tank (LUST) Sites

LUST Site Name	Latitude	Longitude	Substance Released
Auto Zone Inc.	42.582938	-84.806674	Gasoline
Beacon Sales	42.583448	-84.805858	Unknown
Beacon Sales	42.583448	-84.805858	Gasoline
Beacon Sales	42.583448	-84.805858	Gasoline
Crandell Brothers Trucking	42.567022	-84.823455	Diesel
D & L Fuels	42.577397	-84.816475	Diesel
D & L Fuels	42.577397	-84.816475	Gasoline, Gasoline, Gasoline
D & L Fuels	42.577397	-84.816475	Other, Unknown
Davis Pontiac	42.570571	-84.825163	Gasoline
Eaton County Transportation	42.581553	-84.818793	Unknown
Clark #939	42.564807	-84.835218	Gasoline, Gasoline
J. R. Fueslein	42.568523	-84.827083	Not Listed
Jim & L Inc	42.565529	-84.835796	Gasoline, Other
Speedway Unit #7515	42.592922	-84.817345	Gasoline, Gasoline, Gasoline

Brownfield Sites

BEA Number	Address	Latitude	Longitude
199900397LA	106 E Lansing Rd	42.565169	-84.83036
200300725LA	109 Lansing St	42.577748	-84.815788
200701167LA	114 E Lovett St	42.562378	-84.834788
201101571LA	124 N Cochran Ave	42.564236	-84.835872
200200628LA	1260 Packard Hwy	42.582092	-84.811738
201101572LA	132, 138 S Washington St	42.563353	-84.834624
201001465LA	205 E Lawrence Ave	42.563998	-84.834554
200701123LA	2264 Lansing Rd	42.592814	-84.790242
200701124LA	2264 Lansing Rd	42.592814	-84.790242
200801350LA	301, 317 S Cochran Ave	42.56068	-84.835854
201101604LA	301 S Cochran Ave	42.56068	-84.835854
200701214LA	326 S Cochran St	42.559862	-84.835882
200300758LA	405 Maynard St	42.558568	-84.824807
200300732LA	405 Maynard St	42.558568	-84.824807
201001509LA	420 Lansing Rd	42.568416	-84.827258
201001510LA	420 Lansing Rd	42.568416	-84.827258
200901406LA	504 Lansing Rd	42.569063	-84.826629
201201696LA	106 Lansing Rd	42.565013	-84.829903
Part 213	311 Lansing Rd	42.58294	-84.73467
Part 213	1285 Lansing Rd	42.58345	-84.80586

BEA Number	Address	Latitude	Longitude
Part 213	124 N Cochran Ave	42.56481	-84.83522
Part 201	720 Railroad St	42.5668	-84.83162
Part 213	800 Island Hwy	42.56702	-84.82346
part 213	1035 Lansing Rd	42.5774	-84.81648
Part 213	221 E Lawrence	42.56427	-84.8337
Part 213	916 Parkard Hwy	42.58155	-84.81879
Part 213	109 Lansing St	42.56526	-84.8308
Part 213	420 Lansing St	42.56852	-84.82708
Part 213	240 N Cochran Ave	42.56553	-84.8358
200701171LA	221 E Lawrence	42.563999	-84.834366
Part 201	500 Packard Hwy	42.5817	-84.83379
Part 213	1260 Packard Hwy	42.58154	-84.81267
Part 213	687 Lansing Hwy	42.59292	-84.81735

Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, Butternut Creek is supporting most assessed designated uses. It is not supporting fish consumption because of the presence of PCB in the water column and fish tissue in samples from assessed areas in Butternut Creek. More information is needed to determine whether Butternut Creek is supporting Total – and Partial Body Contact Recreation.

Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Total Body Contact Recreation	Insufficient Information[1] Not Assessed[2]			
Partial Body Contact Recreation	Insufficient Information[1] Not Assessed[2]			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Fully Supporting[1]			
Other Indigenous Aquatic Life and Wildlife	Not Assessed[2]			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Assessed[2]			
Fish Consumption	Not Supporting[1]	PCB in Fish Tissue	Y	2013
Fish Consumption	Not Supporting[1]	PCB in Water Column	Y	2013

[1]AUID 040500070101 – 01 Includes Butternut Creek

[2]AUID 040500070101-NAL Includes unassessed lakes in the subwatershed

Biological Surveys: Locations surveyed in the Butternut Creek subwatershed are represented below with their applicable community status. Survey results from 2004 locations indicate poor habitat status at Lansing Road caused by channelization of the stream, which has resulted in shallow water, a straight channel and excess sediment covering natural substrate. Further downstream at Kinsel Highway, increased sinuosity and less sediment provide good (slightly impaired) habitat. The 2009 survey indicates similar, somewhat degraded habitat and acceptable macroinvertebrates.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Butternut Creek	2004	Packard Hwy	Acceptable	Good	
Butternut Creek	2004	Lansing Rd	N/A excessive silt	Poor	
Butternut Creek	2009	Kinsel Hwy	Acceptable	Marginal	

Impairments: The Butternut Creek subwatershed is not meeting its designated uses for fish consumption due to PCB levels. Since PCB and mercury contamination result from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB reduction.

Degradations: Further study is needed to determine whether Butternut Creek is supporting total or partial body contact recreation. While Butternut Creek is meeting all other assessed designated uses, the creek suffers from the effects of channelization, and its habitat quality is degraded. There are a large number of environmental contamination sites in the subwatershed around the City of Charlotte. The creek runs through residential, commercial and industrial areas, where it is minimally buffered. Importantly, the creek is buffered, at least minimally, through agricultural lands. The potential for nutrient-rich residential and agricultural runoff reaching the river and tributaries is moderate to high.

Recommendations: Improvement efforts in the Butternut Creek subwatershed should address commercial, residential and agricultural runoff, to reduce nutrient and other pollutant loading, sedimentation and potential E.coli issues. Adequate stream buffers in cultivated fields, reduced tillage practices and riparian buffers in residential areas along the river and streams are important to reduce pollutant loads. Restoration of brownfield sites will prevent pollutants from leaching into ground and surface waters. Removal of abandoned fuel tanks and closure of abandoned wells will also reduce the potential of pollutants reaching water resources. Wetland restoration in the headwaters areas and alternative channel design are also important steps to improving water quality.

Prioritized Improvement Areas

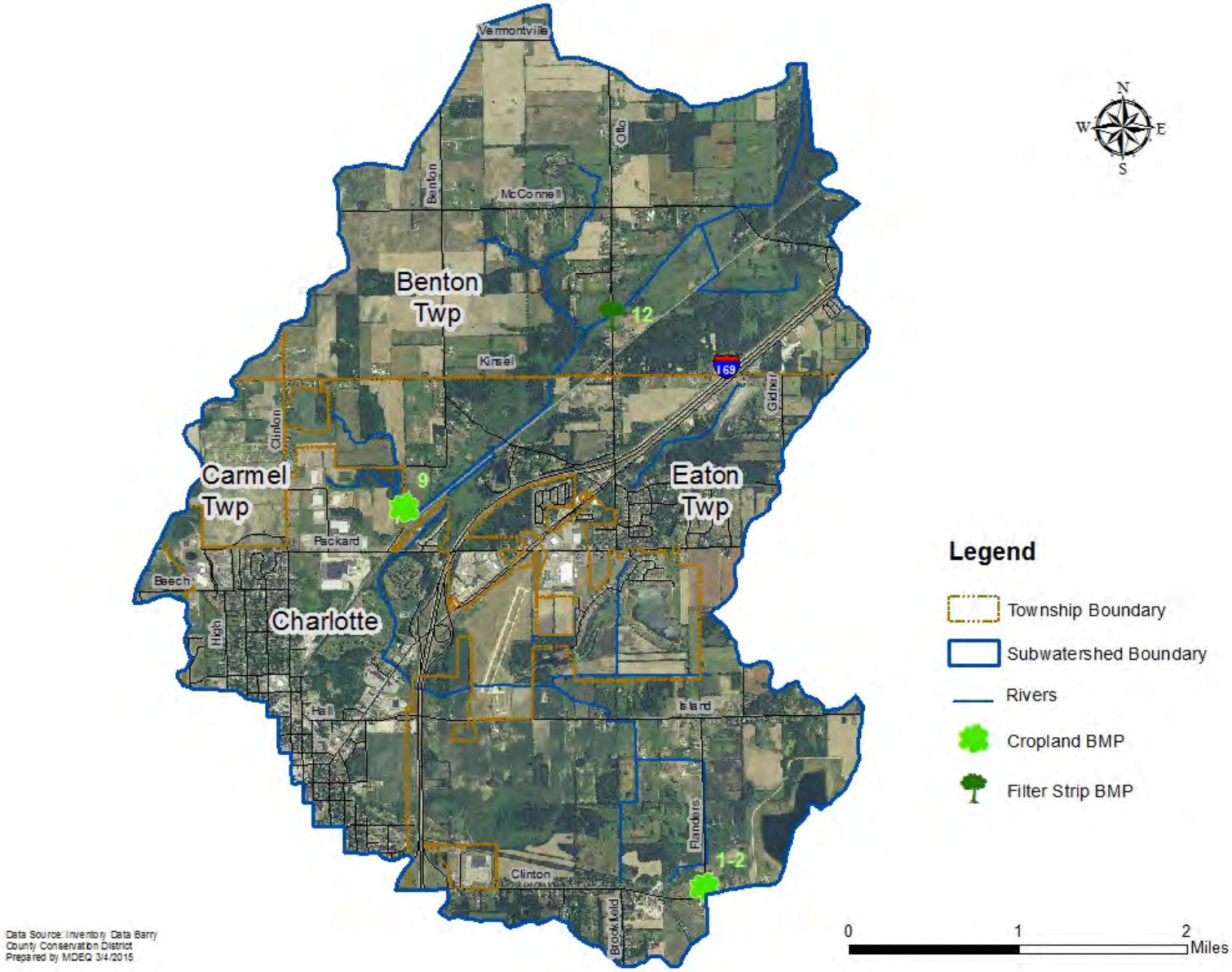
Prioritizing areas for improvement in the Butternut Creek subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of

listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4.

Butternut Creek Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	1-2	Butternut Creek	Reduced till	Filter strip	Nutrients, Sediment
2	Head-waters	Butternut Creek	Wetland restoration		Nutrients, Sediment
3	9	Butternut Creek	Reduced till	Filter strip	Nutrients, Sediment
4	12	Butternut Creek	Filter strip		Nutrients, Sediment
5	TBD	Butternut Creek	Brownfield redevelopment		Chemical leachate
6	TBD	Butternut Creek	Remove abandoned fuel tanks		Chemical leachate
7	TBD	Butternut Creek	Repair/replace failed septic systems		*E. coli*; Nutrients

Figure 5.1.B – Butternut Creek Improvement Areas



5.2 Subwatershed: Milbourn, Allen & Crane Drain HUC: 040500070102

Land Use/Cover:

Size in Acres	Impervious Surface	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
18237.2	4.20%	66.19%	0.00%	15.81%	12.17%	3.89%	0.21%	1.73%	100%

The Milbourn, Allen & Crane Drain subwatershed includes the southern half of the Village of Potterville, which includes subdivisions, apartments and multi-family homes, as well as a portion of the I-69 corridor in its northwestern corner. This area continues to urbanize as residential and retail development spread. Industrial use has declined with the obsolescence of the Lansing Road corridor. Over the last two decades, population in the Milbourn, Allen & Crane Drain subwatershed has increased at a rate between 7-10%, consistent with small urban areas within the Thornapple River Watershed. Beyond this hub, the subwatershed is largely rural-residential and agricultural, with small residential developments along Vermontville Highway and the small lakes, and on the outskirts of Eaton Rapids to the east. The agricultural areas are a mix of row and forage crops, with a substantial traditional muck farm (Kunkle Farms) at the headwaters of King Drain. Presettlement vegetation consisted of beech-maple forest in the uplands, with extensive mixed conifer swamp buffers along the Grusebeck, Milbourn & Garvey and Allen & Crane Drains. These same areas, as well as the confluence of King Drain and the Thornapple Drain, and the area drained by the Burkhead Drain represent locations of significant wetland loss in the subwatershed.

Soils: B, A/D, B/D Runoff class low to very low along headwaters, verging to medium in farmed areas.

Protected Areas: There are no protected areas in the Milbourn, Allen & Crane Drain subwatershed.

Special Features: No special features or listed species are cataloged in the Michigan Natural Features Inventory for this subwatershed.

Hydrologic Features:

Tributaries: Church Creek
Drains: Milbourn& Garvey Drain; Allen& Crane Drain; Garvey Drain; Gruesbeck Drain; King Drain; Fast & Bodell Drain; Thornapple Drain; Burkhead Drain
Lakes: Haas Pond; Snow Lake; Taylor Lake; King Lake
Dams: Haas Dam

Water Temperature Classification: The Milbourn, Allen & Crane Drain system is comprised of warm-transitional streams. The system is mostly drained and channelized, creating higher water temperatures due to decreased groundwater input and lack of canopy.

Point Source Contributions: The following facilities are permitted by the MDEQ to discharge into the waters of the Milbourn, Allen & Crane Drain subwatershed:

Facility Name	Permit Number	Latitude	Longitude	Permitted Discharge (Max)
Charlotte Anodizing	MIS510655	42.58194	-84.72583	Stormwater

Facility Name	Permit Number	Latitude	Longitude	Permitted Discharge (Max)
Products				
Charlotte Municipal Airport	MIS510322	42.5694	-84.8103	Stormwater
Michigan Pallet	MIS510661	42.58039	-84.72157	Stormwater

Environmental Contamination Sites: The Milbourn, Allen & Crane subwatershed contains one brownfield site. The table below provides location data from MDEQ databases.

Brownfield Sites

BEA Number	Address	Latitude	Longitude
Part 201	1490 S Royston Dump Site	42.546	-84.71979

Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, waters in the Milbourn, Allen & Crane Drain subwatershed are supporting most assessed designated uses. In assessed areas, the subwatershed is not supporting fish consumption due to the presence of PCB in the water column and fish tissue. The unnamed tributary (referred to as Church Creek) along the westernmost edge of the subwatershed is not supporting water quality standards for other indigenous aquatic life and wildlife. This assessment is based on repeated low macroinvertebrate counts in sampling conducted by MDEQ .

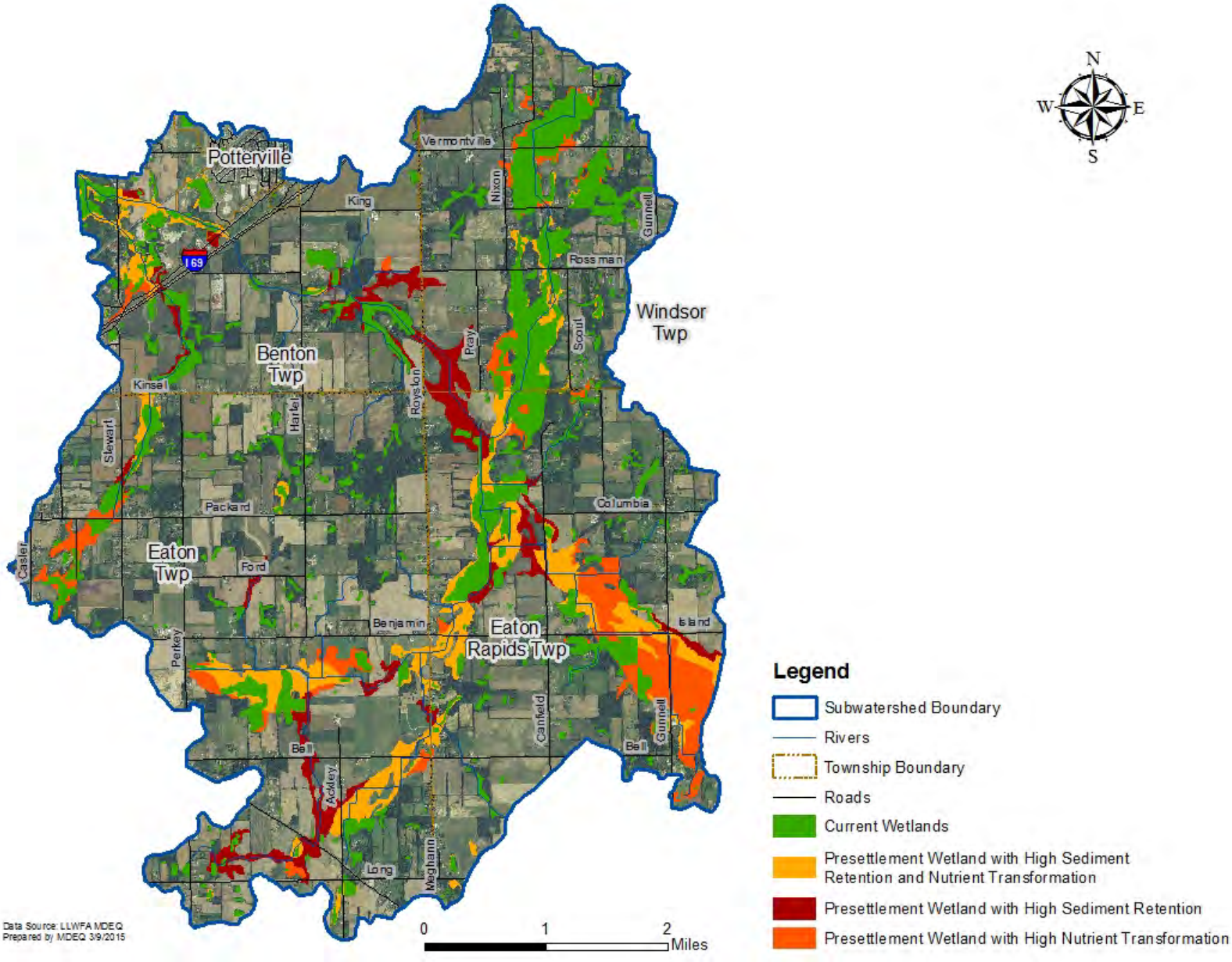
Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Fully Supporting[1]			
Other Indigenous Aquatic Life and Wildlife	Not Supporting[2]	Cause Unknown	Y	2025
Other Indigenous Aquatic Life and Wildlife	Not Assessed[3]			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Supporting[1,2]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1,2]	PCB in Water Column	Y	2014
Fish Consumption	Not Assessed[3]			

[1] AUID: 040500070102-01 Rivers/Streams in HUC including Thornapple River

[2] AUID: 040500070102-02 Includes unnamed tributary to Butternut Creek (Church Creek)

[3] AUID: 040500070102-NA and NAL Includes waters only assessed for Navigation, Agriculture, and Industrial Water Supply

Figure 5.2.A Milbourn Drain Potential Wetland Restoration



Biological Surveys: Locations surveyed in the Milbourn, Allen & Crane Drain subwatershed are represented below with their applicable community status. Survey results indicate slightly degraded to highly degraded habitat and acceptable to poor macroinvertebrate status at surveyed locations. The poor habitat status scores are due to the effects of channelization including high levels of sediment, lack of woody debris and straightening of the streams surveyed. Degraded habitat affects the abundance and diversity of both the fish and macroinvertebrate communities. Church Creek, sampled at Stewart Road South in 1992 and 2009, and at Lansing Road in 2002, is a highly modified stream that is not meeting water quality standards for other indigenous aquatic life and wildlife due to poor habitat and water quality conditions.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Milbourn	1992	Kinsel Hwy	Fair	Poor	Fair
Milbourn	1992	Stewart Rd South	Fair	Poor	Fair
Milbourn	2002	Hartel Rd	Acceptable	Good	Acceptable
Milbourn	2002	Lansing Rd	Poor	Fair	
Milbourn	2009	Stewart Rd South	Poor	Good	
Milbourn	2009	Stewart Rd North	Acceptable	Good	

Impairments: The Milbourn Drain subwatershed is not meeting its designated uses for fish consumption due to PCB levels. Since PCB contamination results from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB reduction. Church Creek is not supporting the designated use of other indigenous aquatic life and wildlife, but the cause is listed as unknown. The creek is channelized, with poor habitat conditions, which may affect its listing.

Degradations: Macroinvertebrate communities and habitat status in areas noted above as poor indicate degraded water quality. The waterways throughout the subwatershed are highly modified, with few natural features remaining. The subwatershed is a mixture of agricultural, residential and industrial uses, with a high percent of impervious surface increasing flashiness in the streams. The potential for nutrient-rich residential and agricultural runoff reaching the streams in this subwatershed is high.

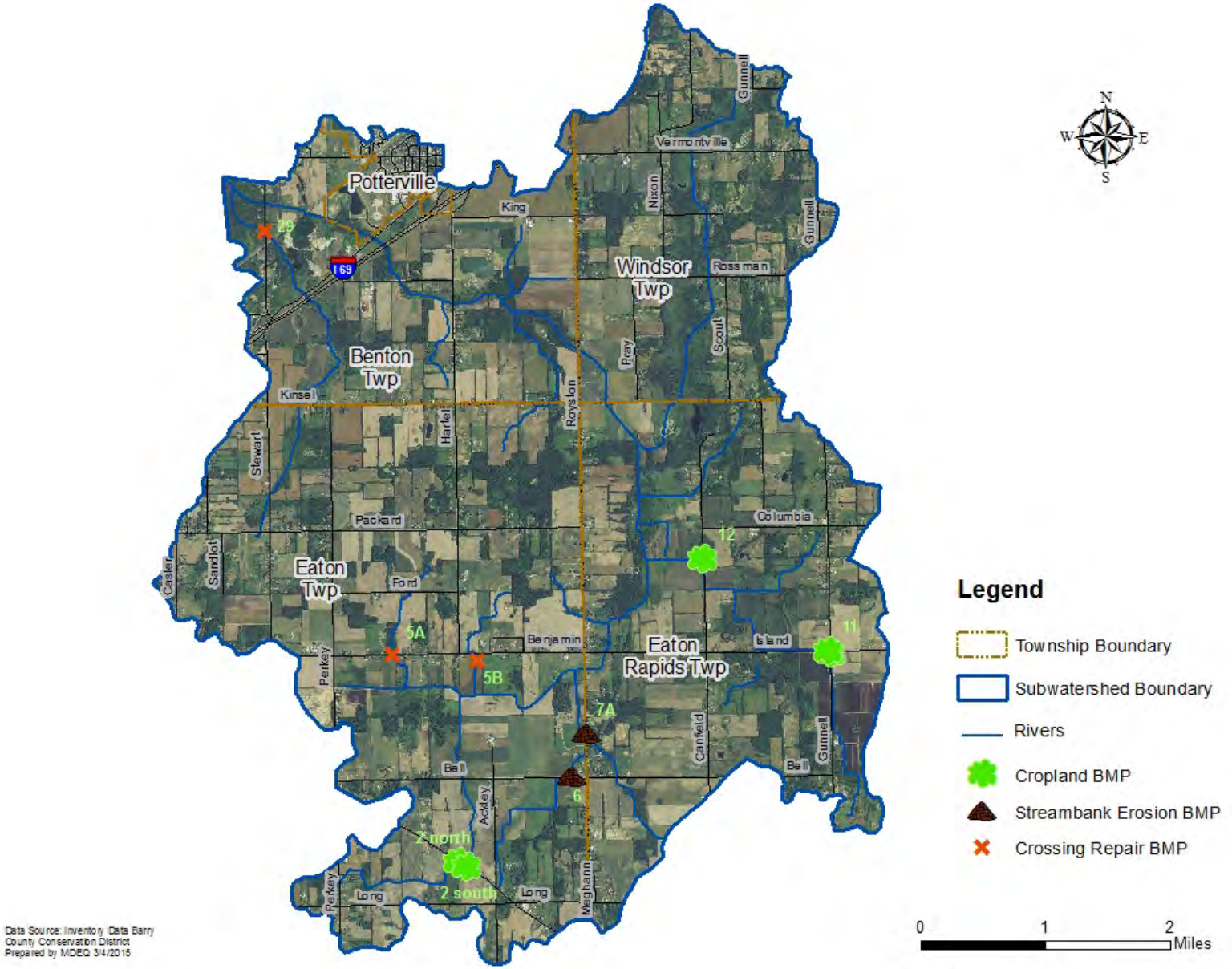
Recommendations: Closer assessment is needed to determine the sources and causes of impairment in Church Creek. Once completed, such assessment will direct additional, specific targets for restoration. Restoration of water quality in Church Creek and improvement efforts in the Milbourn Drain subwatershed overall should address agricultural and residential runoff, and aging septic systems to reduce nutrient and other pollutant loading and sedimentation. Streambank stabilization and natural channel design techniques will reduce sediment and improve stream habitat. Agricultural filter strips and reduced tillage will decrease sediment and nutrient loads. Restoration of wetlands in the headwaters area will improve water quality, reduce flashiness and permit more groundwater recharge. Future planning should include infiltration areas and retention basins to allow filtering and groundwater replenishment. Closure of abandoned wells and removal of abandoned fuel tanks will also reduce the potential for ground and surface water contamination.

Prioritized Improvement Areas: Prioritizing areas for improvement in the Milbourn Drain subwatershed is based upon the needs addressed above as well as field assessment data. Additional sites resulting from future assessment of Church Creek will be considered high priority, as they will help to address the impaired use. The ranking expressed below indicates projects in assessed areas that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4 and 5

Milbourn Drain Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	11	Gruesbeck Drain	Filter strip		Nutrients, Sediment
2	11	Gruesbeck Drain	Filter strip		Nutrients, Sediment
3	12	Gruesbeck Drain	Filter strip		Nutrients, Sediment
4	Head-waters	All	Wetland Restoration		Nutrients, Sediment
5	2 North	Milbourn & Garvey	Reduced till	Filter strip	Nutrients, Sediment
6	2 South	Milbourn & Garvey	Reduced till	Filter strip	Nutrients, Sediment
7	6	Milbourn & Garvey	Streambank stabilization		Sediment
8	7A	Milbourn & Garvey	Streambank stabilization		Sediment
9	29	Church Creek	Culvert replacement		Sediment
10	5A-B	Garvey Drain	Culvert replacement		Sediment
11	TBD	All	Well closure		Chemical leachate
12	TBD	All	Fuel tank removal		Chemical leachate
11	Multi	All	Culvert replacement		Sediment

Figure 5.2.B – Milbourn Drain Improvement Areas



5.3 Subwatershed: Thornapple Drain HUC: 040500070103

Land Use/Cover:

Size in Acres	Impervious Surface	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
13717.3	5.18%	71.56%	0.00%	10.10%	12.37%	5.54%	0.06%	0.37%	100%

Land use in the Thornapple Drain subwatershed continues to industrialize along its northern reaches and eastern border, consistent with growth in the Delta Township portion of Greater Lansing. Heavy industrial businesses along the Mt. Hope and I-69 corridors include General Motors, Alro Steel and Windsor Steel. Outside of the urban area, the subwatershed is characterized by row crop farming. Presettlement vegetation included a large swath of mixed conifer swamp, headwaters of the river – as well as some mixed hardwood swamp. Nearly all wetlands have been drained for agriculture and development.

Protected Areas: USFWS Waterfowl Protection Area; USDA-NRCS Wetland Reserve Project.

Special Features: Habitat areas in the subwatershed may support the endangered king rail.

Hydrologic Features:

Tributaries: Tributary of Lake Interstate
Drains: Thornapple Drain; Munton Drain; Thornapple Extension Drain; Sharp Drain; Thornapple & Old Maid Drain; Carmen Drain; Palmiter & Phelps Drain.
Lakes: Lake Interstate
Dams: None

Water Temperature Classification: The Thornapple Drain and its tributaries are classified as warm streams. Nearly all of the waterways in the subwatershed are actively-maintained drains, historically installed to dry a significant mixed-conifer swamp and associated wetlands that comprised the headwaters of the Thornapple River system. Channelization and agricultural tiling have altered groundwater inputs to the Thornapple Drain subwatershed, and lack of canopy also contributes to the warm-water conditions.

Point Source Contributions: There are no permitted discharges into the waters of the Thornapple Drain subwatershed.

Environmental Contamination Sites: The Thornapple Drain subwatershed contains one active LUST site and one brownfield site. The tables below provide location data from MDEQ databases.

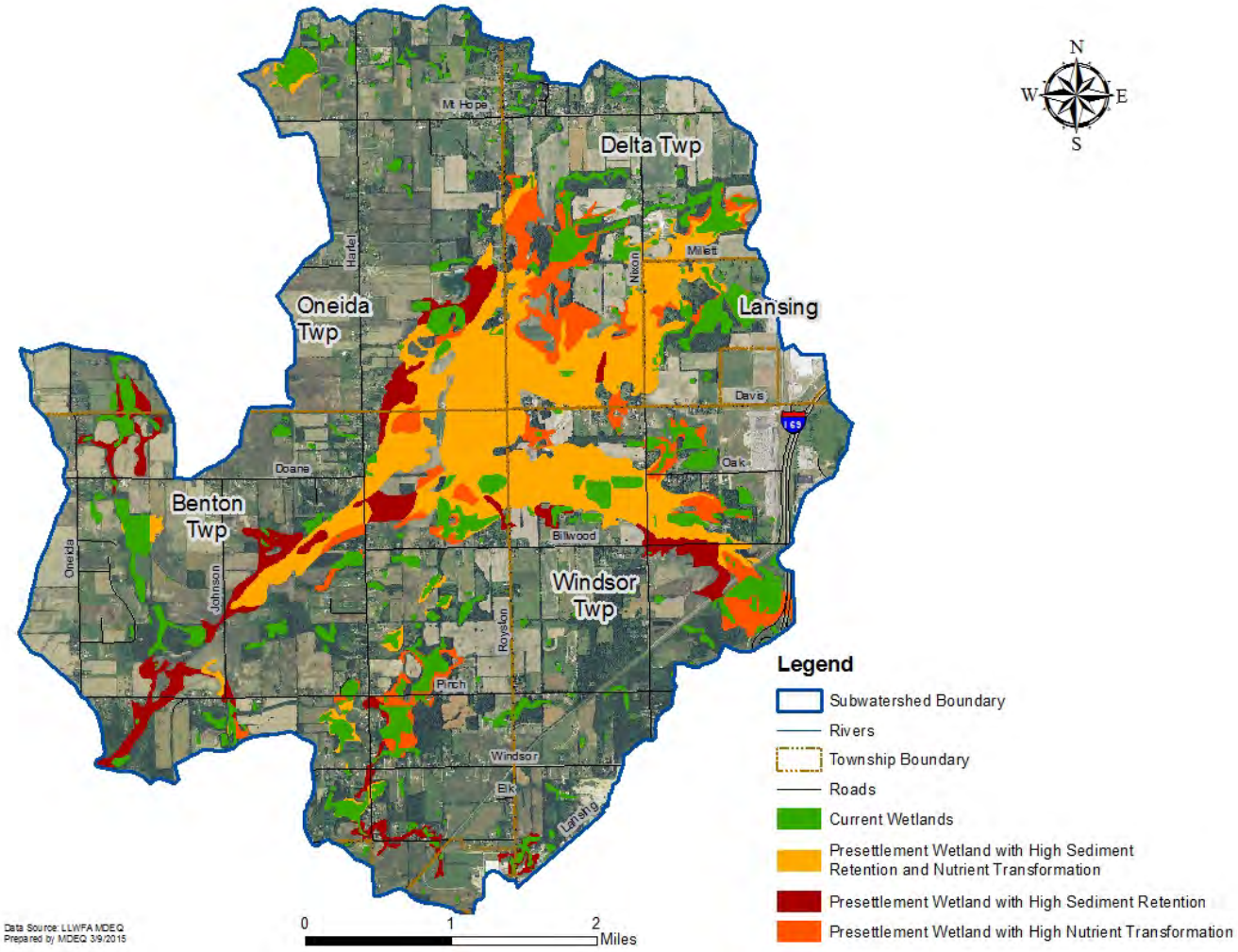
Active Leaking Underground Storage Tank (LUST) Sites

LUST Site Name	Latitude	Longitude	Substance Released
Rumsey & Son	42.668811	-84.669643	Unknown

Brownfield Sites

BEA Number	Address	Latitude	Longitude
Part 201	4574 Windsor Hwy	42.64722	-84.7466

Figure 5.3.A Thornapple Drain Potential Wetland Restoration



Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, Thornapple Drain is supporting most assessed designated uses. It is not supporting fish consumption because of the presence of PCB in the water column and fish tissue in samples from assessed areas in the subwatershed. More information is needed to determine whether Thornapple Drain and its tributaries are meeting water quality standards for total and partial body contact recreation.

Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Total Body Contact Recreation	Insufficient Information[1]Not Assessed[2]			
Partial Body Contact Recreation	Insufficient Information [1]Not Assessed[2]			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Fully Supporting[1]			
Other Indigenous Aquatic Life and Wildlife	Not Assessed[2]			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Assessed [2]			
Fish Consumption	Not Supporting[1]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1]	PCB in Water Column	Y	2014

[1]AUID 040500070103 – Includes Sharp Drain, Thornapple Drain and unnamed tributaries to Thornapple Drain

[2]AUID 040500070103-NAL Includes unassessed lakes – lakes only assessed for Navigation, Agriculture, and Industrial Water Supply.

Biological Surveys: Locations surveyed in the Thornapple Drain subwatershed are represented below with their applicable community status. Survey results indicate slightly degraded to degraded habitat and acceptable macroinvertebrate status where sampled. The location at Gresham Highway was not sampled for macroinvertebrates due to excessive sediment making wading difficult. The Thornapple Drain shows effects of channelization including high levels of sediment, lack of woody debris and straightening of the stream.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Thornapple Drain	2002	Pinch Hwy	Acceptable	Fair	
Thornapple Drain	2004	Gresham Hwy East	N/A excessive silt	Marginal	

Impairments: The Thornapple Drain subwatershed is not meeting its designated uses for fish consumption due to PCB levels. Since PCB contamination result from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB reduction.

Degradations: The macroinvertebrate community and habitat status in the area of Gresham Highway are degraded due to excessive silt obstructing natural habitat. Chief concerns throughout the watershed are the various effects of channelization on habitat and water quality, as well as runoff from agriculture, industry and residential uses.

Recommendations: Improvement should include a strong focus on wetland restoration in this headwater subwatershed. In addition, reduced tillage, grassed waterways, and increased buffers will help reduce sediment and nutrient loads, as will residential buffers along streams. Large, impervious industrial areas require detention basins and improved non-point source elimination practices. Repair or replacement of failing septic systems will reduce nutrient and *E. coli* loads. In addition, closure of abandoned wells and removal of abandoned fuel tanks will reduce the potential for chemicals reaching the waterways.

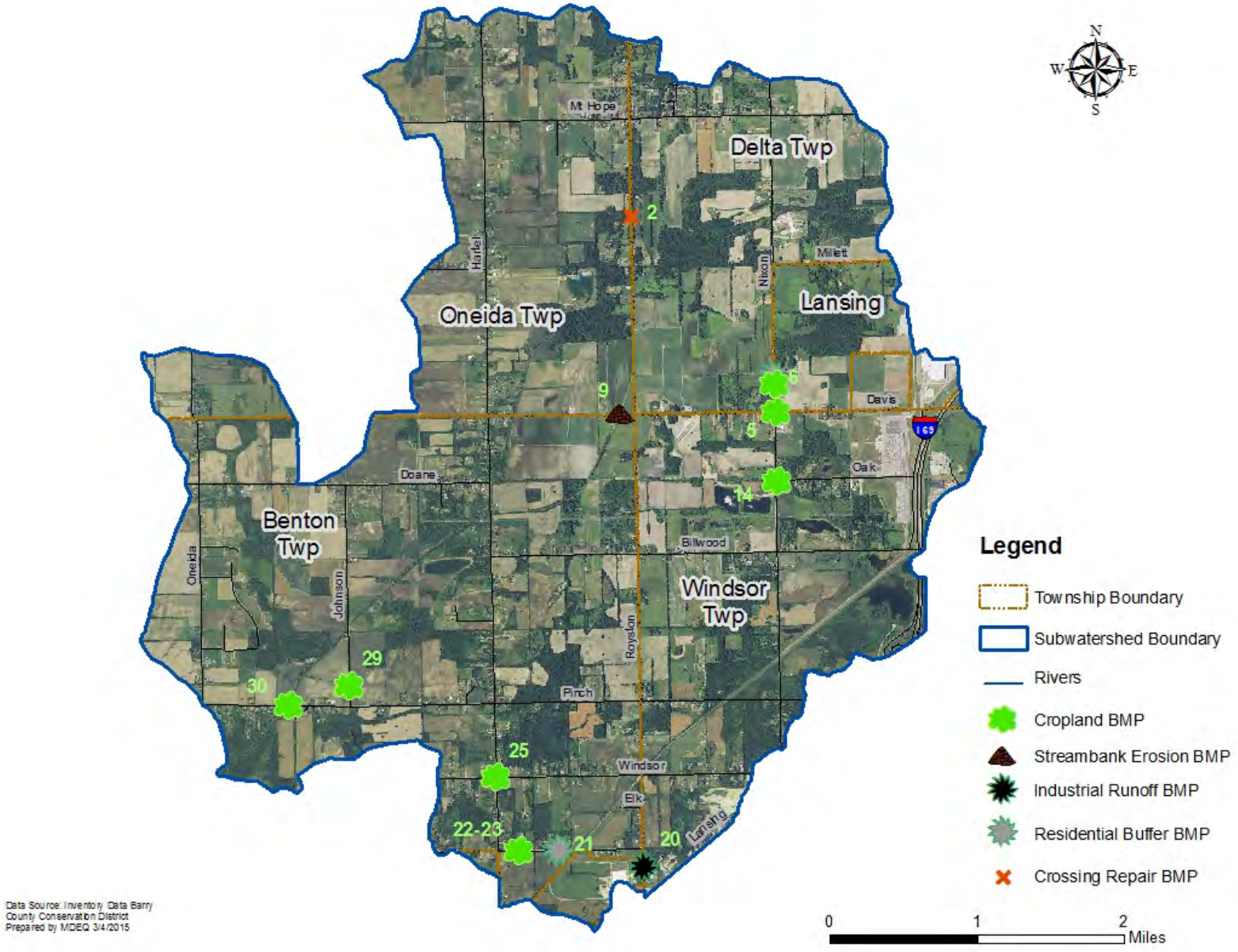
Prioritized Improvement Areas: Prioritizing areas for improvement in the Thornapple Drain subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4 and 5.

Thornapple Drain Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	Head-waters	Thornapple Drain	Wetland restoration		Nutrients, Sediment
2	6	Thornapple Extension	Reduced till	Filter strip	Nutrients, Sediment
3	22-23	Carmen Drain	Reduced till	Filter strip	Nutrients, Sediment
4	14	Unnamed tributary	Reduced till	Filter strip	Nutrients, Sediment
5	29	Palmiter & Phelps Drain	Reduced till	Filter strip	Nutrients, Sediment
6	5	Thornapple Extension	Reduced till	Filter strip	Nutrients, Sediment

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
7	30	Thornapple Drain	Reduced till	Filter strip	Nutrients, Sediment
8	25	Carmen Drain	Reduced till	Filter strip	Nutrients, Sediment
9	20	Carmen Drain	Detention #1		Chemical
10	20	Carmen Drain	Detention #2		Chemical
11	21	Carmen Drain	Residential buffer		Sediment, Nutrients
12	6	Thornapple Extension	Residential buffer		Sediment, Nutrients
13	9	Thornapple Extension	Road repair		Sediment
14	2	Munton Drain	Road crossing repair		Sediment
15	TBD	All	Repair failed septic systems		*E. coli,* Nutrients
16	TBD	All	Close abandoned wells		Chemical leachate
17	TBD	All	Remove abandoned fuel tanks		Chemical leachate

Figure 5.3.B – Thornapple Drain Improvement Areas



5.4 Subwatershed: Fish Creek- Little Thornapple River HUC: 040500070104

Land Use/Cover:

Size in Acres	Impervious Surface	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
19,544.4	3.20%	77.07%	0.00%	13.37%	7.60%	1.25%	0.05%	0.66%	100%

Beyond some residential clusters along main roads, the Fish Creek-Little Thornapple River subwatershed is largely agricultural, with a mix of row and forage crops and a large number of small to mid-sized cattle operations. Most of the area is considered prime farmland if drained. There is still a discernible, though narrow forested floodplain along the Little Thornapple River. The headwaters of the system have been drained for agricultural use, and in many areas the streams are unbuffered. Presettlement vegetation was primarily beech-sugar maple forest, with a narrow band of mixed hardwood swamp along the Little Thornapple River corridor, and areas of mixed conifer swamp in the headwaters. Wetland loss is most significant in the headwaters and along the south fork of the Baker Drain (former conifer swamp).

Soils: B, C, A/D, B/D. Runoff class is uniformly medium, except in the Little Thornapple River floodplain, where it is low.

Protected Areas: There are no protected lands in the Fish Creek – Little Thornapple River subwatershed.

Special Features: No special features or listed species are cataloged in the Michigan Natural Features Inventory for this subwatershed.

Hydrologic Features:

Tributaries: Little Thornapple River; Fish Creek
Drains: Densmore, Perkins & Fish Creek Drain; Baker Drain
Lakes: Wilmore Pond
Dams: Wilmore Dam

Water Temperature Classification: The waters of the Fish Creek – Little Thornapple River subwatershed are classified as warm-transitional streams. With much of the subwatershed channelized for agricultural use, water temperatures are affected by a lack of direct groundwater input and a lack of forest canopy on all but the mainstem of the Little Thornapple River.

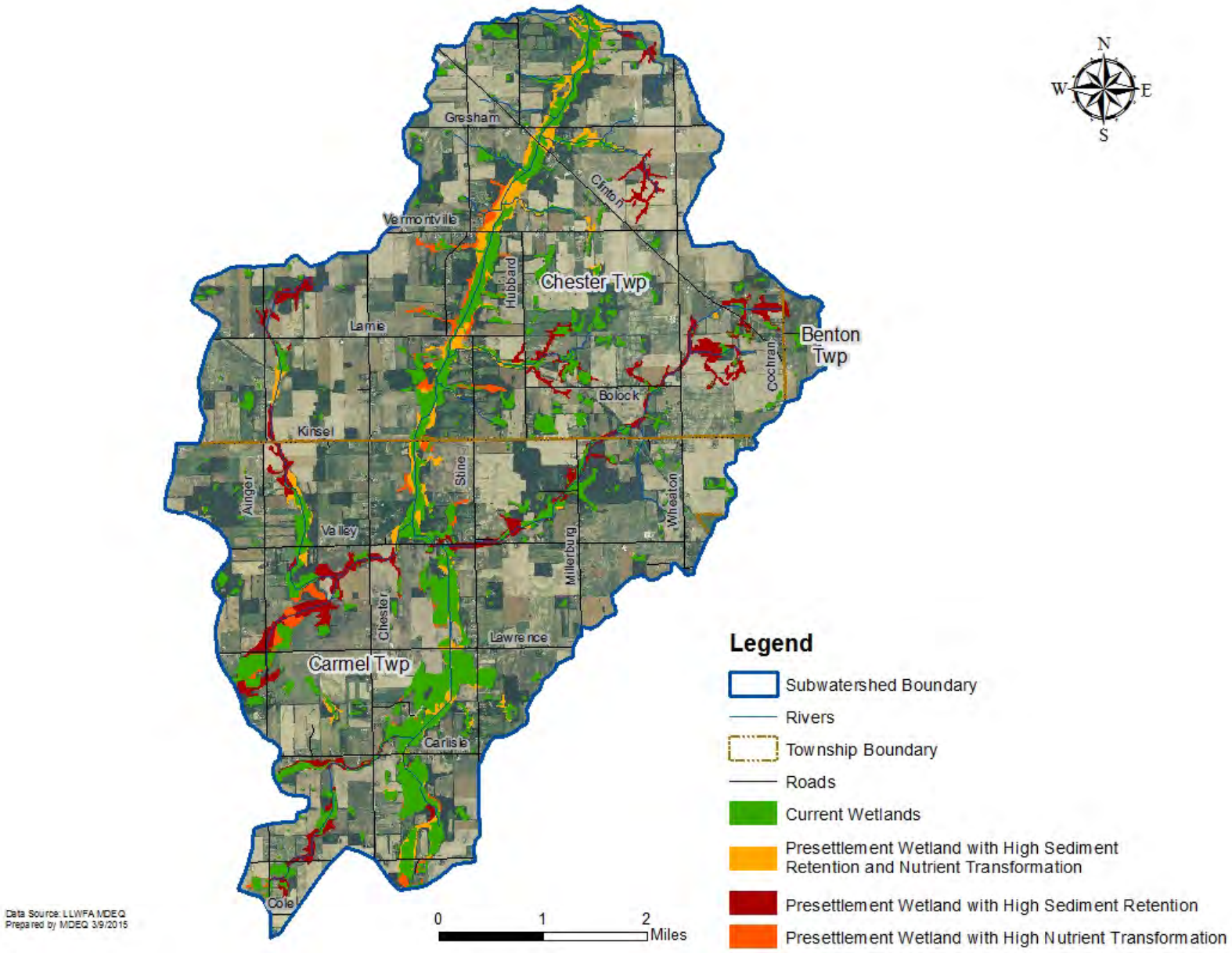
Point Source Contributions: There are no permitted discharges into the waters of the Fish Creek subwatershed.

Environmental Contamination Sites: The Fish Creek subwatershed contains one brownfield site. The table below provides location data from MDEQ databases.

Brownfield Sites

BEA Number	Address	Latitude	Longitude
Part 201	446 Stine Rd	42.575	-84.89707

Figure 5.4.A – Fish Creek Potential Wetland Restoration



Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the Fish Creek subwatershed is fully supporting assessed uses of navigation, industrial water supply and agriculture. Partial and total body contact recreation and fishery assessments have not been completed. While lakes in the subwatershed have not been assessed for other indigenous aquatic life and wildlife, the Little Thornapple River is not supporting this use due to stream alterations resulting from ditching and dredging. Like most state waters, the Little Thornapple River is not supporting fish consumption because of the presence of PCB in the water column and in fish tissue.

Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Not Supporting[1]	Other anthropogenic substrate alterations		
Other Indigenous Aquatic Life and Wildlife	Not Supporting[1]	Other flow regime alterations		
Other Indigenous Aquatic Life and Wildlife	Not Assessed[2]			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Supporting[1]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1]	PCB in Water Column	Y	2014
Fish Consumption	Not Assessed[2]			

[1]AUID 040500070104-01 – Includes Little Thornapple River

[2]AUID 040500070104-NAL – Includes unassessed lakes – lakes only assessed for Navigation, Agricultural and Industrial Water Supply.

Biological Surveys: Locations surveyed in the Fish Creek subwatershed are represented below with their applicable community status. Survey results indicate impaired macroinvertebrate community and habitat status. The Little Thornapple River is a highly modified stream where little natural habitat is present and heavy siltation mars the stream bottom. The Gresham Road site, just downstream on the Little Thornapple River, is much the same, but additional woody debris and boulders increase habitat niches.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Fish Creek	1992	Vermontville Hwy	Fair	Poor	Fair
Fish Creek	2004	Gresham Rd	Acceptable	Marginal	
Fish Creek	2009	Vermontville Hwy	Poor	Good	

Macroinvertebrate collections conducted by the Barry Conservation District under the MiCorps program from 2006-2008 at locations far upstream from the MDEQ monitoring sites indicate varying results, largely due to the presence or absence of sensitive species in a given collection. The channel at Lamie Highway is similarly altered, with some woody debris and undercut banks providing habitat.

Location	Date	Group	Group	Group	Group	Group	Group	Group	Group	Group	Total	Score
	Sampled	1 #R	1 #C	2 #R	2 #C	3 #R	3 #C	1 Total	2 Total	3 Total	Score	Rank
Lamie Hwy.	10-28-06	2	0	5	0	3	1	10	15	4.3	29	Fair
Lamie Hwy	5-12-07	4	0	7	1	3	2	20	24.2	5.3	50	Excellent
Lamie Hwy	10-27-07	2	0	6	0	2	1	10	18	3.2	31	Fair
Lamie Hwy	5-5-08	3	0	6	0	2	2	15	18	4.2	37	Good
Lamie Hwy	11-4-08	1	0	3	0	3	0	5	9	3.3	17	Poor
Lamie Hwy	11-12-09	1	2	3	1	2	1	15.6	12.2	3.2	31	Fair

***E.coli* Monitoring:** The Barry Conservation District conducted weekly *E. coli* monitoring at one location on the Little Thornapple River, at the Gresham Highway crossing, from June to September, 2013 for the purpose of determining whether *E. coli* pollution was an issue in the watershed. Results indicate that the Little Thornapple River is exceeding Michigan's water quality standards for both total body contact and partial body contact recreational uses.

The table below shows results of *E. coli* data collected weekly from June 13 to September 26, 2013. Daily geometric means are compared to the daily maximum for total body contact and partial body contact recreation, with grey shading indicating that the daily maximum for total body contact or the 30-day geometric mean was exceeded. An underline indicates that both the maximum for total body contact and partial body contact were exceeded. Note that a result of 2420 per 100 ml is the limit of the analysis and should be interpreted as >2420 per 100 ml.

Date	Left	Center	Right	Duplicate	Daily Geometric Mean	30 Day Geometric Mean
6/11/2013	1120	1414	866	980	1077	
6/18/2013	161	140	210		168	
6/25/2013	2420	2420	2420	2420	2420	
7/2/2013	2420	2420	1733	2420	2226	
7/9/2013	980	548	687	579	680	1118
7/16/2013	2420	2420	2420		2420	1148

Date	Left	Center	Right	Duplicate	Daily Geometric Mean	30 Day Geometric Mean
7/23/2013	649	727	770		714	1462
7/30/2013	1046	770	770		853	1180
8/6/2013	980	770	866	770	842	939
8/13/2013	2420	2420	2420	2420	2420	1266
8/20/2013	461	435	411	479	446	901
8/27/2013	866	866	727		817	889
9/3/2013	687	649	770		700	886
9/10/2013	2420	2420	1553		2087	1007
9/17/2013	770	548	727	649	668	964
9/24/2013	816	579	649	436	605	740

Impairments: The Fish Creek subwatershed is not meeting its designated uses for fish consumption due to PCB levels. Since PCB contamination results from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB reduction. The Little Thornapple River is not meeting its designated use for other indigenous aquatic life and wildlife due to other anthropogenic substrate alterations and other flow regime alterations – in short, channelization has impaired the stream's ability to support macroinvertebrate and other wildlife communities.

Degradations: E. coli levels found in the 2013 Barry Conservation District monitoring program indicate that the Little Thornapple River's main stem is not meeting Michigan's water quality standards for both total body contact recreation and partial body contact recreation due to fecal contamination. Sources have not been identified. There are several mid-sized livestock operations in the subwatershed, in areas along the river and tributaries. Streams are found within pastures, and there are several areas of unbuffered stream within croplands. The potential for nutrient-rich runoff reaching the river and tributaries is high. Older residences may also be unknowingly contributing to *E. coli* and nutrient loading through failing or improperly connected septic systems.

Recommendations: Additional assessements are needed to locate the sources causing impairment in the Little Thornapple River. Results of such assessment will identify additional high-priority areas for BMP implementation. Further study is needed to determine whether E. coli levels in the Little Thornapple River constitute impairment. Sources of fecal contamination need to be identified and limited. Fish populations in the subwatershed should also be assessed. Restoration and improvement efforts in the Fish Creek subwatershed should address channelization, agricultural and residential runoff, manure management, and aging septic systems to reduce habitat degradation, nutrient loading, sedimentation and potential *E.coli* issues. Filter strips in cultivated fields and pastures, as well as riparian buffers in residential areas along the streams are important to reduce pollutant loads. Streambank restoration using natural channel design will improve in-stream habitat and water quality. Restoration of wetlands in channelized areas will also be effective in filtering nutrients. Closure of abandoned wells and removal of abandoned fuel storage tanks will reduce the potential for chemicals entering the waterway.

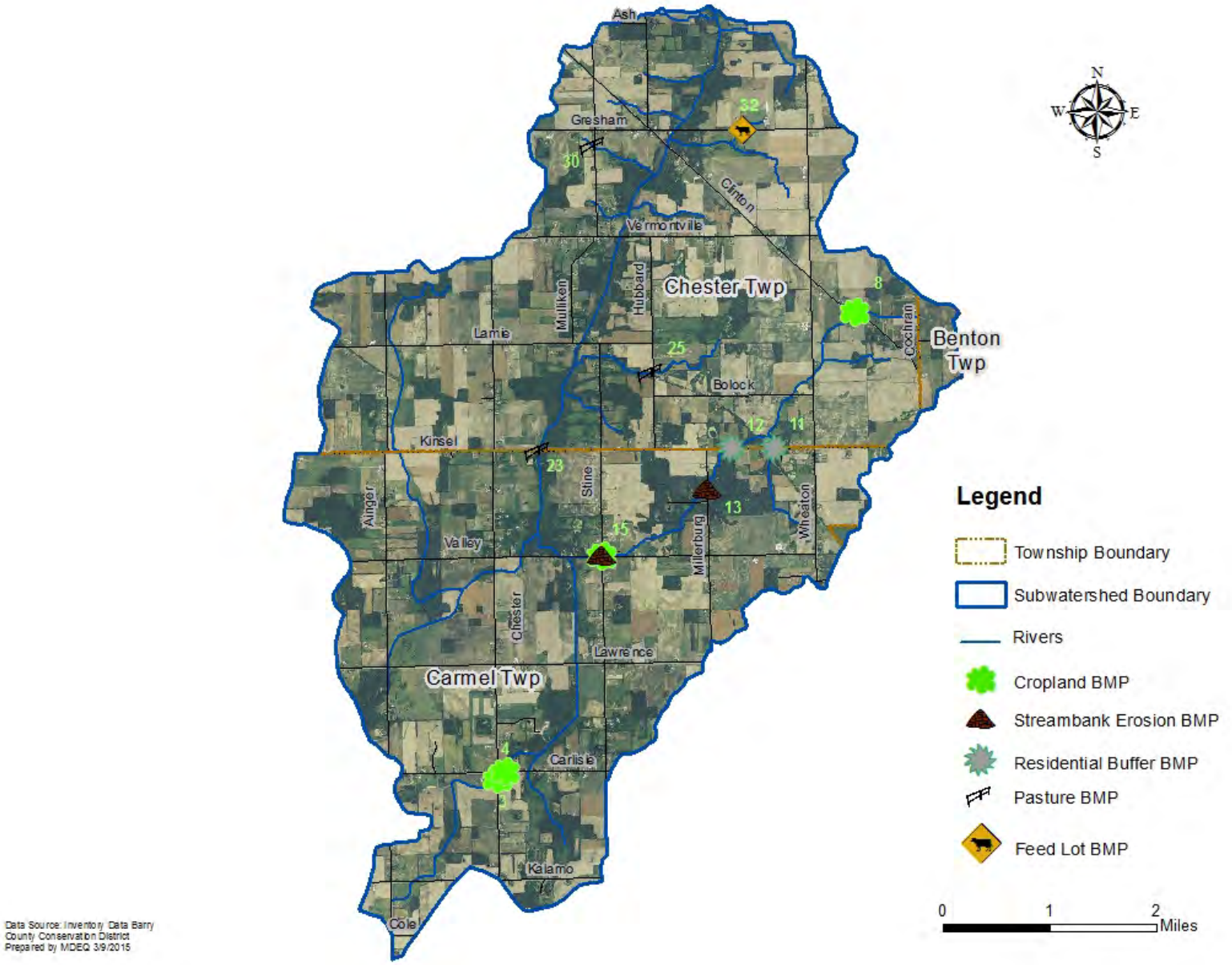
Prioritized Improvement Areas: Prioritizing areas for restoration and improvement in the Fish Creek subwatershed is based upon the needs addressed above as well as field assessment data. Further

assessments made on the Little Thornapple River during plan implementation will identify additional high-priority areas which will address the impaired use. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4 and 5.

Fish Creek Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	3	Little Thornapple	Reduced till	Filter strip	Nutrients, Sediment
2	25	Little Thornapple	Stream stabilization	Fencing	Nutrients, Sediment
3	32	Little Thornapple	Waste facility		Nutrients
4	23	Little Thornapple	Stream stabilization	Fencing	Sediment, Nutrients
5	4	Little Thornapple	Reduced till	Filter strip	Nutrients, Sediment
6	30	Little Thornapple	Stream stabilization	Fencing	Sediment, Nutrients
7	15	Fish Creek	Stream stabilization	Fencing	Sediment, Nutrients
8	Multi	Headwaters	Wetland Restoration		Nutrients
8	8	Little Thornapple	Reduced till	Filter strip	Nutrients, Sediment
9	12	Fish Creek	Residential Buffer		Sediment, Nutrients
10	11	Fish Creek	Residential Buffer		Sediment, Nutrients
11	15	Fish Creek	Road repair		Sediment
12	13	Fish Creek	Road repair		Sediment
13	TBD	All	Repair failing septic systems		*E. coli*, Nutrients
14	TBD	All	Close abandoned wells		Chemical leachate
15	TBD	All	Remove abandoned fuel tanks		Chemical leachate

Figure 5.4.B – Fish Creek Improvement Areas



5.5 Subwatershed: Hayes Drain – Thornapple River HUC: 040500070105

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
13475.5	5.02%	67.07%	0.00%	13.13%	14.70%	4.75%	0.12%	0.24%	100%

Agriculture is predominant in the Hayes Drain subwatershed, with a mixture of forage and row crops, with some small to medium livestock facilities and hobby farms. Housing is rural residential throughout most of the subwatershed. The northern half of the City of Potterville, which lies within the subwatershed, is urbanized, with subdivisions within City limits. Approximately two miles of I-69 pass through the Hayes Drain subwatershed, as does Lansing Road. Restaurants, gas stations and convenience stores associated with the freeway exit are also located within the subwatershed, as is a portion of the Alro Steel facility. Presettlement vegetation was mainly beech-sugar maple forest, with an area of mixed hardwood swamp at the headwaters of Hayes Drain. Portions of the forested river corridor are still intact, but tributary areas are mostly unbuffered. Areas of significant wetland loss include the Thornapple River corridor and headwaters of Hayes Drain and an unnamed tributary west of Potterville.

Protected Areas: Fox Memorial Park is located in the Hayes Drain subwatershed.

Special Features: No special features or listed species are cataloged in the Michigan Natural Features Inventory for this subwatershed.

Hydrologic Features:

Tributaries: unnamed
Drains: Hayes Drain; Hammill Extension Drain
Lakes: Dill's Pond; Johnson's Pond
Dams: Dill's Dam; Johnson's Dam

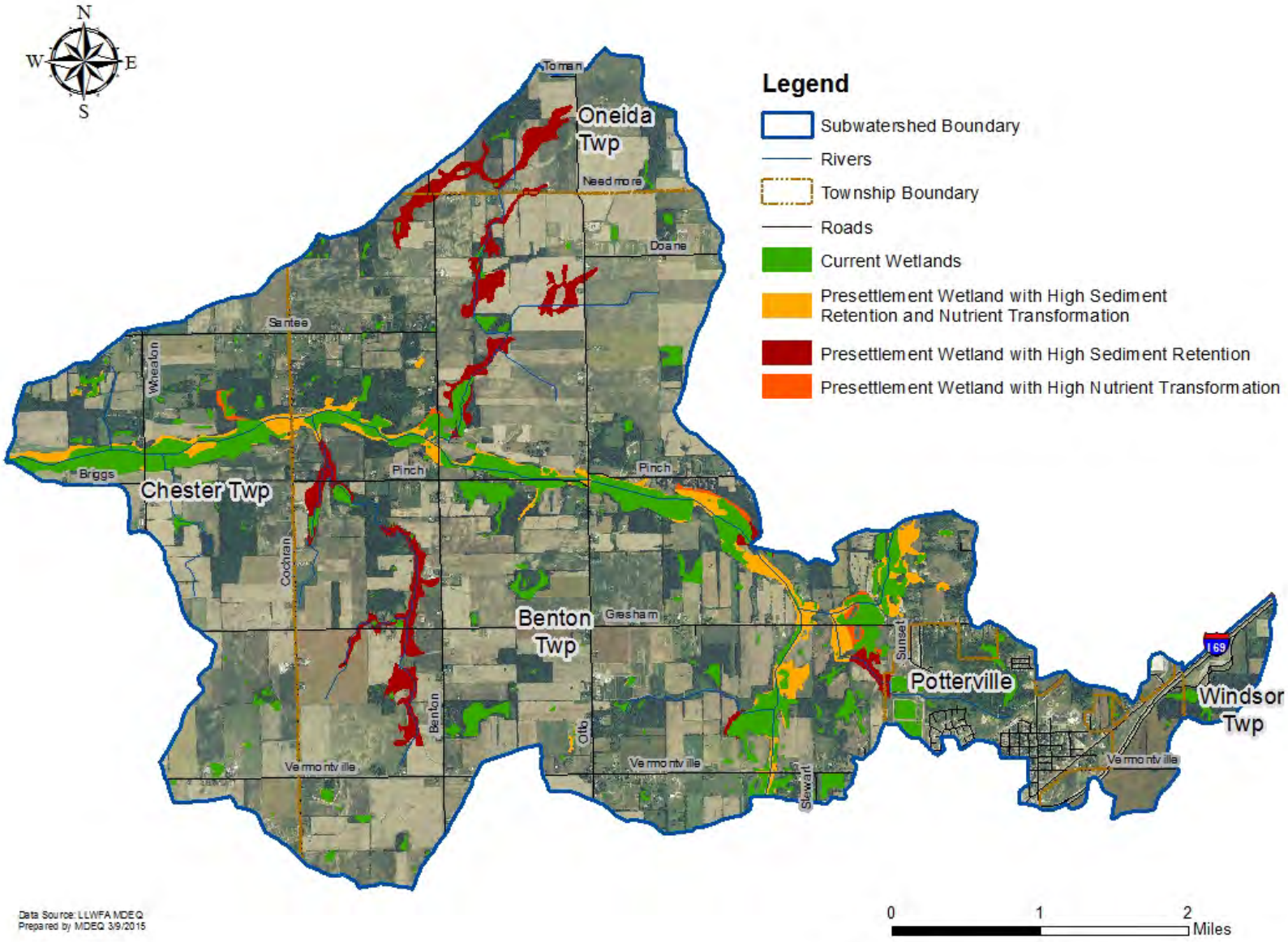
Water Temperature Classification: The Thornapple River and the Hammill Extension Drain are classified as warm-transitional waters, while the Hayes Drain is considered a warm stream.
Point Source Contributions: There are no permitted discharges into the Hayes Drain subwatershed.

Environmental Contamination Sites: The Hayes Drain subwatershed contains seven active LUST sites and four brownfield sites. The tables below provide location data from MDEQ databases.

Active Leaking Underground Storage Tank (LUST) Sites

LUST Site Name	Latitude	Longitude	Substance Released
Former Amoco #9846	42.62657	-84.734667	Unknown
Former Amoco #9846	42.62657	-84.734667	Gasoline, Used Oil
Jims Transmission	42.624455	-84.739223	Gasoline
Potterville Public Schools	42.629963	-84.737227	Not Listed
Superstop #8	42.628683	-84.731147	Diesel
Superstop #8	42.628683	-84.731147	Unknown
Superstop #8	42.628683	-84.731147	Gasoline

Figure 5.5.A – Hayes Drain Potential Wetland Restoration



Brownfield Sites

BEA Number	Address	Latitude	Longitude
Part 213	311 Lansing Rd	42.62651	-85.73467
Part 213	124 Hartel	42.62446	-84.73922
Part 213	420 High St	42.62996	-84.73723
Part 213	505 Lansing Rd	42.62868	-84.73115

Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the Hayes Drain subwatershed is fully supporting assessed uses of navigation, industrial water supply and agriculture. A fishery assessment has not been completed in tributaries and lakes, but the Thornapple River in this section is supporting a warm water fishery. While the river within the subwatershed is fully supporting other indigenous aquatic life and wildlife, additional data is needed to make a determination of use support within its tributaries. Lakes have not been assessed. Like most state waters, the subwatershed is not supporting fish consumption because of the presence of PCB in the water column and both mercury and PCB in fish tissue.

Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Total Body Contact Recreation	Not Assessed[1,2,4] Fully Supporting[3]			
Partial Body Contact Recreation	Not Assessed[1,2,4] Fully Supporting[3]			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Fully Supporting [1] Not Assessed [2,3,4]			
Other Indigenous Aquatic Life and Wildlife	Fully Supporting [1] Insufficient Information[2] Not Assessed [3,4]			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Supporting[1]	Mercury in Fish Tissue	Y	2014
Fish Consumption	Not Supporting [1,2]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting [1,2]	PCB in Water Column	Y	2014
Fish Consumption	Not Assessed [3,4]			

[1] AUID 040500070105-01 Includes Thornapple River
[2] AUID 040500070105-02 Includes Thornapple River
[3] AUID 040500070105-03 Includes Fox Memorial Park Beach
[4] AUID 040500070105-NAL Includes Lakes only 'assessed'

Biological Surveys: Locations surveyed in the Hayes Drain subwatershed are represented below with their applicable community status. Survey results are common for channelized portions of the

watershed, where heavy siltation, lack of woody debris and the loss of riffle-pool sequences limit habitat for fish and macroinvertebrates.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Hayes Drain	1992	Cochran Rd	Fair	Poor	Fair
Hayes Drain	2002	Gresham Hwy East	Acceptable	Good	Acceptable
Hayes Drain	2002	Cochran Rd	Acceptable	Good	

***E.coli* Monitoring:** The Barry Conservation District conducted weekly *E. coli* monitoring at one location on Hayes Drain, at the Gresham Highway crossing, from June to September, 2013 for the purpose of determining whether *E. coli* pollution was an issue in the watershed. Results indicate that Hayes Drain is not meeting Michigan's water quality standards for both total body contact and partial body contact recreational uses.

The table below shows results of *E. coli* data collected weekly from June 11 to September 24, 2013. Daily geometric means are compared to the daily maximum for total body contact and partial body contact recreation, with grey shading indicating that the daily maximum for total body contact or the 30-day geometric mean was exceeded. An underline indicates that both the maximum for total body contact and partial body contact were exceeded. Note that a result of 2420 per 100 ml is the limit of the analysis and should be interpreted as >2420 per 100 ml.

Date	Left	Center	Right	Duplicate	Daily Geometric Mean	30 Day Geometric Mean
6/11/2013	1733	2420	2420		2165	
6/18/2013	248	261	206	179	221	
6/25/2013	1120	1046	1120		1095	
7/2/2013	365	365	411		380	
7/9/2013	727	579	548		613	613
7/16/2013	980	1046	770	921	923	541
7/23/2013	687	488	488	613	563	674
7/30/2013	645	326	579	548	508	583
8/6/2013	548	365	435		443	599
8/13/2013	2420	961	2420		1779	715
8/20/2013	548	548	613		569	647
8/27/2013	2420	1553	1986	1986	1962	799
9/3/2013	548	687	579	613	605	810
9/10/2013	1300	1203	1414	1120	1254	962
9/17/2013	579	866	816		742	1035
9/24/2013	921	1203	1120		1075	964

Impairments: The Hayes Drain subwatershed is not meeting its designated uses for fish consumption due to PCB levels. Since PCB contamination results from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB reduction.

Degradations: *E. coli* levels found in the 2013 Barry Conservation District monitoring program indicate that the Thornapple River at Hayes Drain subwatershed is not meeting Michigan's water quality standards for both total body contact recreation and partial body contact recreation due to fecal contamination. Tributaries in the subwatershed are channelized, creating less than optimal habitat and increasing sedimentation in the river due to bank instability. Portions of the tributaries in agricultural areas are unbuffered or marginally buffered, increasing nutrient and sediment loading. Cattle access to tributaries and the river may also affect *E. coli* levels. Residential riparian areas as well as the potential for aging or improperly constructed septic systems may be contributing to nutrient and *E. coli* issues.

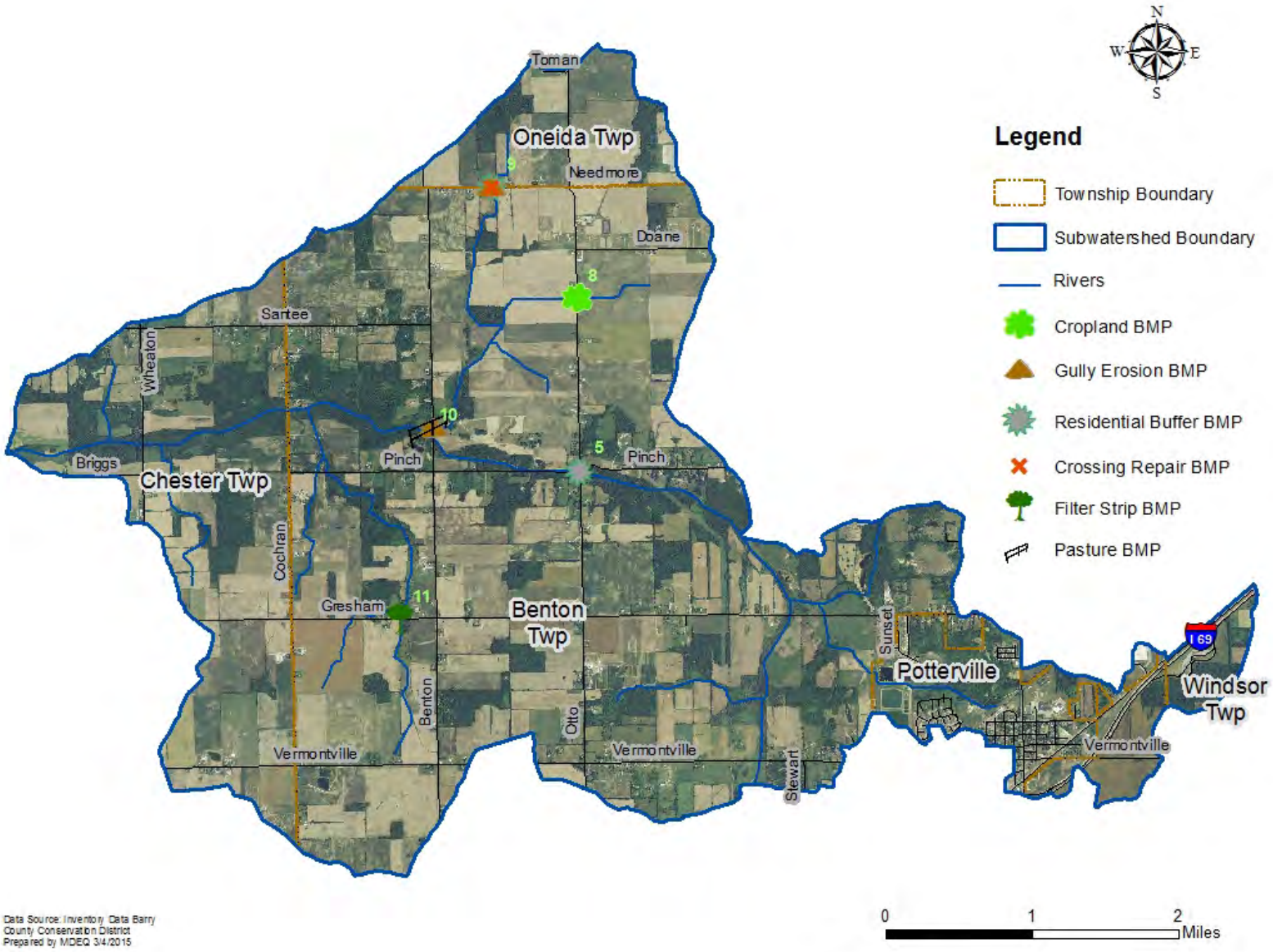
Recommendations: Further study is needed to determine whether Hayes Drain is meeting Michigan's water quality standards for total and partial body contact recreation. Field studies are needed to determine the sources of contamination evident in the 2013 E. coli monitoring results. The Thornapple River within the subwatershed requires further study to determine whether it is supporting the use of other indigenous aquatic life and wildlife. Improvement efforts in the Hayes Drain subwatershed should address agricultural and residential runoff, cattle access and aging septic systems to reduce nutrient loading, sedimentation and potential *E.coli* issues. Stream buffers in cultivated fields and riparian buffers in residential areas are important to reduce pollutant loads. Undersized culverts and road wash-outs contributing to stream alteration and sedmentation should be replaced. When opportunites arise with private landowners, wetland restoration should be pursued, especially in high priority areas expressed in Figure 5.5.A. Opportunities to close abandoned wells or remove abandoned fuel storage tanks should also be taken to reduce the potential for chemical contamination reaching the waterway.

Prioritized Improvement Areas: Prioritizing areas for improvement in the Hayes Drain subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would currently yield the highest benefit to the watershed. Further study regarding the level of fecal contamination may lead to additional high-priority locations for BMPs. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4.

Hayes Drain Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	11	Hayes Drain	Filter strip		Nutrients , Sediment
2	8	Hammill Drain	Reduced till	Filter strip	Nutrients, Sediment
3	10	Hammill Drain	Stream stabilization	Fencing	Sediment, Nutrients
4	9	Hammill Drain	Residential Buffer		Sediment, Nutrients
5	5	Thornapple River	Residential Buffer		Sediment, Nutrients
6	9	Hammill Drain	Road repair		Sediment
7	10	Hammill Drain	Road repair		Sediment
8	9	Hammill Drain	Culvert replacement		Sediment
9	TBD	All	Repair failed septic tanks		*E. coli,* Nutrients
10	TBD	All	Abandoned well closure		Chemical leachate
11	TBD	All	Fuel tank removal		Chemical leachate

Figure 5.5.B – Hayes Drain Improvement Areas



5.6 Subwatershed: Darken & Boyer Drain – Thornapple River HUC: 040500070201

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
15475.9	3.86%	75.98%	0.00%	13.86%	7.18%	2.66%	0.00%	0.31%	100%

The Darken & Boyer Drain subwatershed is dominated by agricultural use, mainly row and forage crops. The subwatershed is considered prime farmland if drained, and tillable acres have been maximized through an extensive drain system consisting of all tributaries in the system. Housing is rural residential, with scattered clusters of small-lot residential development. There are no significant commercial or industrial developments in the subwatershed. Presettlement vegetation consisted of beech-sugar maple forest with a riparian corridor of mixed hardwood swamp along the Darken & Boyer Drain. The headwaters area drained by the Cole-Wright-Helms Drain was once a significant emergent marsh, with areas of mixed conifer- and black ash swamp along the tributaries. Wetland loss is considerable throughout this area and also along the riparian zone of Darken & Boyer Drain.

Protected Areas: No lands in the Darken & Boyer Drain subwatershed are protected.

Special Features: No special features or listed species are cataloged in the Michigan Natural Features Inventory for this subwatershed.

Hydrologic Features:

Tributaries: See drains
Drains: Darken & Boyer Drain; Cole-Wright-Helms Drain; Wright-Pardee-Skinner Drain
Lakes: none
Dams: none

Water Temperature Classification: The drains in the Darken & Boyer Drain subwatershed are all classified as warm water streams. The portion of the Thornapple River within this subwatershed is classified as a warm-transitional river.

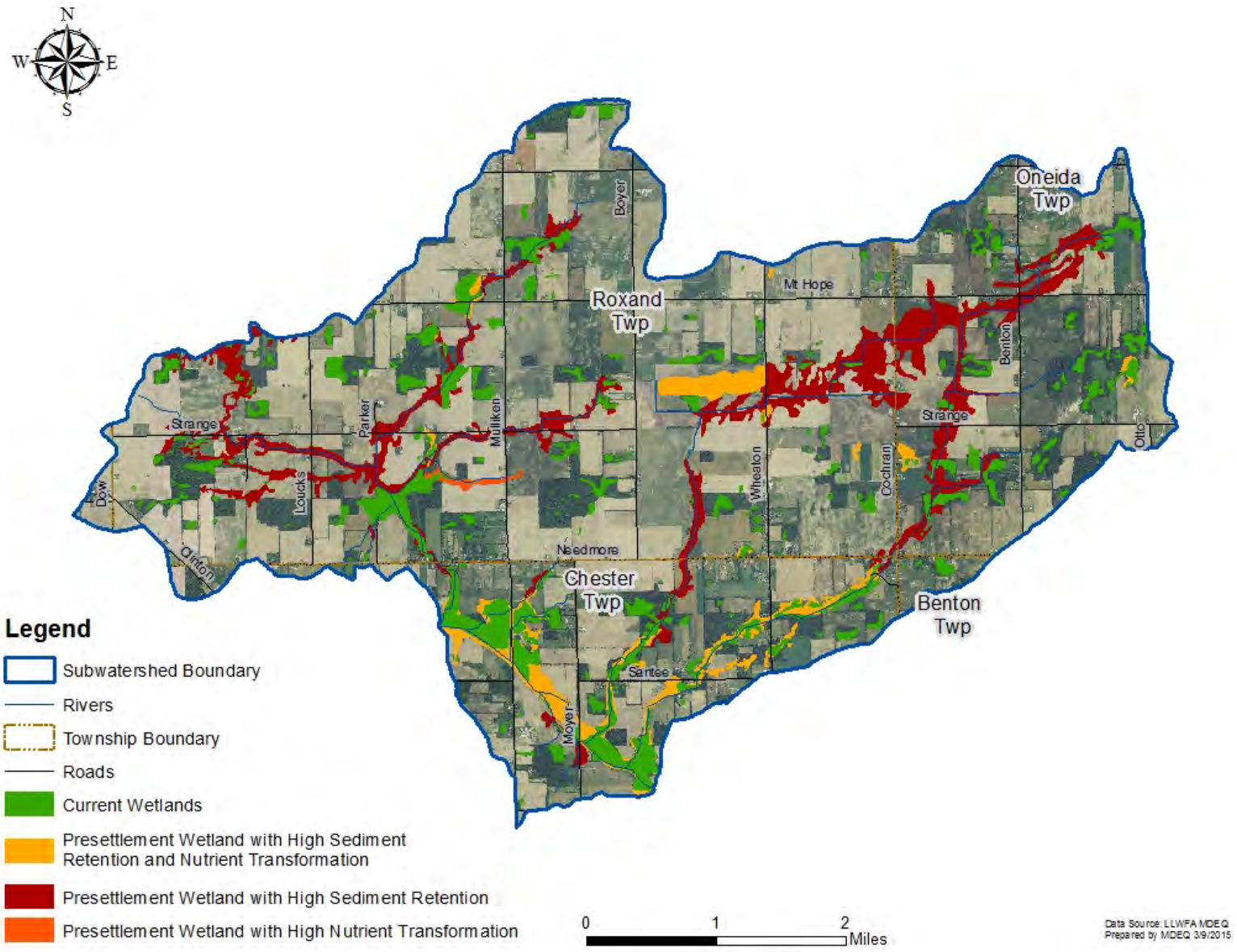
Point Source Contributions: There are no permitted discharges into the Darken & Boyer Drain subwatershed.

Environmental Contamination Sites: The Darken & Boyer Drain subwatershed contains one brownfield site. The table below provides location data from MDEQ databases.

Brownfield Sites

BEA Number	Address	Latitude	Longitude
Part 213	8582 N Clinton Trl	42.68825	-84.95216

Figure 5.6.A – Darken & Boyer Drain Potential Wetland Restoration



Water Quality Issues: According to the *2014 Integrated Report*, the Darken & Boyer Drain subwatershed is fully supporting assessed uses of navigation, industrial water supply and agriculture. An assessment of total and partial body contact recreation has not been completed. Regarding other indigenous aquatic life and wildlife, additional data is needed to make a determination of use support on this section of the Thornapple River. Like most state waters, the subwatershed is not supporting fish consumption because of the presence of PCB in the water column and both mercury and PCB in fish tissue.

Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Insufficient Information			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Supporting	Mercury in Fish Tissue	Y	2013
Fish Consumption	Not Supporting	PCB in Fish Tissue	Y	2013
Fish Consumption	Not Supporting	PCB in Water Column	Y	2013

[1] AUID 040500070201-01 Includes Thornapple River

[2] AUID 040500070201-03 Includes Darken and Boyer Drain, Cole Wright Helms Drain, and Unnamed Tributaries to Darken and Boyer Drain

Impairments: The Darken & Boyer subwatershed is not meeting its designated uses for fish consumption due to PCB levels. Since PCB contamination results from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB reduction.

Degradations: While the Darken & Boyer Drain is meeting all other assessed uses, its overall condition is substandard due to channelization and lack of natural subwatershed features including wetlands, natural floodplains and riffle-pool sequences within its channels. Heavy agricultural use, tiling and insufficient buffering of streams suggest a high potential for nutrient-rich runoff reaching the river and tributaries. Erosion due to undercut banks and runoff is also apparent in the system.

Recommendations: While the subwatershed lacks pollutants stemming from industrialization and urbanization, improvements in other areas are necessary to improve water quality. Improvement efforts in the Darken & Boyer subwatershed should focus on agricultural, and when applicable, residential runoff to reduce nutrient loading, sedimentation and potential *E.coli* issues. Reduced tillage and stream buffers in cultivated fields, stream stabilization and cattle exclusion in pastures and riparian buffers in residential areas along the river streams are important to reduce pollutant loads. Restoration of wetlands in channelized areas, especially those identified as high priority in Figure 5.6.A, will also be effective in filtering nutrients and restoring natural conditions. Repair or replacement of failing septic

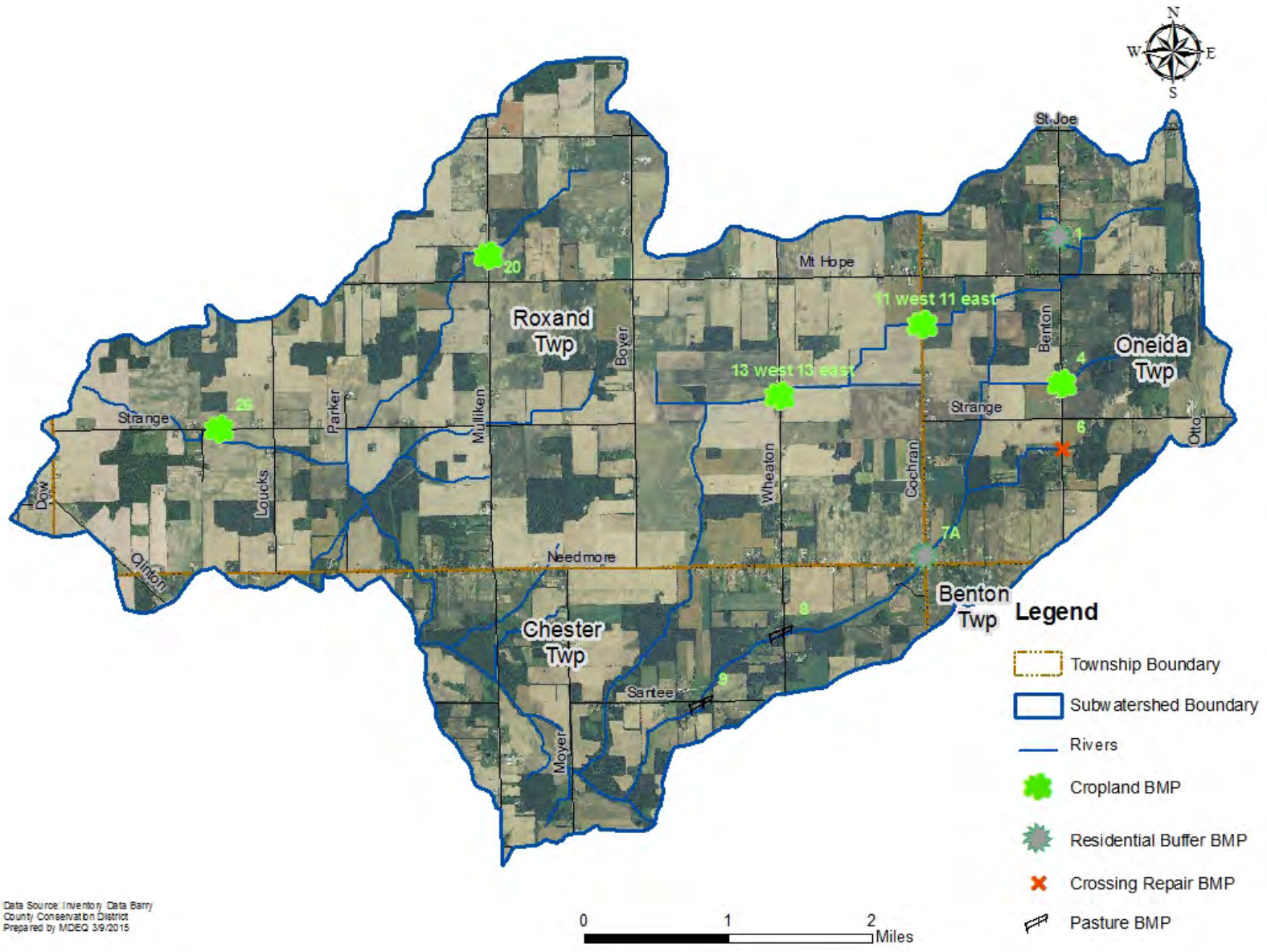
systems will reduce the potential for *E. coli* contamination. Closure of abandoned wells and removal of unused fuel storage tanks will help reduce the potential of chemical contamination.

Prioritized Improvement Areas: Prioritizing areas for improvement in the Darken & Boyer subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4 and 5.

Darken & Boyer Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	11 west	Cole Wright Helms	Reduced till	Filter strip	Nutrients, Sediment
2	13 East	Cole Wright Helms	Reduced till	Filter strip	Nutrients, Sediment
3	11 East	Cole Wright Helms	Reduced till	Filter strip	Nutrients, Sediment
4	13 West	Cole Wright Helms	Reduced till	Filter strip	Nutrients, Sediment
5	26	Darken & Boyer	Reduced till	Filter strip	Nutrients, Sediment
6	Head-waters	All	Wetland restoration		Nutrients, Sediment
7	20	Darken & Boyer	Reduced till	Filter strip	Nutrients, Sediment
8	9	Wright Pardee Skinner	Stream stabilization	Fencing	Sediment, Nutrients
9	8	Wright Pardee Skinner	Stream stabilization	Fencing	Sediment, Nutrients
10	4	Wright Pardee Skinner	Reduced till	Filter strip	Nutrients, Sediment
11	20	Darken & Boyer	Residential Buffer		Nutrients, Sediment
12	7A	Cole Wright Helms	Residential Buffer		Nutrients, Sediment
13	1	Cole Wright Helms	Residential Buffer		Nutrients, Sediment
14	6	Cole Wright Helms	Culvert replacement		Sediment
15	TBD	All	Failed septic system repair		*E. coli*, Nutrients
16	TBD	All	Well closure		Chemical leachate
17	TBD	All	Fuel tank removal		Chemical leachate

Figure 5.6.B – Darken & Boyer Drain Improvement Areas



5.7 Subwatershed: Lacey Creek **HUC 040500070202**

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
15839.2	2.82%	68.55%	0.00%	17.18%	11.42%	0.71%	0.49%	1.64%	100%

In the Lacey Creek subwatershed, agriculture is the predominant use, with a mixture of row and forage crops throughout the tillable lands. Patches of forest remain in low and undrained areas, but much of the creek and its tributaries have lost their forested buffers. Residential use is almost exclusively rural-residential and farmsteads, except for lakefront development on Lacey Lake. There are no industrialized or commercial areas in the subwatershed. Presettlement vegetation included beech-sugar maple forest with areas of mixed conifer or mixed hardwood swamp in the headwaters and tributaries. A wide riparian buffer of emergent marsh existed around present-day Lacey Lake and along the creek upstream of the lake. Wetland loss is most prevalent along the stream corridors and in drained areas that were the headwaters of the creek and its tributaries.

Protected Areas: There are no protected areas within the Lacey Creek subwatershed.

Special Features: Habitat areas in the subwatershed may support the following threatened, endangered or special concern species: spike-rush, whorled pogonia, Virginia bluebells, Indiana bat, round pigtoe mussel and the Eastern massasagua. The subwatershed may also include one or more great blue heron rookeries.

Hydrologic Features:

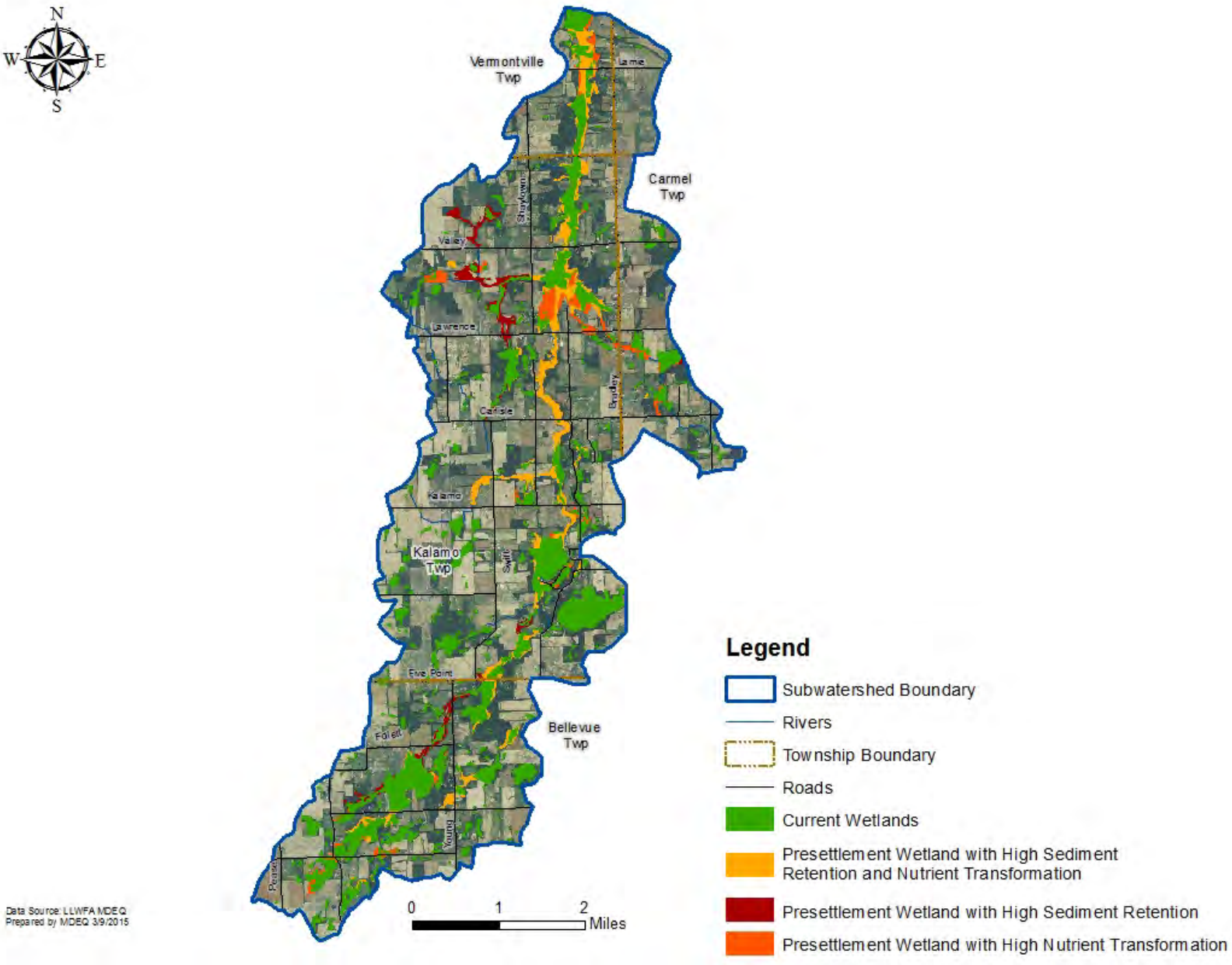
Tributaries: Morfey Brook; Lacey Creek
Drains: Powers Drain; Gayton & Powers Extension Drain
Lakes: Lacey Lake
Dams: Lacey Lake Dam

Water Temperature Classification: Water temperature in Lacey Creek above Valley Highway is classified as warm-transitional, with all waters below Valley Highway, including Lacey Lake, listed as warm water.

Point Source Contributions: There are no permitted discharges into the Lacey Creek subwatershed.

Environmental Contamination: There are no listed sites of environmental contamination in the Lacey Creek subwatershed.

Figure 5.7.A – Lacey Creek Potential Wetland Restoration



Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the Lacey Creek subwatershed is supporting most designated uses that have been assessed, excepting fish consumption due to PCB and mercury in fish tissue, and PCB in the water column. Additional information is required to determine whether a portion of Lacey Creek and an unnamed tributary are supporting the Other Indigenous Aquatic Life and Wildlife use, but the rest of the creek is considered fully supporting this use.

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Fully Supporting [2] Not Assessed [1,3]			
Other Indigenous Aquatic Life and Wildlife	Insufficient Information[1] Fully Supporting[2] Not Assessed[3]			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Supporting	PCB in Fish Tissue[1,2] Mercury in Fish Tissue[1]	Y	2014
Fish Consumption	Not Supporting	PCB in Water Column[1,2]	Y	2014
Fish Consumption	Not Assessed[3]			

[1] AUID 040500070202-01 Includes Lacey Creek and Unnamed Tributary near Carlisle Hwy

[2] AUID 040500070202-02 Includes Lacey Creek

[3] AUID 040500070202-NAL Includes Lakes only 'assessed' for Navigation, Agriculture, and Industrial Water Supply

Biological Surveys: Locations surveyed in the Lacey Creek subwatershed are represented below with their applicable community status. Survey results indicate slightly degraded to degraded habitat and acceptable macroinvertebrate scores at most locations. The poor to marginal habitat status scores are due to the effects of channelization including high levels of sediment, lack of woody debris and straightening of the stream. Degraded habitat affects the abundance and diversity of both the fish and macroinvertebrate communities.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Lacey Creek	1992	Valley Hwy	Fair	Poor	Fair
Lacey Creek	2002	Valley Hwy	Acceptable	Fair	Acceptable
Lacey Creek	2009	Kinsel Hwy	Acceptable	Marginal	
Lacey Creek	2009	Lamie Hwy	Acceptable	Marginal	

Macroinvertebrate collections conducted by the Barry Conservation District under the MiCorps program from 2006-2009 indicate declining numbers and diversity in the sensitive, or Group 1 taxa, perhaps related to increasing sediment loads recorded at the Lamie Highway site.

Location	Date Sampled	Group 1 #R	Group 1 #C	Group 2 #R	Group 2 #C	Group 3 #R	Group 3 #C	Group 1 Total	Group 2 Total	Group 3 Total	Total Score	Score Rank
Lamie Hwy	10-28-06	4	0	8	1	2	0	20	27.2	2.2	49	Excellent
Lamie Hwy	5-12-07	2	2	6	3	1	0	20.6	27.6	1.1	49	Excellent
Lamie Hwy.	10-27-07	3	0	5	1	3	0	15	18.2	3.3	37	Good
Lamie Hwy	5-5-08	4	0	3	4	2	1	20	21.8	3.2	45	Good
Lamie Hwy.	11-4-08	1	0	7	1	1	0	5	24.2	1.1	30	Fair
Lamie Hwy	11-12-09	1	2	5	1	2	0	15.6	18.2	2.2	36	Good

Impairments: The Lacey Creek subwatershed is not meeting its designated uses for fish consumption due to PCB and mercury levels. Since PCB and mercury contamination result from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB or mercury reduction.

Degradations: Lacey Creek and its tributaries are channelized, causing sedimentation, flashiness and unstable banks, which contribute to the marginal to poor habitat scores. Heavy agricultural and livestock use increase sediment and nutrient loads. Cattle access to tributaries is an issue in the subwatershed.

Recommendations: The upper reach of Lacey Creek and an unnamed tributary near Carlisle Highway require further study to determine whether they are supporting the use of other indigenous aquatic life and wildlife. Improvement in the Lacey Creek subwatershed should focus on improved tillage and buffering practices in croplands and reducing cattle access to streams. Riparian buffers are also critical in residential areas, including Lacey Lake. Road and stream erosion, common in rural portions of the watershed, also need to be addressed to reduce sediment loads. When opportunities arise with private

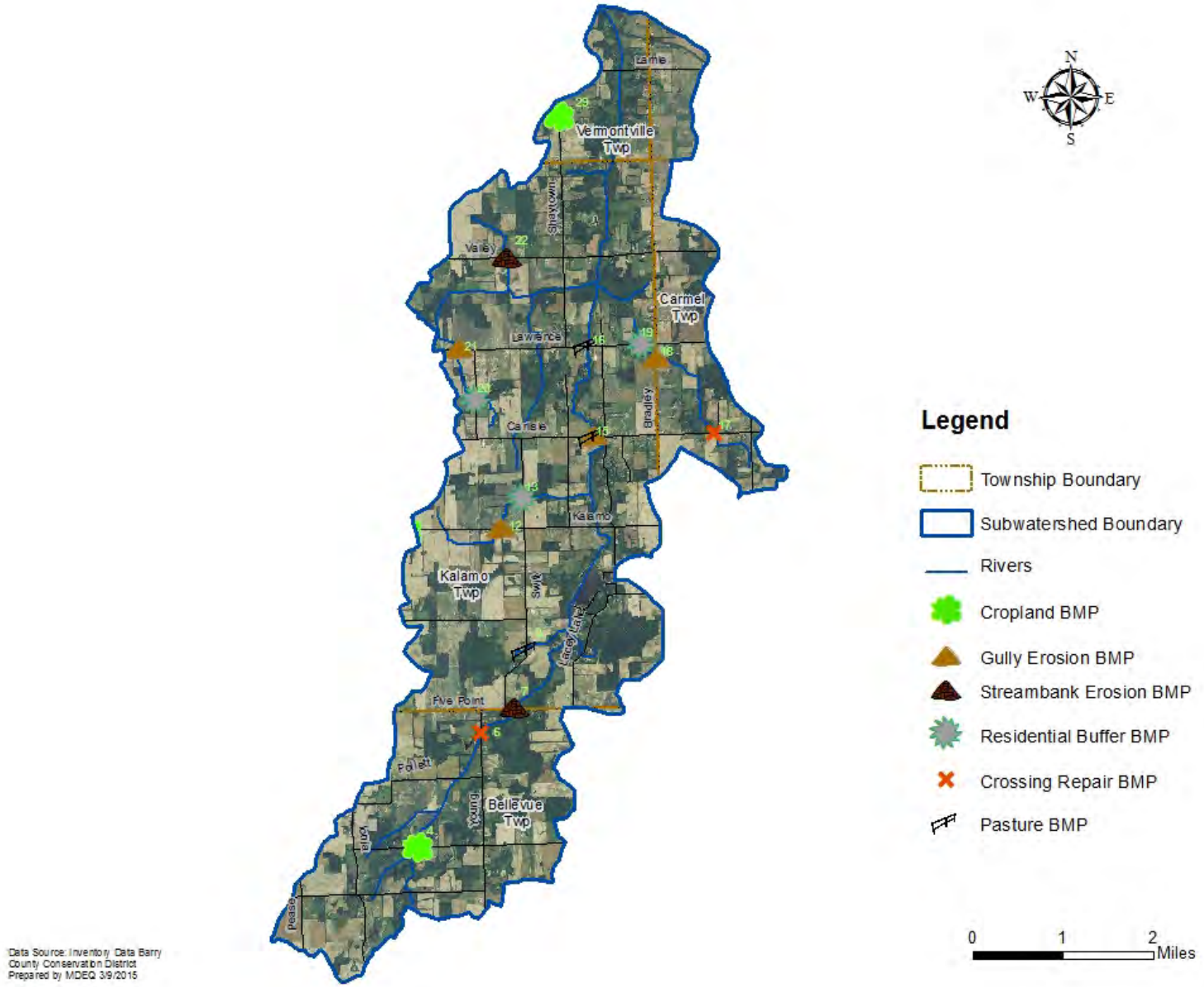
landowners, wetland restoration – especially in priority areas indicated in Figure 5.7.A, should be pursued. Repair or replacement of failed septic systems will reduce nutrients and the potential for E. coli contamination. Additionally, closure of abandoned wells and fuel storage tanks will reduce chemical pollutants from reaching the waterways.

Prioritized Improvement Areas: Prioritizing areas for improvement in the Lacey Creek subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4 and 5.

Lacey Creek Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	11	Unnamed tributary	Reduced till	Filter strip	Nutrients, Sediment
2	9	Lacey Creek	Stream stabilization	Fencing	Sediment, Nutrients
3	29	Morfey Brook	Reduced till	Filter strip	Nutrients, Sediment
4	4	Lacey Creek	Reduced till	Filter strip	Nutrients, Sediment
5	16	Morfey Brook	Streambank stabilization	Fencing	Sediment, Nutrients
6	15	Lacey Creek	Streambank stabilization	Fencing	Sediment, Nutrients
7	20	Unnamed tributary	Residential buffer		Sediment, Nutrients
8	22	Unnamed tributary	Streambank stabilization		Sediment
9	19	Unnamed tributary	Residential buffer		Sediment, Nutrients
10	13	Unnamed tributary	Residential buffer		Sediment, Nutrients
11	7	Lacey Creek	Streambank stabilization		Sediment
12	12,15, 18, 21	All	Road repair		Sediment
13	6, 17	All	Culvert repair		Sediment
14	TBD	All	Repair of failed septic systems		*E. coli,* Nutrients
15	TBD	All	Well closure		Chemical leachate
16	TBD	All	Fuel tank removal		Chemical leachate

Figure 5.7.B – Lacey Creek Improvement Areas



5.8 Subwatershed: Thompson Creek– Thornapple River HUC: 04050007203

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
12790.5	2.85%	75.73%	0.00%	15.29%	7.95%	0.46%	0.07%	0.49%	100%

Thompson Creek supports primarily row and forage crop agriculture, as well as medium-sized livestock operations. Lands are considered prime farmland and prime farmland if drained – the latter regions have been drained to support cropping. The area is sparsely populated, with no significant commercial or industrial uses. Presettlement vegetation consisted mainly of beech-sugar maple forest with mixed hardwood swamp along the Thornapple River and Thompson Creek corridors. An area of emergent marsh was located along the creek just south of the Allegan Road crossing. Wetland loss is considerable throughout the subwatershed, in drained tributary and headwater areas and along the Thornapple River corridor where forested floodplain has been lost. A significant area of wet forest still exists along the river between Gresham Highway and M-50. This region is not bisected by any roads and provides protection for the river and riverine species.

Protected Areas: There are no protected areas in the Thompson Creek subwatershed.

Special Features: The *Significant Features in the Tri-County Region* report produced by the Michigan Natural Features Inventory identifies the riparian corridor along the mainstem of the Thornapple River in the Thompson Creek subwatershed as the third-highest ranking potential conservation area in Eaton County. The Michigan Natural Features Inventory identifies the following listed species in the Cedar Creek subwatershed: elktoe mussel, slippershell mussel, round pigtoe mussel, ellipse mussel, rainbow mussel, Henslow's sparrow, and Indiana bat. The subwatershed may also support one or more great blue heron rookeries.

Hydrologic Features:

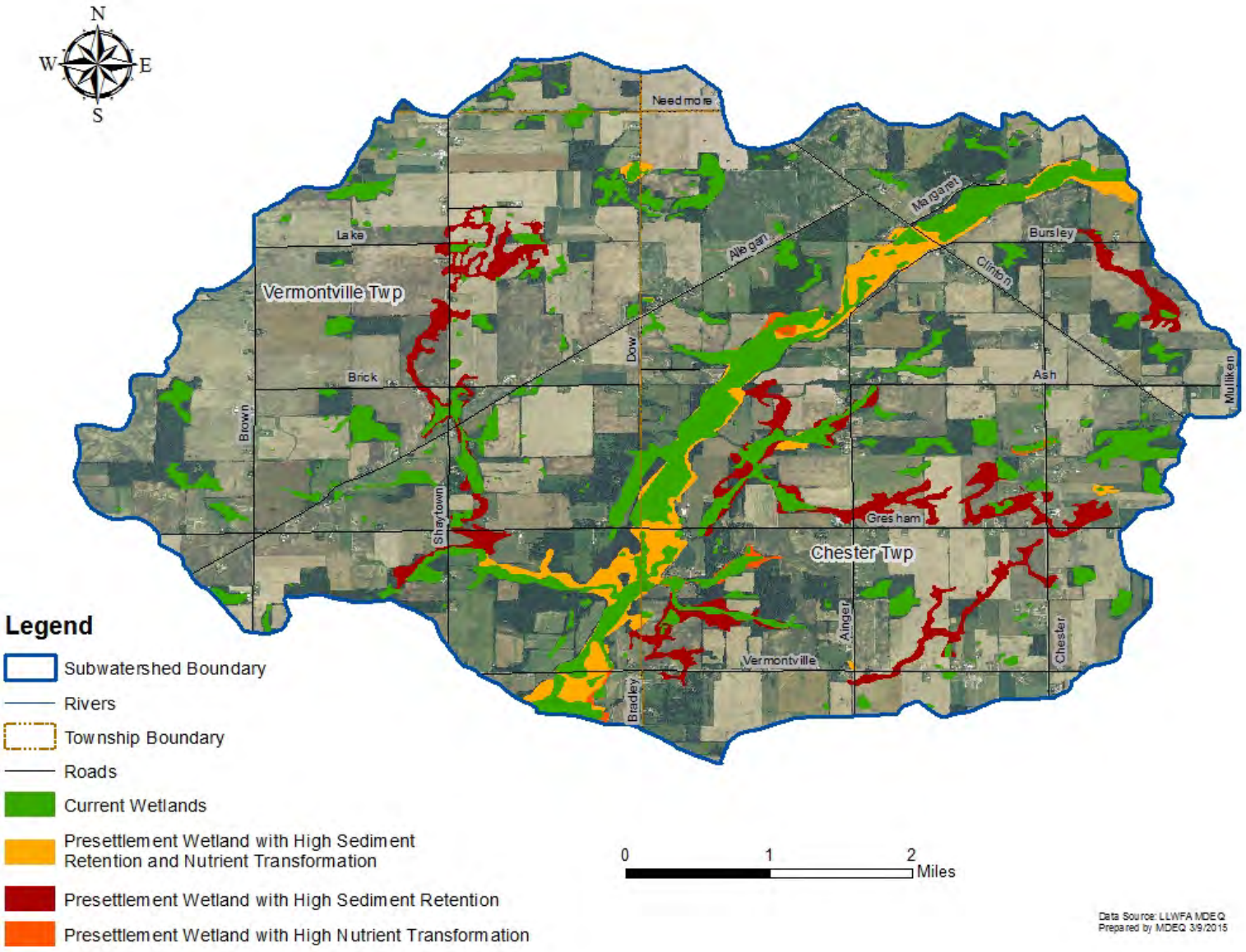
Tributaries: Haner (Thompson) Creek
Drains: unnamed
Lakes: none
Dams: none

Water Temperature Classification: The Thornapple River within the subwatershed and minor tributaries to the south are classified as warm-transitional, with Thompson Creek listed as a warm-water stream.

Point Source Contributions: There are no permitted discharges into the Thompson Creek subwatershed.

Environmental Contamination: There are no listed sites of environmental contamination in the Thompson Creek subwatershed.

Figure 5.8.A – Thompson Creek Wetland Restoration Potential



Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the Thompson Creek subwatershed is fully supporting assessed uses of navigation, industrial water supply and agriculture. The subwatershed has not been assessed for total or partial body contact recreation. A fishery assessment has not been completed. While the section of the Thornapple River in the subwatershed is fully supporting other indigenous aquatic life and wildlife, additional data is needed to make a determination of use support in Thompson Creek. Like most state waters, the subwatershed is not supporting fish consumption because of the presence of PCB in the water column and in fish tissue.

Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Fully Supporting[1] Insufficient Information[2] Not Assessed[3,4]			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Supporting[1,2]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1,2] Not Assessed[3,4]	PCB in Water Column	Y	2014

[1] AUID 040500070203-01 Includes Thornapple River

[2] AUID 040500070203-02 Includes Thompson Creek

[3] AUID 040500070203-NA and NAL Includes Waters only 'assessed' for Navigation, Agriculture, and Industrial Water Supply

Biological Surveys: Surveys include macroinvertebrate community, habitat and occasionally fish community. Locations surveyed in the Thompson Creek subwatershed are represented below with their applicable community status. Survey results indicate improving habitat and acceptable macroinvertebrate scores at this single location over four study years. The fish community showed some degradation between 1992 and 2002, with the latter survey containing mostly tolerant species.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Thompson Creek	1992	Gresham Hwy	Good	Poor	Good
Thompson Creek	2002	Gresham Hwy West	Acceptable	Fair	Acceptable
Thompson Creek	2004	Gresham Hwy West	Acceptable	Marginal	
Thompson Creek	2009	Gresham Hwy West	Acceptable	Good	
Thompson Creek	2009	M-50	Acceptable	Good	

Impairments: The Thompson Creek subwatershed is not meeting its designated uses for fish consumption due to PCB levels. Since PCB contamination results from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB reduction.

Degradations: The main stem of the Thornapple River in this subwatershed is inaccessible for over two miles, due to private land holdings; however, the channel and floodplain appear, in aerial photographs, to remain natural. Multiple small tributaries and Thompson Creek are agricultural drains, susceptible to agricultural runoff and bank erosion in unbuffered areas. There are several small to medium livestock operations in the subwatershed, and many utilize streams as pasture watering facilities, providing animals free access. Aging farmsteads have the potential of unknowingly contributing to pollutant loads through failing or improperly installed septic systems.

Recommendations: Thompson Creek requires further study to determine whether it is supporting the use of other indigenous aquatic life and wildlife. Improvements in the Thompson Creek subwatershed should focus on reducing livestock access and agricultural runoff. Fencing and buffers in pasturelands, and reduced tillage coupled with buffers on croplands will improve water quality. Reduction of residential pollutant loads through septic system repairs where needed and riparian buffers will also limit nutrient concentrations in the streams. Erosion control along collapsing streambanks, gravel roads and at road crossings will reduce sediment loads. Wetland restoration in the headwaters of Thompson Creek and smaller tributaries will reduce high flow and runoff inputs into the river. Protection of the river corridor between Gresham Highway and M-50 is important to long-term water quality in the subwatershed. Closure of abandoned wells and removal of abandoned fuel storage tanks will reduce the potential for chemicals entering the waterway.

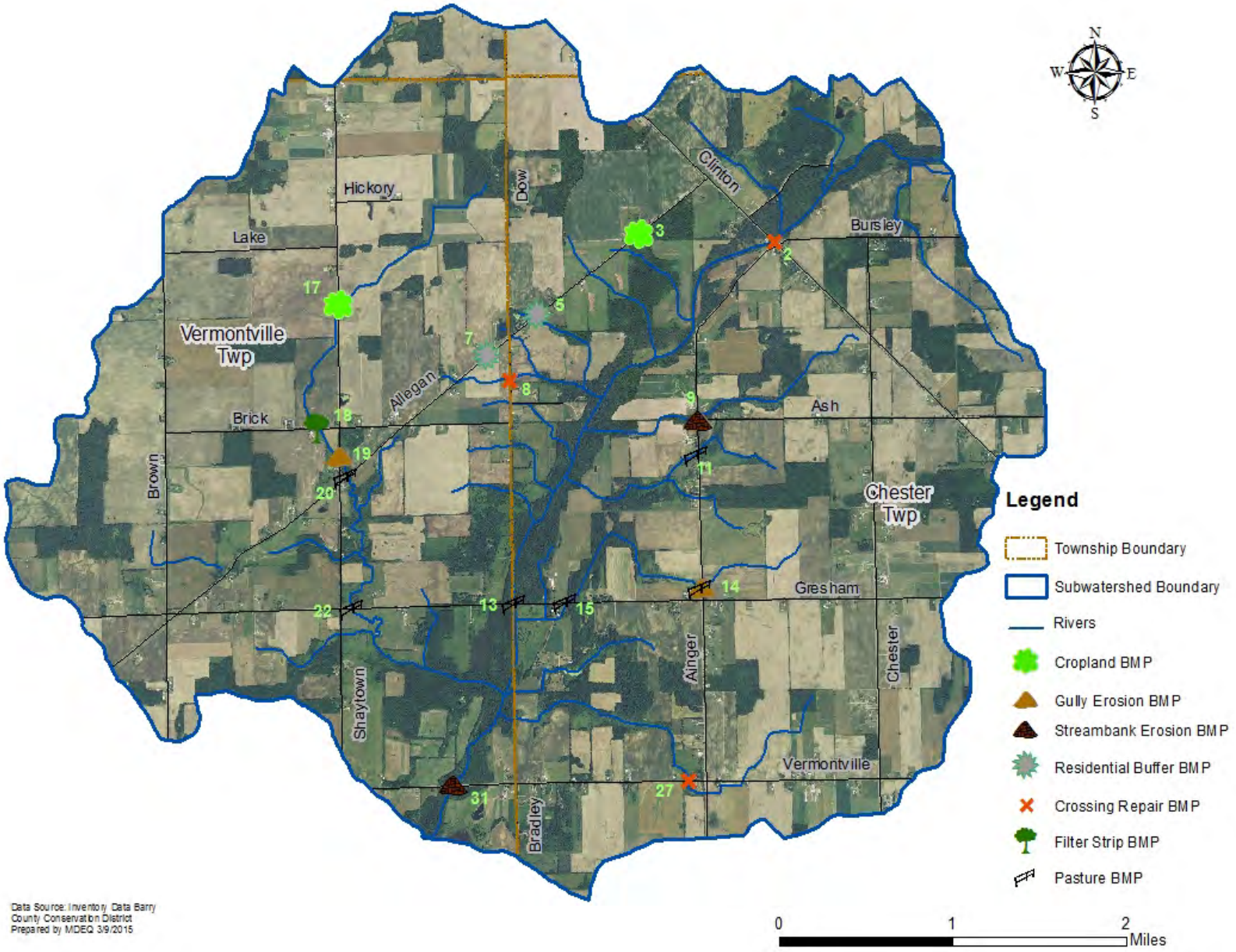
Prioritized Improvement Areas: Prioritizing areas for improvement in the Thompson Creek subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future

requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4 and 5.

Thompson Creek Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	17	Thompson Creek	Reduced till	Filter strip	Nutrients, Sediment
2	22	Unnamed tributary	Stream stabilization	Fencing	Sediment, Nutrients
3	14	Unnamed tributary	Stream stabilization	Fencing	Sediment, Nutrients
4	3	Unnamed tributary	Reduced till	Filter strip	Nutrients, Sediment
5	11	Unnamed tributary	Stream stabilization	Fencing	Sediment, Nutrients
6	15	Unnamed tributary	Stream stabilization	Fencing	Sediment, Nutrients
7	18	Thompson Creek	Stream stabilization	Fencing	Sediment, Nutrients
8	7	Unnamed tributary	Residential buffer		Sediment, Nutrients
9	20	Thompson Creek	Stream stabilization	Fencing	Sediment, Nutrients
10	5	Unnamed tributary	Residential buffer		Sediment, Nutrients
11	9	Unnamed tributary	Stream stabilization		Sediment
12	13	Thornapple River	Stream stabilization	Fencing	Sediment, Nutrients
13	31	Thornapple River	Stream stabilization		Sediment
14	9, 14, 19	All	Road repair		Sediment
15	2,3,8,27	All	Culvert replacement		Sediment
16	TBD	All	Repair failing septic systems		*E. coli,* Nutrients
17	TBD	All	Well closure		Chemical leachate
18	TBD	All	Fuel tank removal		Chemical leachate

Figure 5.8.B – Thompson Creek Improvement Areas



5.9 Subwatershed: Shanty Brook **HUC: 040500070204**

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
10167.3	3.14%	64.94%	0.00%	14.07%	17.65%	1.79%	0.24%	1.32%	100%

Land use in the Shanty Brook subwatershed is largely agricultural in drained, tillable areas in the upper and central subwatershed where row crops and forage crops dominate. Non-prime areas are utilized as pasture for medium-sized livestock operations. Only remnants of forested floodplain corridors remain along Shanty Brook and its tributaries. Most agricultural fields do maintain vegetated buffers along the stream corridors. The subwatershed is sparsely populated, with no industrial or commercial areas of note. Presettlement vegetation consisted of mainly beech-sugar maple forest with areas of mixed conifer swamp in the headwaters of Hayon Creek, the Bundige and Wilcox Drain and the confluence of Bundige and Wilcox with Shanty Brook. The mouth of Shanty Brook was an area of mixed hardwood swamp – this area remains forested today. Wetland loss is found throughout the subwatershed in all drained areas and along riparian corridors. Losses are greatest along the lower reach of the mainstem along the riparian corridor.

Protected Areas: There are no protected lands in the Shanty Brook subwatershed.

Special Features: The Michigan Natural Features Inventory identifies the following listed species in the Shanty Brook subwatershed: grasshopper sparrow and dickcissel.

Hydrologic Features:

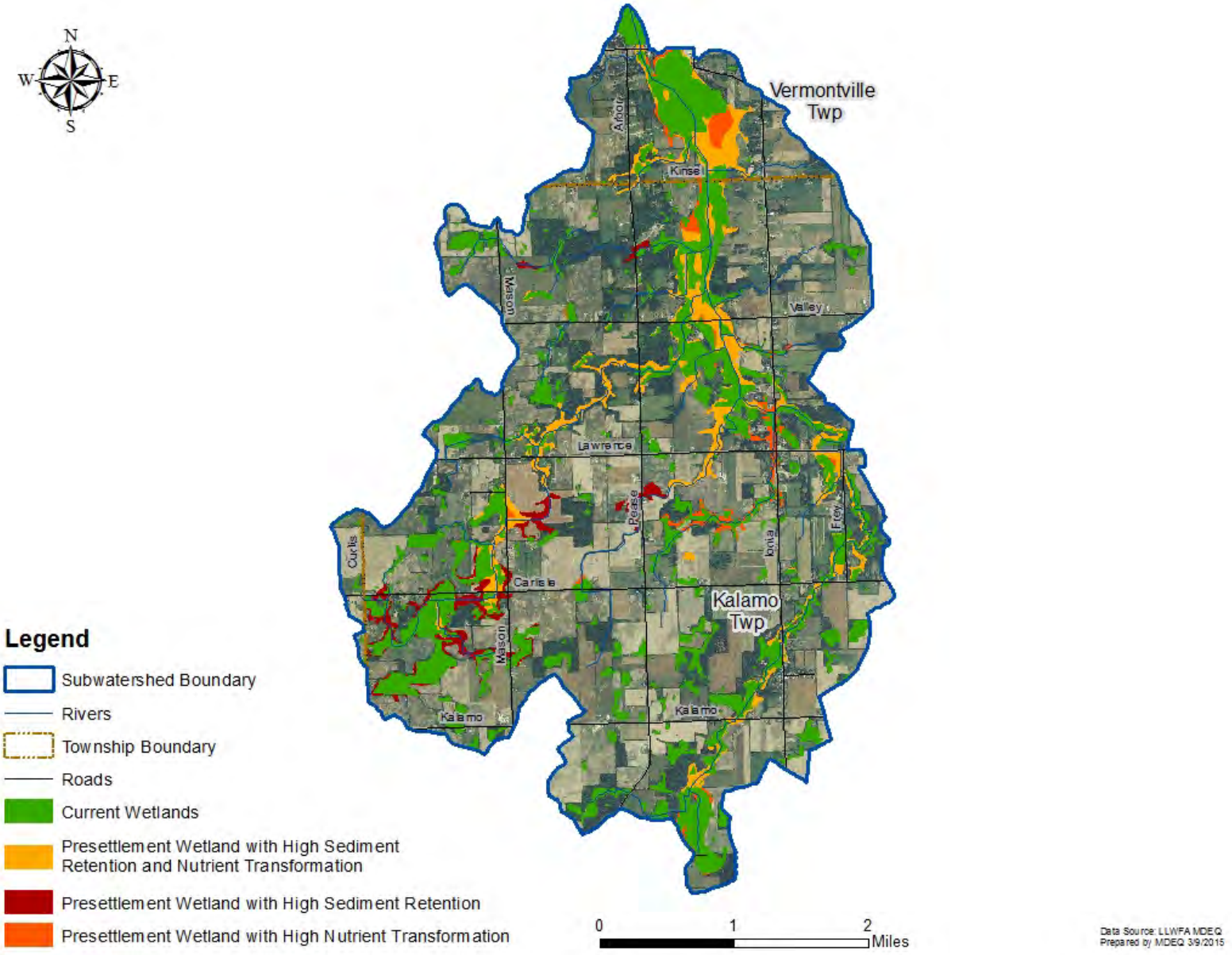
Tributaries: Hayon Creek; Shanty Brook (Creek)
Drains: Bundige & Wilcox Drain; Fairfax Drain; Shepard Drain, Hurd Drain; Mast Drain; Gridley Drain; Shanty Drain
Lakes: none
Dams: Hulsebos Dam

Water Temperature Classification: The waters of Shanty Brook and Hayon Creek are classified as warm streams below their confluence with the Bundige and Wilcox Drain. The Bundige and Wilcox Drain and the lower portion of Shanty Brook are classifies as warm-transitional streams.

Point Source Contributions: There are no permitted point source discharges in the Shanty Brook subwatershed.

Environmental Contamination: There are no listed sites of environmental contamination in the Shanty Brook subwatershed.

Figure 5.9.A – Shanty Brook Wetland Restoration Potential



Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the Shanty Creek subwatershed is fully supporting assessed uses of navigation, industrial water supply and agriculture. A warm water fishery assessment has not been completed, and more information is needed to determine support of a cold water fishery. Shanty Brook and Hayon Creek are fully supporting other indigenous aquatic life and wildlife. Like most state waters, the subwatershed is not supporting fish consumption because of the presence of PCB in the water column and in fish tissue.

Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Fully Supporting[1] Not Assessed[2]			
Cold Water Fishery	Insufficient Information			
Fish Consumption	Not Assessed[2]			
Fish Consumption	Not Supporting[1]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1]	PCB in Water Column	Y	2014

[1] AUID 040500070204-01 Includes Hayon Creek and Shanty Brook

[2]AUID 040500070204-NAL Includes Lakes only 'assessed' for Navigation, Agriculture, and Industrial Water Supply

Biological Surveys: Only one location has been surveyed in the Shanty Brook subwatershed since 1991. Survey results indicate a good habitat and acceptable macroinvertebrate score despite channel alterations.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Shanty Brook	2004	Valley Hwy	Acceptable	Good	

Macroinvertebrate collections conducted by the Barry Conservation District under the MiCorps program from 2006-2008 support the 2004 MDEQ findings, showing fairly consistent levels of Group 1 – sensitive taxa, with changes in diversity and abundance of Group 2 – somewhat sensitive taxa.

Location	Date	Group	Group	Group	Group	Group	Group	Group	Group	Group	Total	Score
	Sampled	1 #R	1 #C	2 #R	2 #C	3 #R	3 #C	1 Total	2 Total	3 Total	Score	Rank
Valley Hwy	10-28-06	4	0	8	1	2	1	20	27.2	3.2	50	Excellent
Valley Hwy	5-12-07	4	0	4	1	2	0	20	15.2	2.2	37	Good
Valley Hwy	10-27-07	3	0	2	1	3	0	15	9.2	3.3	28	Fair
Valley Hwy	5-5-08	5	0	5	1	3	1	25	18.2	4.3	48	Good
Valley Hwy	11-4-08	2	0	7	1	3	0	10	24	3.3	38	Good
Valley Hwy	11/12/09	2	0	4	2	5	0	10	18.4	5.5	34	Good

Impairments: The Shanty Brook subwatershed is not meeting its designated uses for fish consumption due to PCB levels. Since PCB contamination results from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB reduction.

Degradations: There are some areas of erosion and some livestock access, as well as a need for residential buffers along the creek. Road and road crossing issues contribute to sedimentation in the stream.

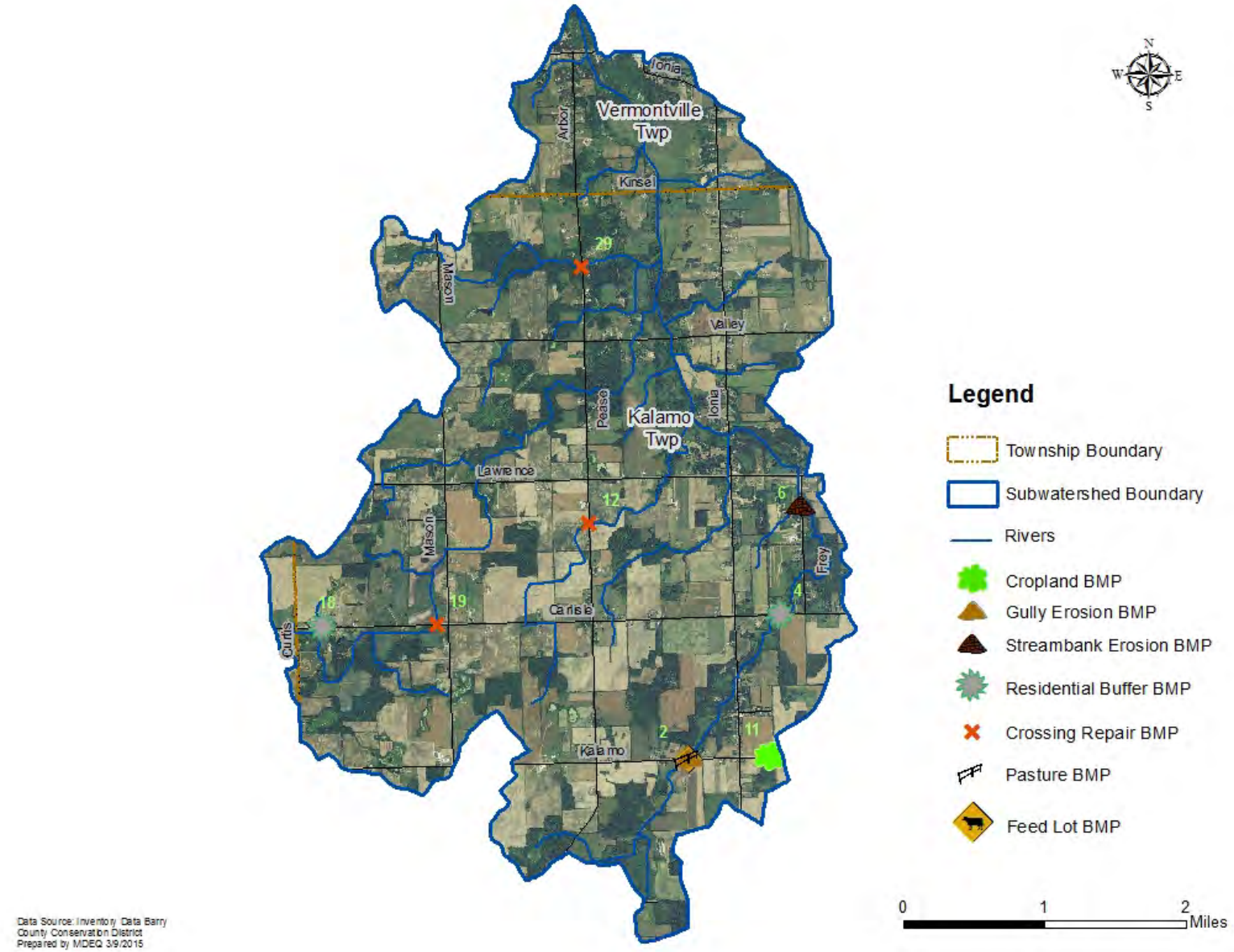
Recommendations: Surveyed habitat and macroinvertebrate communities indicate a stream in relatively good health. Though much of the subwatershed is drained, streams are generally well buffered. Improvement efforts in the Shanty Brook subwatershed include reduced tillage, improved buffers, stabilization and livestock access restriction. Reduction of erosion and stream alteration due to undersized culverts at road crossings should also be addressed. Restoration of wetlands in channelized areas, especially those prioritized in Figure 5.9.A will also be effective in filtering nutrients. Repair of failing septic systems is important to reduce the potential for *E. coli* contamination. Abandoned well closure and removal of unused fuel storage tanks will reduce the potential for pollutants reaching the waterways.

Prioritized Improvement Areas: Prioritizing areas for improvement in the Shanty Brook subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4 and 5.

Shanty Brook Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	2	Gridley Drain	Stream stabilization	Fencing	Sediment, Nutrients
2	2	Gridley Drain	Waste facility		Nutrients
3	14	Unnamed tributary	Reduced till	Filter Strip	Sediment, Nutrients
4	6	Shanty Drain	Stream stabilization		Sediment
5	4	Shanty Drain	Residential Buffer		Sediment, Nutrients
6	18	Bundige & Wilcox Drain	Residential buffer		Sediment, Nutrients
7	2	Gridley Drain	Road repair		Sediment
8	12	Fairfax Drain	Culvert replacement		Sediment
9	19	Bundige &Wilcox Drain	Culvert replacement		Sediment
10	29	Unnamed tributary	Culvert replacement		Sediment
11	TBD	All	Repair failed septic systems		*E. coli;* Nutrients
12	TBD	All	Well closure		Chemical leachate
13	TBD	All	Fuel tank removal		Chemical leachate

Figure 5.9.B – Shanty Brook Improvement Areas



5.10 Subwatershed: Quaker Brook **HUC: 040500070205**

Land Use/Cover:

Size in Acres	% Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
12201.9	3.86%	57.99%	0.00%	20.26%	7.26%	3.92%	0.45%	7.63%	100%

Current land use in the Quaker Brook subwatershed is primarily agricultural. Below Lawrence Road, both Quaker Brook and its main tributary to the west are largely protected by forested floodplain including wooded wetlands. Quaker Brook subwatershed incorporates the southern end of the Village of Nashville and includes a residential and business corridor along M-66 and the settlement of Assyria. Significant businesses include a 90-acre gravel pit owned by C&D Hughes Excavating and Moo-Ville Creamery, a large agribusiness dairy. Smaller livestock operations and a dog breeding kennel are located in the upper portion of the subwatershed, with row crops dominating the western section. A 170 acre gravel pit owned by T-M Asphalt and the Barry County Road Commission's 11.8 acre gravel pit are located in the brook's headwaters. Presettlement vegetation was predominately beech-maple forest with floodplain areas of hardwood and conifer swamp. Significant wetland loss has occurred along the lower portion of the Quaker Brook main stem (a designated drain north of Cloverdale Road) and in the upper portion of the main tributary in areas corresponding with the drain systems. Bank erosion and frequent dredging activities below Maple Grove Road have severely impacted aquatic habitat, stream temperature and water quality. Construction and maintenance of M-66 Highway and east-west travel corridors M-79 and Lawrence Road have impacted Quaker Brook and its tributaries by re-routing streambeds and altering drainage patterns.

Protected Areas: There are no protected lands in the Quaker Brook subwatershed.

Special Features: The Michigan Natural Features Inventory (MNFI) catalogs no listed species or natural communities in the Quaker Brook subwatershed.

Hydrologic Features:

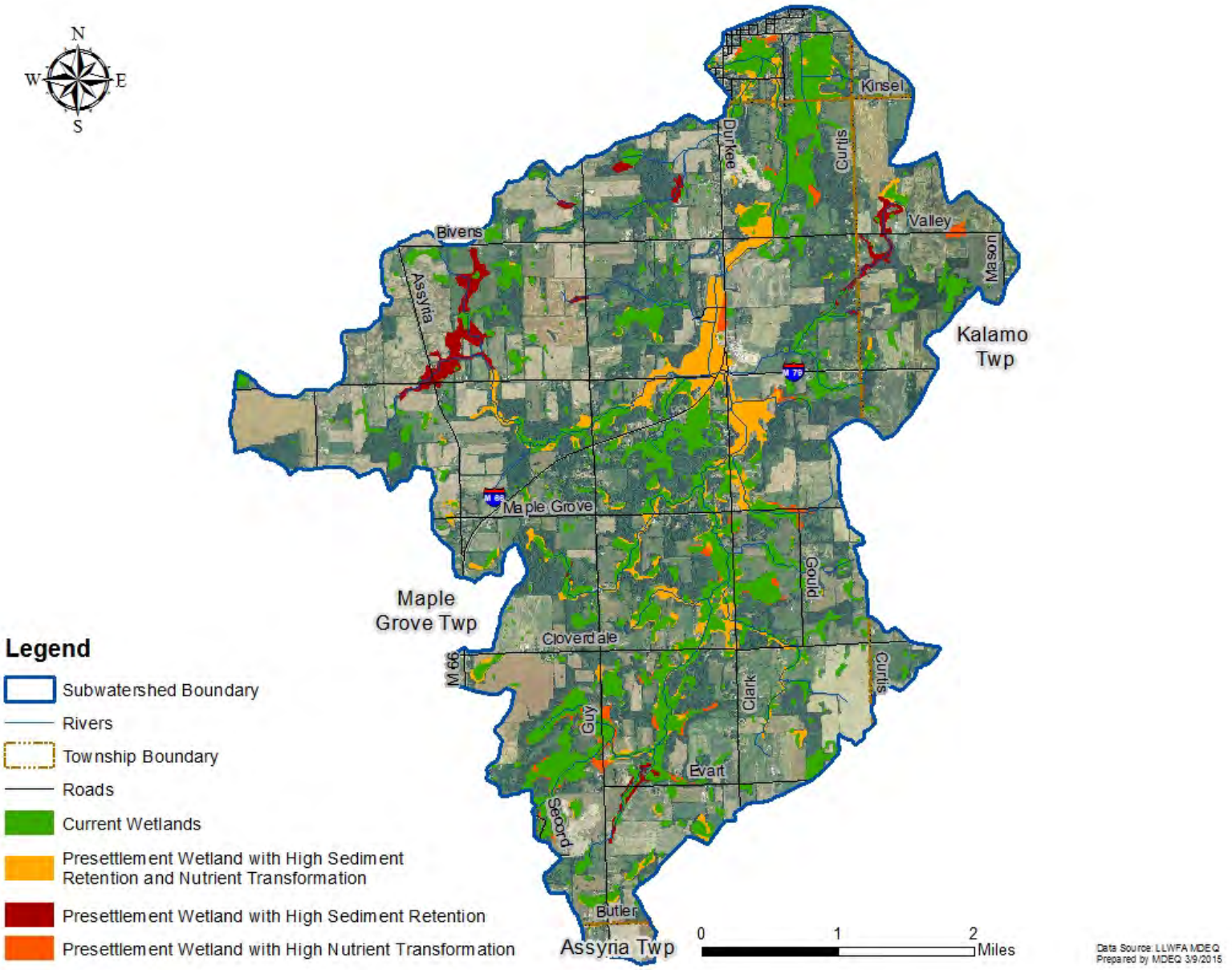
Tributaries: unnamed
Drains: Dillin, Hyde & Marshall, Dean, Morganthaler, Bullis & Hawkes
Lakes: Lake One
Dams: none
Other: USGS Gage Station #04117000 - Quaker Brook near Nashville

Water Temperature Classification: Quaker Brook and its tributaries are classified as warm transitional streams. Though Quaker Brook is a designated trout stream, alterations in the subwatershed, stream and tributaries have increased water temperatures to the degree that DNR ceased stocking the stream in 1997.

Point Source Contributions: There are no permitted discharges into the waters of the Quaker Brook subwatershed.

Environmental Contamination Sites: The Quaker Brook subwatershed contains one active LUST site and five brownfield sites. The tables below provide location data from MDEQ databases.

Figure 5.10.A – Quaker Brook Potential Wetland Areas



Active Leaking Underground Storage Tank (LUST) Sites

LUST Site Name	Latitude	Longitude	Substance Released
Maple Valley Concrete Products	42.594125	-85.094476	Gasoline

Brownfield Sites

BEA Number	Address	Latitude	Longitude
200000681GR	230 S Main St	42.601933	-85.093608
201303456GR	301 S Main St	42.60117	-85.093603
Part 213	P.O. Box 357	42.59413	-85.09448
Part 213	106 S Main St	42.60294	-85.09387
Part 213	133 S Main St	42.60238	-85.09331

Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, Quaker Brook is supporting most assessed designated uses. It is not supporting fish consumption because of the presence of PCB in the water column and fish tissue. The "insufficient information" on the cold water fishery designated use represents the need for additional DEQ data to make a determination due to the absence of trout in the most recent DNR fish survey.

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Fully Supporting[1] Not Assessed[2]			
Cold Water Fishery	Insufficient Information[1] Not Assessed[2]			
Fish Consumption	Not Supporting[1]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1]	PCB in Water Column	Y	2014
Fish Consumption	Not Assessed[2]			

[1] AUID 040500070205-01 Includes Quaker Brook

[2]AUID 040500070205-NAL Includes Lakes only 'assessed' for Navigation, Agriculture, and Industrial Water Supply

Biological Survey: The MDEQ Biological Surveys of the Thornapple River included macroinvertebrate and habitat status data for stations on Quaker Brook. Macroinvertebrate populations are in the acceptable range, while habitat status ranged from good to poor. Reports noted

flow flashiness, lack of natural channel features such as woody debris, riffles and sinuosity, and heavy sedimentation – all results of channelization – as the causes of marginal to poor habitat status. Specifically, Quaker Brook was noted as highly modified, with approximately 80% of the stream bottom composed of sand. Nutrient enrichment was also investigated at this time by sampling total phosphorus and nitrogen concentrations. In 2009, total phosphorous at the test site on Cloverdale Road was 0.148 mg/L, with Total Kjeldahl Nitrogen at 0.88 mg/L, both the highest concentrations of sites sampled in that season, but both within the expected range for the SMNITP ecoregion. The fish community was not rated due to lack of salmonids in this designated cold water stream.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Quaker Brook	1998	Lawrence Rd	Acceptable	Good	Not rated - no salmonids
Quaker Brook	1998	M-79	Acceptable	Fair	Not rated - no salmonids
Quaker Brook	2002	Clark Rd	Acceptable	Good	Not rated - no salmonids
Quaker Brook	2002	M-79	Acceptable	Good	
Quaker Brook	2009	M-66 North	Acceptable	Poor	
Quaker Brook	2009	Francis St	Acceptable	Marginal	
Quaker Brook	2009	Cloverdale Rd	Acceptable	Marginal	

Fish Survey: A Fish Collection Survey was conducted by DNR in 2006, prior to the relocation of the M-79 and M-66 intersection south of Nashville. The survey yielded 12 fish species: American brook lamprey, brook trout (1), blacknose dace, brook stickleback, creek chub, common shiner, central stoneroller, white sucker, green sunfish, Johnny darter, central mudminnow, and rainbow darter. The single brook trout was believed to have been naturally produced. The survey recommends Quaker Brook for habitat improvement. A 1997 DNR Fish Collection Survey conducted in areas upstream of Maple Grove Road and upstream of Clark Road yielded 16 species with no trout identified. This study concluded that habitat conditions were not favorable to brook trout. This, and lack of trout found in the survey, were cause for ceasing stocking efforts in the stream.

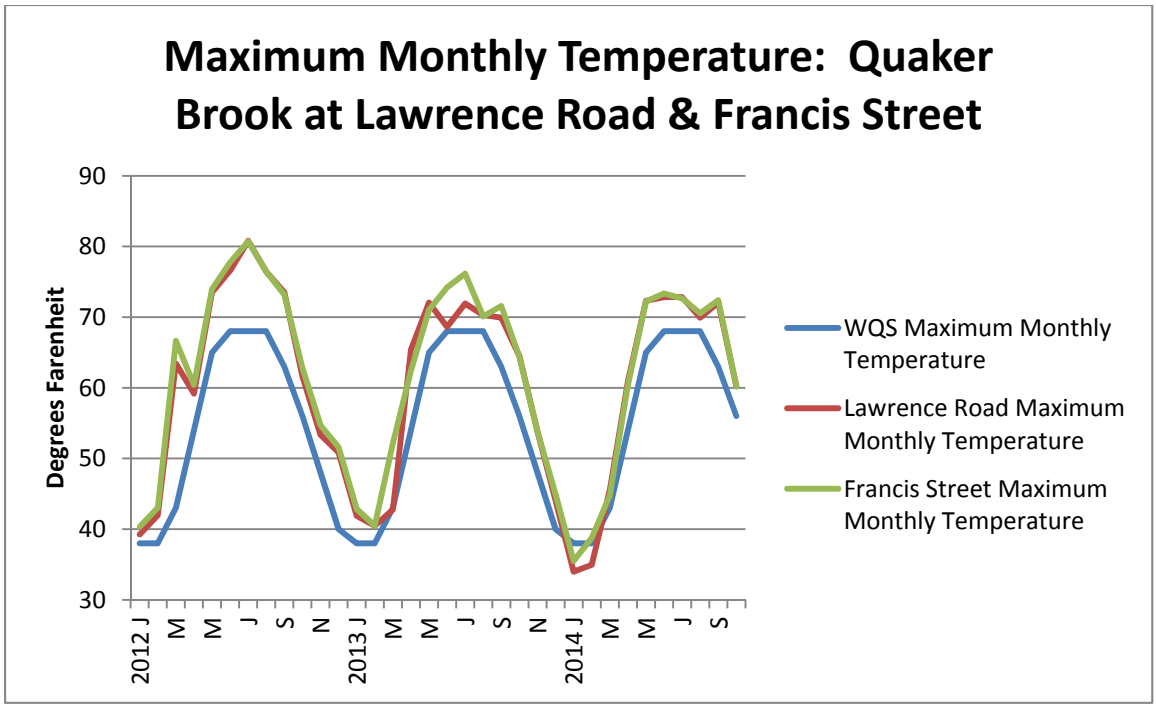
Macroinvertebrate Survey: Macroinvertebrate collections conducted by the Barry Conservation District under the MiCorps program from 2006-2010 upstream of the Francis Street crossing show a decline over this period in diversity of Group 2 – somewhat sensitive – macroinvertebrate species. The absence of gilled snails – sensitive macroinvertebrates – in most collections after May, 2007 (excepting November, 2009) correlates with habitat data from the same study indicating an increase in substrate embeddedness in riffles from 0-25% in the first sample to greater than 50% from 2008 onward.

Location	Date Sampled	Group 1 #R	Group 1 #C	Group 2 #R	Group 2 #C	Group 3 #R	Group 3 #C	Group 1 Total	Group 2 Total	Group 3 Total	Total Score	Score Rank
W. Francis St.	10-25-06	3	0	9	1	2	3	15	30.2	5.2	50	Excellent
W. Francis St.	05-12-07	2	0	5	1	4	1	10	18.2	5.4	34	Good
W. Francis St.	10-27-07	2	0	5	1	2	2	10	18.2	4.2	32	Fair
W. Francis St.	05-12-08	1	0	3	1	3	0	5	12.2	4.3	22	Fair
W. Francis St.	10-22-08	2	0	3	1	3	0	10	12.2	3.3	26	Fair
W. Francis St.	11-04-09	1	2	6	1	1	1	15.6	21.2	2.1	39	Good
W. Francis St.	05-10-10	1	0	4	1	2	1	5	16.2	3.2	24	Fair

Crossing Surveys: Road-stream crossing surveys conducted on 17 sites in the Quaker Brook subwatershed by the Barry Conservation District in 2006-2007 indicate habitat issues including the predominance of sand and muck substrate, lack of woody debris and severely undercut banks in channelized areas. Agricultural erosion was noted at several locations, as was bank collapse due to channel design and lack of riparian buffers. Also noted were residential runoff and erosion areas in portions of the upper subwatershed as well as in the Village of Nashville, largely due to lack of riparian buffers.

An additional windshield survey of critical areas in the subwatershed was conducted in 2011 in conjunction with a fish passage barrier study by the Barry Conservation District. The windshield survey catalogued visible sources of non-point pollution. Locations where erosion was present were measured in the field to calculate total sediment contributions. Stream lengths at cattle access sites and sites with inadequate buffers were measured using aerial photographs. The general condition and functionality of all culverts and bridges were surveyed as a part of a fish passage barrier study. Undersized, perched, plugged or damaged culverts were considered as critical areas when they impeded fish passage or caused severe erosion, impoundment or scour pools.

The Barry Conservation District utilized HOBO temperature loggers to monitor temperature on three cold water tributaries in the Thornapple River watershed from January 2012 through October 2014Two loggers were placed on Quaker Brook – one at Lawrence Road and one at Francis Road. These locations were chosen to be upstream and downstream of streambank restoration projects on Quaker Brook. Maximum monthly temperature data from Quaker Brook are charted below, with tables expressed in Appendix 4. Monthly temperatures for Quaker Brook at both locations regularly exceed Michigan's water quality standards for cold water streams. Quaker Brook exceedences reach a maximum of 12 degrees Fahrenheit (July 2012).



Impairments: The Quaker Brook watershed is meeting most of its designated uses except for fish consumption due to PCB in the water column and fish tissues and its use as a coldwater fishery. Since PCB contamination is a result of atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB reduction.

Degradations: DNR fish collection surveys indicate that the main stem of the brook is not supporting a coldwater fishery. Marginal to poor habitat ratings are linked to excessive substrate imbeddedness, lack of natural channel features and flow flashiness. Warm water temperatures on this cold water stream are the result of stream widening, canopy loss and disconnection from groundwater sources due to wetland loss and channelization.

Recommendations: Improvements in the Quaker Brook watershed must address sources of erosion and sedimentation to improve habitat. Stream buffers are necessary in key areas, not only to combat erosion, but also to reduce relatively high nutrient levels associated with runoff. Restoration of natural channel features, including channel width, sinuosity, structure and canopy is also critical in the main stem and altered tributaries. Wetland restoration in this heavily channelized subwatershed is important particularly in the central area, where most of the loss has occurred. Further improvements include reduction of illicit sewer connections and failed septic systems associated with older, rural residential housing in this vicinity. E. coli monitoring is also needed to determine the priority level for reducing potential sources of human and animal fecal contamination. Closure of abandoned wells and removal of fuel storage tanks will reduce the opportunities for chemical pollution.

Prioritized Improvement Areas: Prioritizing areas for improvement in Quaker Brook is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all restoration projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s).

Quaker Brook Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	B17 – B23	Quaker Brook	2-stage bank		Sediment, Nutrients (17 to 23)
2	B3	Unnamed tributaries	Reduced till	Filter strip	Nutrients, Sediment
3	B6	Hyde & Marshall Drain	Grassed waterway	Reduced till	Sediment, Nutrients
4	B7	Dean Drain	Stream stabilization	Fencing	Livestock access
5	B19	Bullis & Hawks Drain	Stream stabilization	Fencing	Livestock access
6	B31	Morganthaler Drain	Stream stabilization	Fencing	Livestock access
7	B29	Morganthaler Drain	Stream stabilization	Fencing	Livestock access
8	B18	Unnamed tributary	Stream stabilization	Fencing	Livestock access
9	B25	Quaker Brook	2-stage bank		Sediment, Temperature
10	B39	Unnamed tributary	Culvert repair		Perched culvert, Sediment
11	A4	Quaker Brook	Culvert repair		Perched culvert
12	B19	Bullis & Hawks Drain	Culvert repair		Plugged culvert
13	B10	Morganthaler Drain	Culvert repair		Plugged culvert
14	B18	Tributary	Road repair		Sediment
15	B31	Morganthaler Drain	Road repair		Sediment
16	B14	Quaker Brook	Culvert repair		Sediment
17	B38	Unnamed tributary	Culvert repair		Damaged culvert, Sediment
18	B6	Hyde & Marshall Drain	Culvert repair		Sediment
19	B7A	Dean Drain	Culvert repair		Sediment
20	B11	Tributary	Culvert repair		Sediment
21	B12	Tributary	Culvert repair		Sediment
22	B28	Tributary	Culvert repair		Sediment
23	B33	Tributary	Culvert repair		Sediment
24	A18	Tributary	Culvert repair		Sediment
25	A25	Tributary	Culvert repair		Sediment
26	A14	Tributary	Culvert repair		Sediment
27	B13	Tributary	Culvert repair		Sediment
28	B14	Quaker Brook	Culvert repair		Sediment
29	B20	Quaker Brook	Road repair		Sediment
30	B31	Tributary	Road repair		Sediment
31	B33	Tributary	Road repair		Sediment
32	B38	Tributary	Road repair		Sediment
33	B39	Tributary	Road repair		Sediment

Priority 1 – This channelized portion of Quaker Brook spans approximately 6717 feet, from Lawrence Road to Bivens Road, south of Nashville. Running through unbuffered agricultural fields, the area is prone to severe erosion and bank collapse. The channel and structures are wide, ranging from 20' to 26' where surveyed channel width in unobstructed areas is 15'. The channel is characterized by shallow water (<1') and braiding, with sediment deposition along the banks. Bank angles are 70° to 90° and range from 3'- 4.5'. Manure spreading occurs regularly in adjacent fields. Best management practice recommendations for this site are to utilize natural channel design to recreate floodplain area, reduce erosion and allow for sediment deposition and sinuosity. Incorporation of woody debris and use of native sedges, grasses and shrubs in the floodplain buffer will provide canopy, habitat and reduction of nutrient loading.

Priority 2 – Two channelized tributaries in cropped fields at a significant grade below a growing Animal Feeding Operation are subject to runoff from the feedlot and regular manure spreading through irrigation. Both tributaries are unbuffered and subject to erosion during high flows. Best management practices recommended for this site are riparian buffers on both banks of both streams (totaling approximately 5000') and cover crops on adjacent fields.

Priority 3 – Gully erosion affects approximately 1.6 acres of cropland in this headwater area of the Hyde & Marshall Drain. In wet years, crops have failed on this site. Best management practices for this site include a wetland restoration or, alternately, permanent grass planting.

Priorities 4 – 8 – These five sites are pasture areas where livestock access contributes to bank collapse, erosion, and nutrient loading. They are ranked by overall effect based on amount of access and regular flow conditions of the tributary. The best management practices recommended for these sites are exclusion through fencing and provision of alternate water supplies.

Rank	Site #	Fencing (ft.)
4	7	1,814
5	19	1,130
6	31	352
7	29	130
8	18	193

Priority 9 – Quaker Brook between Bivens Road and Sherman Street is a channelized portion of the main stem characterized by shallow water and poor habitat. Best management practices for this area include reduction or elimination of dredging activities to permit channel naturalization, incorporation of woody debris in a manner that does not impede high flow, and increasing canopy.

Priority 10 – This 5' culvert is perched 1.5' at the outlet, creating a 10' x 7' scour pool and restricting fish passage. Additionally, gully erosion on the upstream side contributes sediment to the stream. The culvert is also significantly undersized, increasing flow and bank scour downstream. A culvert replacement is recommended.

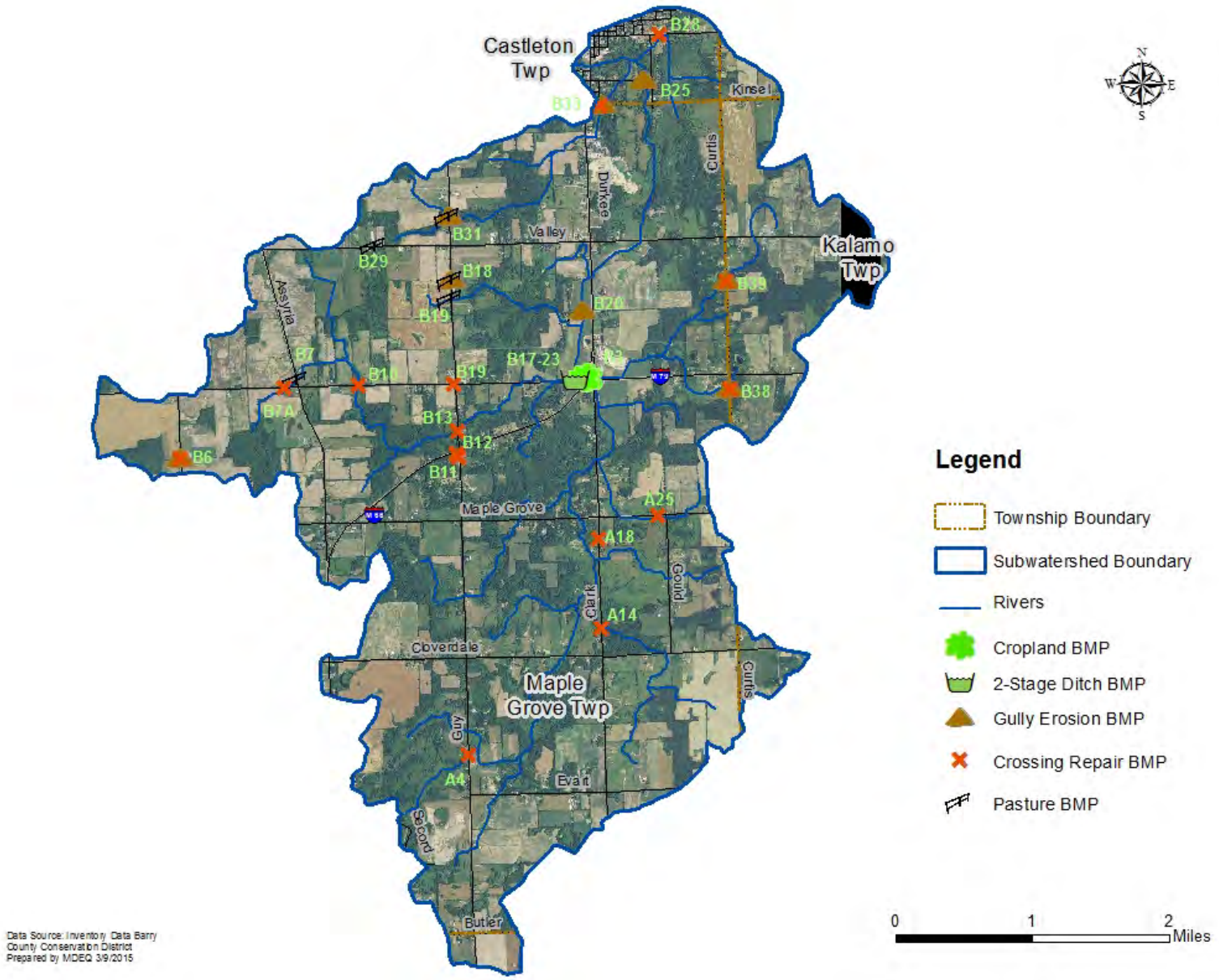
Priority 11 – This 2' culvert is perched 0.5' at the outlet, creating a 14' by 10' scour pool and restricting fish passage. A culvert replacement is recommended.

Priority 12 – 13 – These culverts are plugged with debris, causing erosion upstream of each structure and restricting fish passage. Debris removal and gully repair are recommended.

Priority 14 – Gullies have formed on the upstream and downstream sides of this culvert structure, with road material eroding into the stream. Erosion fabric and riprap are recommended for this site.

Priority 15 – Excessive road erosion has created an extensive gully (684’ x 4.7’ x 1.2’) with material washing into the stream. Alternate road drainage is recommended to prevent repeated erosion problems at this site.
Priority 16 – 28 These damaged or undersized culverts should undergo replacement to reduce sources of erosion and improve fish passage.
Priority 29 - 33 These are areas where road run-off is directly entering the waterways. Road repair at these locations will reduce sedimentation.

Figure 5.10.B Quaker Brook Improvement Areas



5.11 Scipio Creek – Thornapple River **HUC: 040500070206**

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
16209.4	4.06%	58.60%	0.00%	19.74%	14.72%	3.39%	0.19%	3.36%	100%

The Scipio Creek subwatershed includes the villages of Vermontville and Nashville, both small communities supporting commercial and light industrial uses as well as urban residential use. Outside of the villages, land use is primarily agricultural, with forage and row crops as well as small livestock and hobby farms. Some of the farms surrounding Scipio Creek are managed by members of the Amish community who maintain small numbers of livestock on their farmsteads. Farmland classifications include some areas of prime farmland, but mainly farmland of local importance. Presettlement vegetation was mainly beech-sugar maple forest, with areas of mixed conifer, mixed hardwood and black ash swamp, as well as an area of emergent marsh along the Scipio Creek floodplain. Scipio Creek maintains a wide forested buffer along the mainstem and most tributaries, as does the portion of the Thornapple River in this subwatershed. For this reason, the Scipio Creek floodplain between Lake Highway and Gresham Highway is ranked as the second-highest potential conservation area in Eaton County, according to the MNFI study, *Significant Natural Features Areas in the Tri-County Region.* Wetland loss is far less significant in the Scipio Creek subwatershed than in others in the watershed. Drained areas include the headwaters of small tributaries. Some forested wetland along the Thornapple River has been lost to cropping.

Protected Areas: Due to the removal of the Nashville Dam in 2009, the dam impoundment was drained, leaving 60 acres of floodplain that is protected from development due to its wetland classification. Though the area is owned by numerous private landowners, it is now providing habitat for waterfowl, reptiles, amphibians and mammals in an area surrounded by the Village of Nashville. The Department of Natural Resources owns two parcels along the Thornapple River comprising approximately 60 acres.

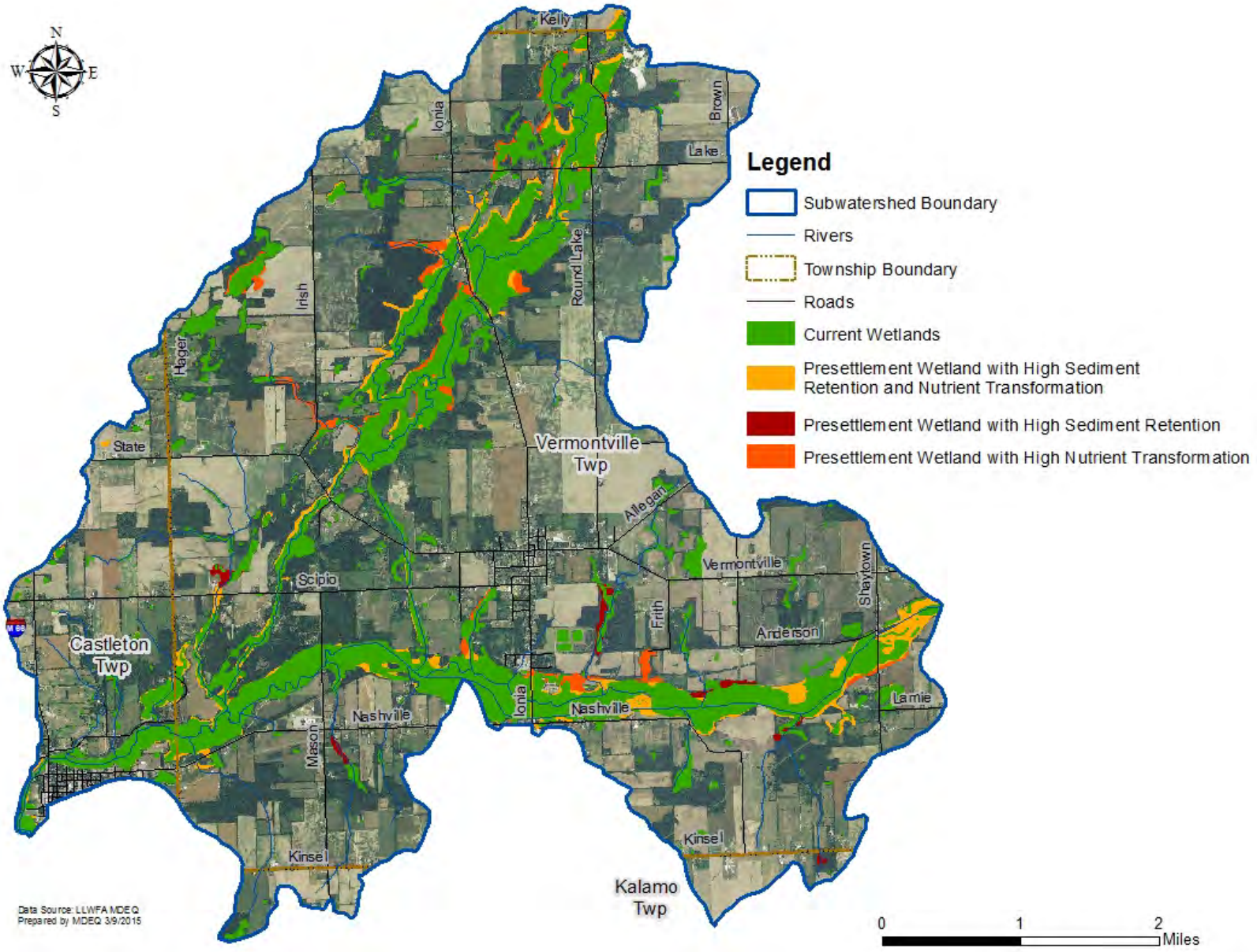
Special Features: No special features or listed species are cataloged in the Michigan Natural Features Inventory for this subwatershed.

Hydrologic Features:

Tributaries: Scipio Creek
Drains: unnamed
Lakes: Scipio Highway dam impoundment
Dams: Unnamed dam below Scipio Highway

Water Temperature Classification: Waters in the Scipio Creek subwatershed, including the Thornapple River, are classified as warm-transitional.

Figure 5.11.A – Scipio Creek Potential Wetland Areas



Point Source Contributions: The following facility is permitted by the MDEQ to discharge into the waters of the Scipio Creek subwatershed:

Facility Name	Permit Number	Latitude	Longitude	Permitted Discharge (Max)
Vermontville WWTP	MI0024261	42.619166	-85.018333	Suspended Solids 4mg/l-monthly--Ammonia Nitrogen (N)4mg/l-monthly--Total Phosphorus 1.0mg/l-monthly--Fecal Coliform Bacteria 400cts/100ml/7days

Environmental Contamination Sites: The Scipio Creek subwatershed contains four active LUST sites and nine brownfield sites. The tables below provide location data from MDEQ databases.

Active Leaking Underground Storage Tank (LUST) Sites

LUST Site Name	Latitude	Longitude	Substance Released
Maple Valley Bus Garage	42.606752	-85.08038	Diesel, Unknown
Maple Valley Bus Garage	42.606752	-85.08038	Gasoline
J.J Party Store	42.629497	-85.013945	Not Listed
J.J Party Store	42.629497	-85.013945	Not Listed

Brownfield Sites

BEA Number	Address	Latitude	Longitude
200500892LA	203 W Third St	42.625662	-85.025944
201101603LA	203 W Third St	42.625662	-85.025944
199700113LA	495 E Main St	42.629212	-85.014498
200000444LA	495 E Main St	42.629317	-85.013795
199800238LA	10642 W Grand Ledge Hwy	42.625386	-85.027506
Part 201	2701,2774,2901 Shaytown Rd	42.61056	-84.97596
Part 213	495 E Main St	42.6295	-85.01395
Part 201	Vermontville Hwy	42.6355	-85.04186
Part 213	998 Reed St	42.60675	-85.08038

Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the Scipio Creek subwatershed is fully supporting assessed uses of navigation, industrial water supply and agriculture. A fishery assessment has not been completed for Scipio Creek or lakes, but waters of the Thornapple River above the Nashville Dam are supporting the warm water fishery use. While Scipio Creek is fully supporting other indigenous aquatic life and wildlife, additional data is needed to make a determination of use support on this section of the Thornapple River. Like most state waters, the subwatershed is not supporting fish consumption because of the presence of PCB in the water column and in fish tissue.

Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed[1,3] FullySupporting[2]			
Other Indigenous Aquatic Life and Wildlife	Insufficient Information[1] Fully Supporting[2] Not Assessed[3]			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Assessed[3]			
Fish Consumption	Not Supporting[1,2]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1,2]	PCB in Water Column	Y	2014

[1] AUID 040500070206-01 Includes Scipio Creek

[2] AUID 040500070206-02 Includes Thornapple River

[3] AUID 040500070206-NAL Includes Lakes only 'assessed' for Navigation, Agriculture, and Industrial Water Supply

Biological Surveys: The poor to marginal habitat status scores are due to the effects of channelization including high levels of sediment, lack of woody debris and straightening of the stream. Degraded habitat normally affects the abundance and diversity of both the fish and macroinvertebrate communities, but the Thornapple River at Mason Road maintains good communities of both despite heavy sedimentation in the crossing area, perhaps due to the naturalized channel upstream of the site.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Scipio Creek	1992	Mason Rd	Good	Poor	Good
Scipio Creek	1998	u/s Nashville WWTP	Acceptable	Good	Excellent
Scipio Creek	2009	Sherman St	Acceptable	Good	
Scipio Creek	2009	Ionia Rd	Acceptable	Marginal	

***E.coli* Monitoring:** The Barry Conservation District conducted weekly *E. coli* monitoring at one location on the Thornapple River in Scipio Creek subwatershed from June to September, 2013 for the purpose of determining whether *E. coli* pollution was an issue in the watershed. Results indicate that the Scipio Creek subwatershed is not meeting water quality standards for both total body contact and partial body contact recreation.

The table below shows results of *E. coli* data collected weekly from June 11 to September 24, 2013. Daily geometric means are compared to the daily maximum for total body contact and partial body contact recreation, with grey shading indicating that the daily maximum for total body contact or the 30-day geometric mean was exceeded. An underline indicates that both the maximum for total body contact and partial body contact were exceeded. Note that a result of 2420 per 100 ml is the limit of the analysis and should be interpreted as >2420 per 100 ml.

Date	Left	Center	Right	Duplicate	Daily Geometric Mean	30 Day Geometric Mean
6/11/2013	921	1300	1413	2420	1422	
6/18/2013	115	77	119	90	99	
6/25/2013	770	687	548		662	
7/2/2013	461	517	411		461	
7/9/2013	1112	649	649		777	489
7/16/2013	2420	2420	2420	2420	2420	554
7/23/2013	365	365	326	461	376	759
7/30/2013	326	248	435	441	353	655
8/6/2013	345	308	435		359	628
8/13/2013	870	830	961		885	642
8/20/2013	517	387	411		435	438
8/27/2013	866	727	1046	1203	943	511
9/3/2013	579	866	649	517	640	562
9/10/2013	1553	1203	1986	2420	1731	760
9/17/2013	866	980	980		940	872
9/24/2013	649	816	1203		860	869

Impairments: The Scipio Creek watershed is not meeting its designated uses for fish consumption due to PCB levels and for partial and total body contact recreation. Since PCB contamination results from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB reduction.

Degradations: E. coli levels found in the 2013 Barry Conservation District monitoring program indicate that the Thornapple River in the Scipio Creek subwatershed is not meeting water quality standards for both total body contact recreation and partial body contact recreation due to fecal contamination. More information is needed to determine if Scipio Creek is supporting its designated use for other indigenous aquatic life and wildlife. Excessive substrate imbeddedness in the Thornapple River above the former Nashville Dam is still present and suggests that this segment of the river has been impacted by loading from upstream sources. Scipio Creek itself is fairly inaccessible but well buffered along most of the main stem area, with cobble substrate and woody debris present at the Vermontville Highway crossing. There are several brownfield sites in the subwatershed, clustered in Vermontville and Nashville. Beyond these small developed areas, the subwatershed is agricultural, with fewer maintained drains than most similar subwatersheds. Buffers along streams are marginal at best. Small livestock pastures permit access to streams contributing nutrients and sediment to the system. Older rural

residential units have an increased likelihood of failed septic systems or illicit sewer connections carrying untreated sewage into the waterways.

Recommendations: Improvement in the Scipio Creek subwatershed should include reduced tillage and improved filter strips, as well as livestock access restriction. Areas of road and channel erosion need to be addressed with stabilization practices. Repair of failing septic systems may reduce the levels of *E. coli* in the subwatershed. Where there is private landowner support, especially in priority areas designated in Figure 5.11.A, wetland restoration should be undertaken to improve water storage and quality and increase habitat. Opportunites should be taken to close abandoned wells and remove unused fuel storage tanks to protect from chemical contamination of the ground and surface waters.

Protection: Because the creek, river and wetlands are largely naturalized with significant buffers, efforts should be made to protect these areas through conservation easements.

Scipio Creek Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant
1	B19 North	Unnamed tributary	Reduced till	Filter strip	Nutrients, Sediment
2	A8	Scipio Creek	Reduced till	Filter strip	Nutrients, Sediment
3	B3	Unnamed tributary	Stream stabilization	Fencing	Sediment, Nutrients
4	B20	Unnamed tributary	Reduced till	Filter strip	Nutrients, Sediment
5	A4	Scipio Creek	Reduced till	Filter strip	Nutrients, Sediment
6	A9	Unnamed tributary	Reduced till	Filter strip	Nutrients, Sediment
7	A7	Unnamed tributary	Reduced till	Filter strip	Nutrients, Sediment
8	B9	Unnamed tributary	Reduced till	Filter strip	Nutrients, Sediment
9	A4	Scipio Creek	Reduced till	Filter strip	Nutrients, Sediment
10	B24 South	Unnamed tributary	Reduced till	Filter strip	Nutrients, Sediment
11	B12	Unnamed tributary	Reduced till	Filter strip	Nutrients, Sediment
12	B5	Unnamed tributary	Stream stabilization	Fencing	Sediment, Nutrients
13	B21	Unnamed tributary	Filter strip		Sediment, Nutrients
14	B9	Unnamed tributary	Reduced till	Filter strip	Nutrients, Sediment
15	B10	Unnamed tributary	Stream stabilization		Sediment
16	B-D	Unnamed tributary	Grassed waterway		Sediment, Nutrients
17	3	Unnamed tributary	Road repair		Sediment
18	10	Scipio Creek	Culvert replacement		Sediment
19	TBD	All	Repair failed septic systems		*E. coli;* Nutrients
20	TBD	All	Well closure		Chemical leachate
21	TBD	All	Fuel tank removal		Chemical leachate

Prioritized Protection Areas:

An important potential conservation area is located in the central portion of Scipio Creek, where a large swath of forested floodplain and marshland is still intact. The Thornapple River between Vermontville and Nashville is also a naturalized area, protected by its lowland forest. Protecting this valuable natural resource through conservation easements will also protect water quality on this important system. Opportunities to restore wetland, floodplain or river and stream channels in these two areas should be undertaken as part of the protection effort.

Scipio Creek Protection Areas

Rank	Ref #	Waterbody	Practice	Acres	Protection Elements
1	A6	Scipio Creek	Conservation Easement	180	Wetlands, Forested floodplain
2	B6-17	Thornapple River	Conservation Easement	200	Wetlands, Foodplain
3	Up-stream Nashville	Thornapple River	Conservation Easement	80	Floodplain, Forested floodplain

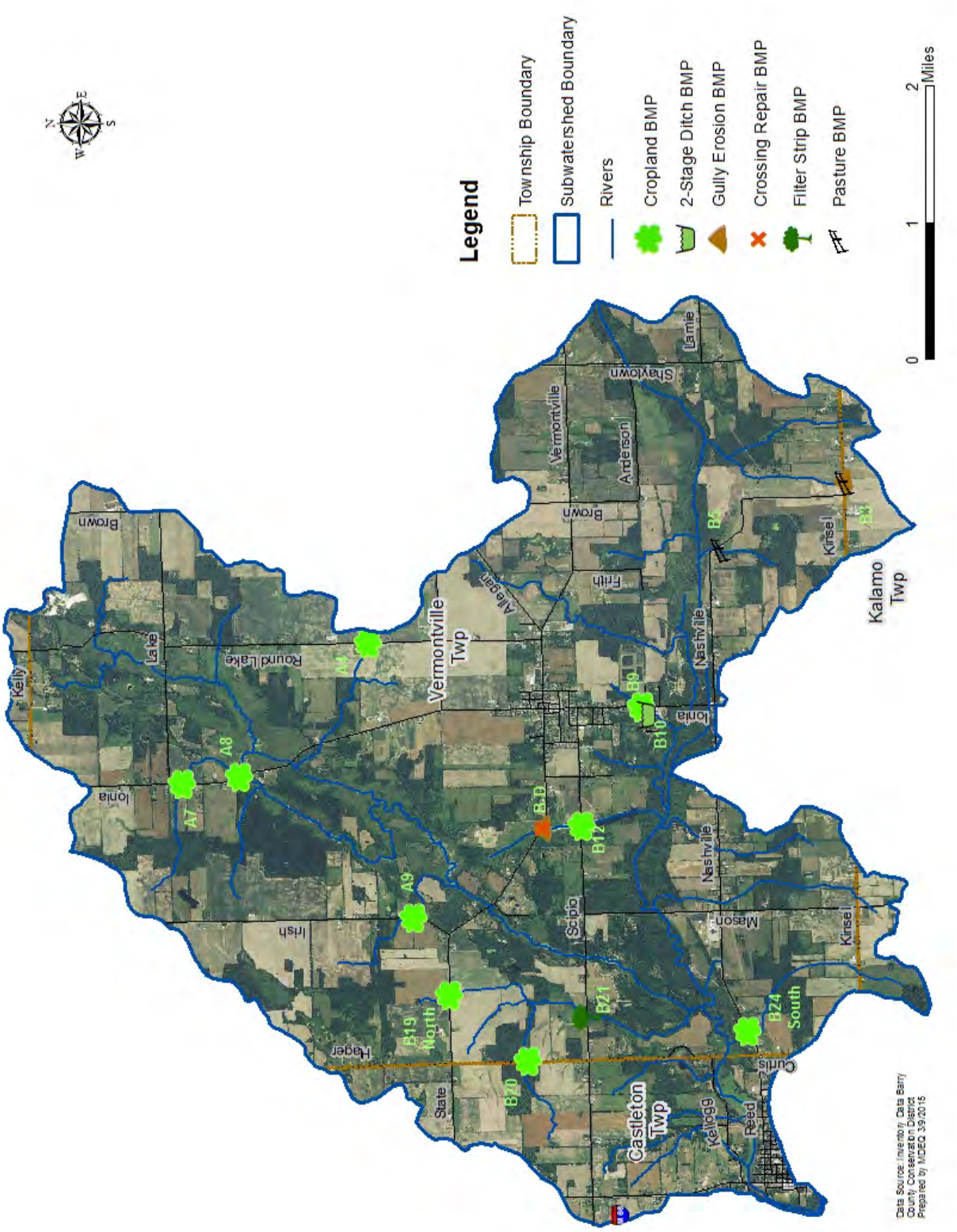


Figure 5.11.B Scipio Creek Improvement Areas

5.12 Headwaters Mud Creek **HUC: 040500070207**

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
18705	3.86%	79.24%	0.00%	12.87%	2.88%	2.23%	1.46%	1.32%	100%

The Headwaters Mud Creek subwatershed is heavily agricultural, supporting row crops, hay, dairy and livestock operations. The area is considered prime farmland if drained, and nearly all of the tributaries have been ditched to improve agricultural production. Developed areas include Sunfield Village, with residential, commercial and industrial uses, and residential areas around the lakes in the Saddlebag Lake cluster. Presettlement vegetation was diverse. Within a predominately beech-sugar maple forest, there were significant areas of mixed conifer swamp at the headwaters of Mud Creek. Smaller plots of black ash swamp and mixed conifer swamp were found at the head of Mud Creek and the Winters & Extension Drain. The two clusters of lakes, including Saubee and Saddlebag, created an extensive, likely shallow lake nearly the size of Thornapple Lake. Wetland loss is significant throughout the subwatershed, with the highest concentrations at the headwaters of Mud Creek and in the east portion of the subwatershed.

Protected Areas: There are no protected lands in the Headwaters Mud Creek subwatershed.

Special Features: No special features or listed species are cataloged in the Michigan Natural Features Inventory for this subwatershed.

Hydrologic Features:

Tributaries: Tributary of Lake Kilpatrick; Tributary of Carr Lake; Tributary of Saddlebag Lake

Drains: Winters & Extension Drain; Gardner Drain; Kahler Drain; Miller & Hynes Drain; Mud Creek

Lakes: Lake Kilpatrick; Carr; Saddlebag; Saubee; Tamarack; Looking Glass; Heart; Round; Mud-North; Mud-South

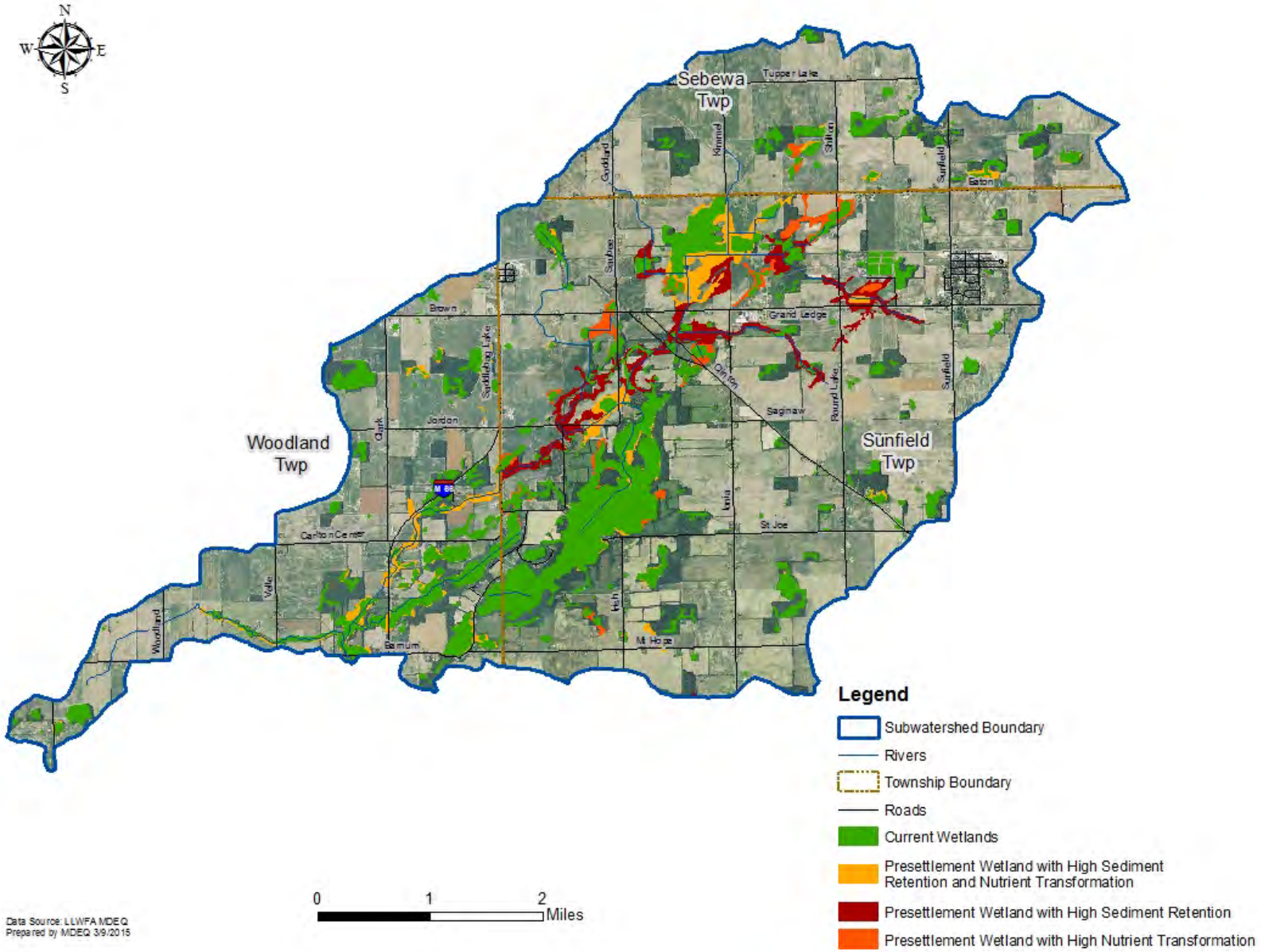
Dams: none

Water Temperature Classification: The streams and lakes in the Headwaters Mud Creek subwatershed are classified as warm.

Point Source Contributions: The following facilities are permitted by the MDEQ to discharge into the waters of the Headwaters Mud Creek subwatershed.

Facility Name	Permit Number	Latitude	Longitude	Permitted Discharge (Max)
Carbon Green Bioenergy	MI0057989	42.7678	-85.0741	Total Phosphorus .8lbs.day-Mercury 0.0000066lbs/day-Noncontact cooling water
Quality Hardwoods	MIS510318	42.7619	-84.9903	Stormwater
Sunfield WWSL	MI0024198	42.761111	-85.00222	Suspended Solids 100mg/l-7days- Phosphorus 250lbs/yr--Stormwater

Figure 5.12.A Headwaters Mud Creek Potential Wetland Restoration



Environmental Contamination Sites: The Headwaters Mud Creek subwatershed contains six active LUST sites and eleven brownfield sites. The tables below provide location data from MDEQ databases.

Active Leaking Underground Storage Tank (LUST) Sites

LUST Site Name	Latitude	Longitude	Substance Released
Sandborns Services	42.7625	-84.992387	Unknown
Equipment Programming Elec.	42.755759	-85.039755	Gasoline
Sunfield Elementary School	42.758155	-84.997067	Not Listed
M's Kountry Junction	42.75601415	-85.04919077	Gasoline
J & M Party Store	42.755522	-84.995378	Not Listed
American Bean & Grain	42.762467	-84.991487	Not Listed

Brownfield Sites

BEA Number	Address	Latitude	Longitude
200200685LA	206 Main St	42.762411	-84.992696
200100576LA	254 Main St	42.762405	-84.992359
Part 213	254 Main St	42.76247	-84.99149
Part 213	9875 W Grand Ledge Hwy	42.75576	-85.03976
Part 201	77 W Grand Ledge Hwy	42.75582	-84.99566
Part 213	10642 W Grand Ledge Hwy	42.75601	-85.04919
Part 213	206 Main St	42.7625	-84.99239
Part 213	95 W Grand Ledge Hwy	42.75552	-84.99538
Part 213	School St	42.75816	-84.99707
Part 201	211 Milburn St	42.76255	-85.07384
Part 213	7051 Saddlebag Lake Rd	42.7566	-85.07566

Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the Headwaters Mud Creek subwatershed is fully supporting assessed uses of navigation, industrial water supply and agriculture. A fishery assessment has not been completed on lakes, and additional study is needed to determine the status of this portion of Mud Creek. While the portion of the creek in the subwatershed is fully supporting other indigenous aquatic life and wildlife, lakes have not been assessed. No assessments have been made regarding total and partial body contact recreation. Like most state waters, the subwatershed is not supporting fish consumption because of the presence of PCB in the water column and in fish tissue.

Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Insufficient Information[1] Not Assessed[2,3]			
Other Indigenous Aquatic Life and Wildlife	Fully Supporting[1] Not Assessed[2,3]			
Cold Water Fishery	Not Assessed[1,3] Insufficient Information[2]			
Fish Consumption	Not Assessed[2,3]			
Fish Consumption	Not Supporting[1]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1]	PCB in Water Column	Y	2014

[1] AUID 040500070207-01 Includes Mud Creek

[2] AUID 040500070207-02 Includes Entire Saubee Lake

[3] AUID 040500070207-NAL Includes Lakes only 'assessed' for Navigation, Agriculture, and Industrial Water Supply

Biological Surveys: Surveys include macroinvertebrate community, habitat and occasionally fish community. Locations surveyed in the Headwaters Mud Creek subwatershed are represented below with their applicable community status. Survey results are common for channelized portions of the watershed, where heavy siltation, lack of woody debris and the loss of riffle-pool sequences limit habitat for fish and macroinvertebrates. Sediment loading and frequent dredging of the unstable channels severely limits the development of macroinvertebrate and fish communities.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Headwaters Mud Creek	1991	M-43 Hwy	Poor	Poor	Fair
Headwaters Mud Creek	1991	Saubee Rd	Fair	Poor	Good
Headwaters Mud Creek	2009	Barnum Rd	Acceptable	Marginal	

Impairments: The Headwaters Mud Creek subwatershed is not meeting its designated uses for fish consumption due to PCB levels. Since PCB contamination results from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB reduction.

Degradations: Based on MDEQ surveys, habitat status is poor to marginal in Mud Creek, due to the effects of channelization. This is likely also affecting the fish community. *E. coli* levels near the mouth of Mud Creek were assessed in 2013 by the Barry Conservation District, and it was concluded that lower Mud Creek was not meeting water quality standards for *E. coli*, and it is not clear if sources originate in the headwaters area. Channelization is the primary issue in this subwatershed, creating flashiness, heavy sediment loading, associated nutrient contributions and unstable banks. Also contributing to sediment loading in the subwatershed is inadequate buffering of stream channels in crop and pasture areas, as well as field erosion.

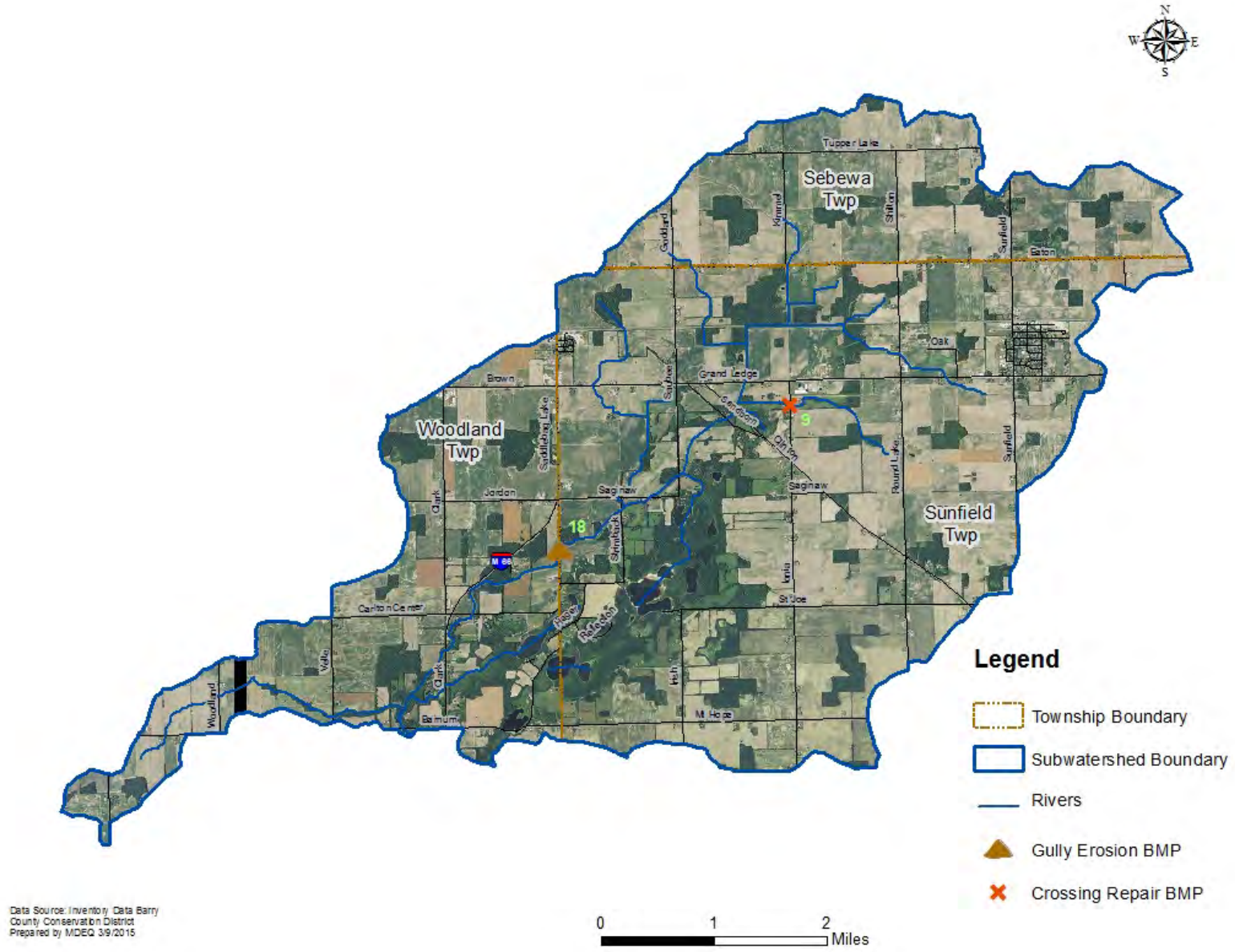
Recommendations: The portion of Mud Creek within the subwatershed requires further study to determine whether it is supporting a warm water fishery. A study is needed to evaluate *E. coli* levels in the Headwaters Mud Creek subwatershed. Improvement efforts in the Headwaters Mud Creek subwatershed should address agricultural runoff, natural channel design and aging septic systems to reduce nutrient loading, sedimentation and potential *E.coli* issues. Reduced tillage and stream buffers in cultivated fields and riparian buffers in residential areas along the lakeshores and streams are important to reduce pollutant loads. Restoration of wetlands in channelized areas, especially those prioritized in Figure 5.12.A, will also be effective in filtering nutrients. Opportunites to close abandoned wells and remove unused fuel storage tanks should be sought throughout the subwatershed.

Prioritized Improvement Areas: Prioritizing areas for improvement in the Headwaters Mud Creek subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4 and 5.

Headwaters Mud Creek Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	18	Mud Creek	Road repair		Sediment
2	9	Mud Creek	Culvert repair		Sediment
3	TBD	All	Repair failed septic systems		*E. coli*; Nutrients
4	TBD	All	Well closure		Chemical leachate
5	TBD	All	Fuel tank removal		Chemical leachate

Figure 5.12.B – Headwaters Mud Creek Improvement Areas



5.13 Mud Creek **HUC: 040500070208**

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
19911.3	2.81%	69.91%	0.00%	21.63%	3.89%	0.93%	0.16%	3.48%	100%

Agriculture is the mainstay in this area of prime farmland, with row and forage crops dominating the landscape. Two large poultry operations and one large dairy are located within the Mud Creek subwatershed. Much of the subwatershed has been drained for agricultural use, with remaining, mostly forested wetlands found along the floodplain and in a few tributary headwater areas. There are no urban centers, and even along the M-66 corridor, land use is primarily agricultural and rural residential. Large-scale drainage and wetland loss have affected water quality through heavy sediment and nutrient loading and flashiness following precipitation events.

Protected Areas: There are no protected lands within the Mud Creek subwatershed

Special Features: The Michigan Natural Features Inventory (MNFI) catalogs no listed species or natural communities in the Mud Creek subwatershed. However, the area just above Barger Road, where the Mud Creek and Thornapple River floodplains converge, is considered a high-priority Potential Conservation Area in the MNFI's 2007 report for Barry County. The remaining forested stream corridor and the mouth of Mud Creek are considered medium-priority conservation areas.

Hydrologic Features:

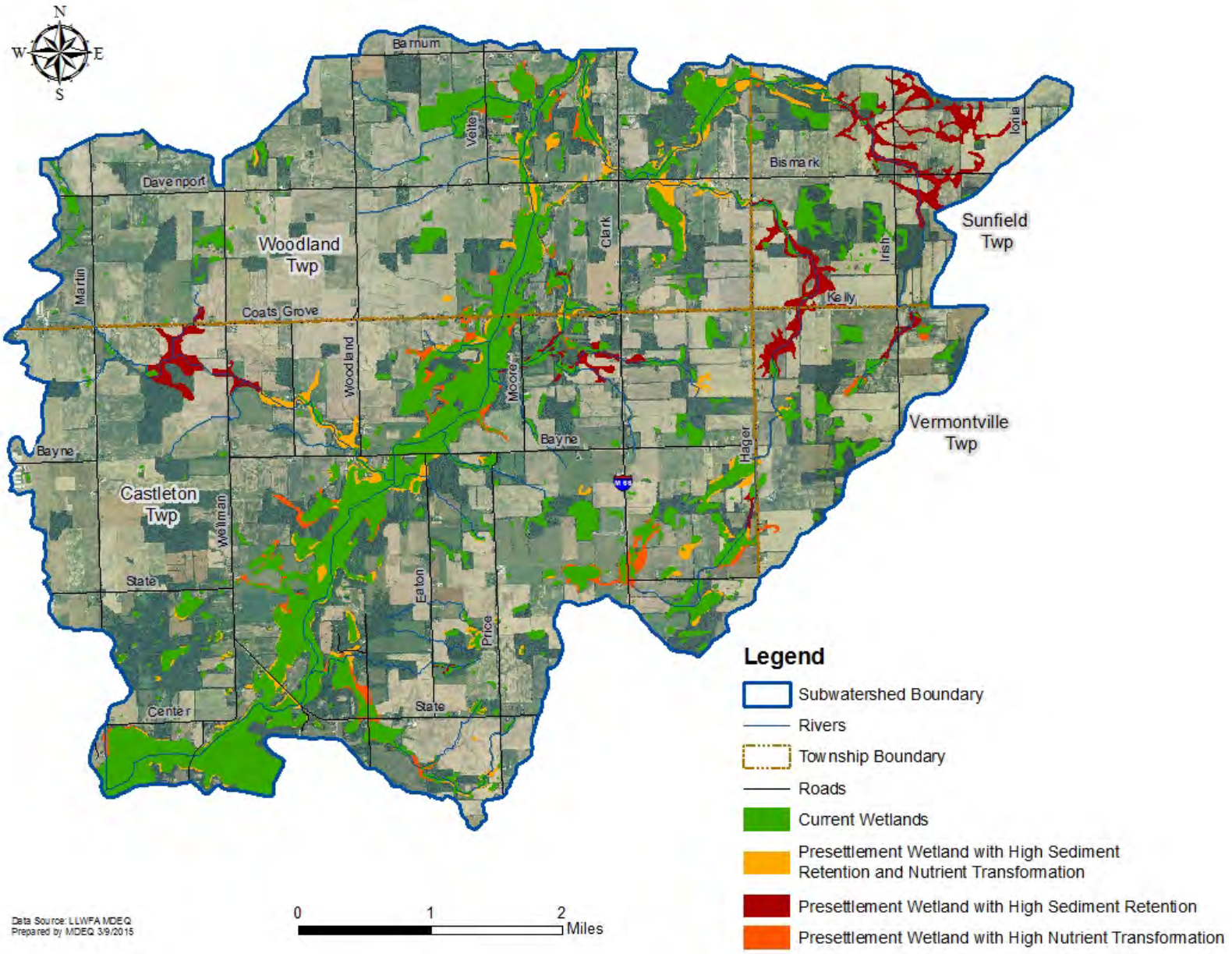
Tributaries: Hagar Creek; Gravel Brook
Drains: State Road Extension Drain; Hart Drain; Barry & Eaton Drain; Doolin Drain; Spindler Drain; Hilton Drain
Lakes: First; Second
Dams: None

Water Temperature Classification: Mud Creek and its tributaries above Coats Grove Road are classified as warm streams, while the waters below Coats Grove Road are considered warm-transitional streams.

Point Source Contributions: There are no permitted discharges into the waters of the Mud Creek subwatershed.

Environmental Contamination: There are no listed sites of environmental contamination in the Mud Creek subwatershed.

Figure 5.13.A – Mud Creek Potential Wetland Restoration



Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the Mud Creek subwatershed is fully supporting assessed uses of navigation, industrial water supply and agriculture. Mud Creek and its tributaries are not supporting their use as a warm water fishery due to other anthropogenic substrate alterations and other flow regime alterations. An assessment of total and partial body contact has not been completed. While Mud Creek and tributaries in the subwatershed are fully supporting other indigenous aquatic life and wildlife, lakes have not been assessed. Like most state waters, the subwatershed is not supporting fish consumption because of the presence of PCB in the water column and in fish tissue.

Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Supporting[1]	Other anthropogenic substrate alterations; Other flow regime alterations		
Warm Water Fishery	Not Assessed [2]			
Other Indigenous Aquatic Life and Wildlife	Fully Supporting[1] Not Assessed[2]			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Supporting[1]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1] Not Assessed[2]	PCB in Water Column	Y	2014

[1] AUID 040500070208-01 Includes Gravel Brook, Hager Creek and Mud Creek

[2]AUID 040500070208-NAL Includes Lakes only 'assessed' for Navigation, Agriculture and Industrial Water Supply

Biological Surveys: Locations surveyed in the Mud Creek subwatershed are represented below with their applicable community status. Survey results indicate degraded to highly degraded habitat and acceptable to fair macroinvertebrate scores at most locations. The poor to marginal habitat status scores are due to the effects of channelization including high levels of sediment, lack of woody debris and straightening of the stream. Degraded habitat affects the abundance and diversity of both the fish and macroinvertebrate communities.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Mud Creek	1991	Coats Grove Rd	Fair	Poor	Fair
Mud Creek	1991	Barger Rd	Fair	Poor	
Mud Creek	1998	Coats Grove Rd	Acceptable	Poor	Poor
Mud Creek	2004	Coats Grove Rd	Acceptable	Marginal	
Mud Creek	2009	Davenport Rd	Acceptable	Marginal	

Macroinvertebrate collections conducted by the Barry Conservation District under the MiCorps program from 2006-2009 show similar results. A major flood event in spring, 2009 transported sediment and increased woody debris at both sampling locations, perhaps accounting for the increase in collections at these sites.

Location	Date	Group	Group	Group	Group	Group	Group	Group	Group	Total	Score
	Sampled	1 #R	1 #C	2 #R	2 #C	3 #R	3 #C	1 Total	2 Total	3 Total	Score	Rank
Barger Rd	10-28-06	3	2	6	2	1	3	25.6	24.4	4.1	54	Excellent
Davenport Rd	10-28-06	2	0	6	2	4	1	10	24.4	5.4	40	Good
Davenport Rd	05-12-07	4	0	3	2	3	0	20	15.4	3.3	39	Good
Bayne Rd	08-08-07	4	0	3	4	3	0	20	21.8	3.3	45	Good
Davenport Rd	10-27-07	3	0	5	2	5	0	15	21.4	5.5	42	Good
Bayne Rd	10-27-07	3	0	5	1	5	0	15	18.2	5.5	39	Good
Bayne Rd	10-22-08	2	0	4	1	3	0	10	15.2	3.3	29	Fair
Davenport Rd	10-22-08	3	0	4	3	3	1	15	21.6	4.3	41	Good
Bayne Rd	11-07-09	3	1	5	3	4	1	20.3	24.6	5.4	50	Excellent
Davenport Rd	11-07-09	3	1	6	2	5	1	20.3	24.4	6.5	51	Excellent

***E.coli* Monitoring:** The Barry Conservation District conducted weekly *E. coli* monitoring at one location on Mud Creek, at the Barger Road crossing, from June to September, 2013 for the purpose of determining whether *E. coli* pollution was an issue in the watershed. Results indicate that Mud Creek is not meeting Michigan's water quality standards for both total body contact and partial body contact recreation.The table below shows results of *E. coli* data collected weekly from June 13 to September 26, 2013. Daily geometric means are compared to the daily maximum for total body contact and partial body contact recreation, with grey shading indicating that the daily maximum for total body contact or the 30-day geometric mean was exceeded. An underline indicates that both the maximum for total body contact and partial body contact were exceeded. Note that a result of 2420 per 100 ml is the limit of the analysis and should be interpreted as >2420 per 100 ml.

Date	Left	Center	Right	Duplicate	Daily Geometric Mean	30 Day Geometric Mean
6/13/2013	2420	2420	2420	2420	2420	
6/20/2013	61	84	42		60	
6/27/2013	93	135	88	125	108	
7/3/2013	111	172	144	131	138	
7/11/2013	248	276	308	326	288	245
7/18/2013	121	133	155		136	134
7/25/2013	96	124	105		108	147
8/1/2013	228	192	166		194	166
8/8/2013	530	197	125	128	202	182
8/15/2013	192	146	185	158	169	160
8/22/2013	161	99	150	124	131	154
8/29/2013	361	344	457		384	179
9/5/2013	143	194	135		155	189
9/12/2013	153	166	157		159	184
9/19/2013	228	122	102	150	144	172
9/26/2013	192	172	178	152	173	173

Impairments: The Mud Creek watershed is not meeting its designated uses for fish consumption due to PCB levels and for partial and total body contact recreation in the subwatershed. Since PCB contamination result from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB reduction. Mud Creek and its tributaries Gravel Brook and Hagar Creek are not meeting their designated use as a warm water fishery. The fishery is impaired because the subwatershed is heavily channelized, providing agricultural drainage with few areas of natural buffer. Mud Creek is heavy with sediment, exceeding two feet in depth in some locations. Flashiness due to drainage from Sunfield to Thornapple Lake has created unstable banks, and frequent dredging removes critical habitat. Assessments indicating poor habitat status provide a likely reason for the fish collection results.

Degradations: Assessments indicate poor to marginal habitat status in the subwatershed. This is largely the effect of channelization and flashiness associated with extensive agricultural drainage. *E. coli* levels found in the 2013 Barry Conservation District monitoring program indicate that high levels of *E. coli* are degrading Mud Creek's total body contact recreation and partial body contact recreation due to fecal contamination. Large livestock and poultry operations create the need for manure application in many fields. Of additional concern is the likelihood of failed septic systems or illicit sewer connections carrying untreated sewage from rural residential areas into the creek or its tributaries.

Recommendations: Restoration of the impaired fishery in the Mud Creek subwatershed should address runoff, erosion and flow regimes to reduce nutrient loading, sedimentation and bank erosion. Additional assessment is needed to determine specific locations contributing tho the impairment on Mud Creek. Such studies, undertaken in the implementation phase of this project, will provide

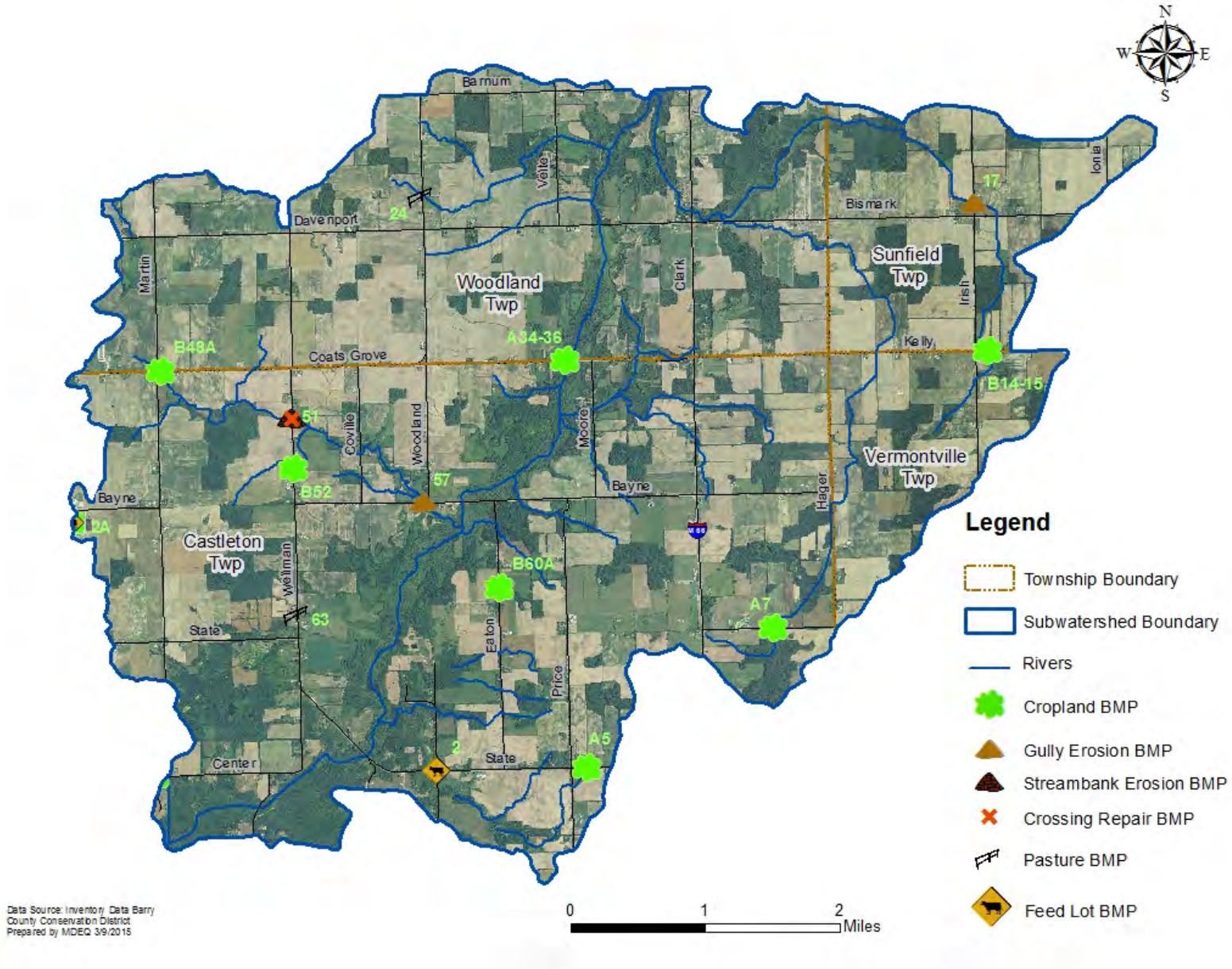
additional, high-priority sites for BMPs. Reduced tillage and filter strips in cultivated fields, restricting livestock access and buffering pastures will result in reduced pollutant loads. Restoration of wetlands, especially those prioritized in Figure 5.13.A, will also be effective in providing storage to slow the rate of flow and to filter nutrients. Stream restoration utilizing natural channel design will also improve habitat to support the fishery. Road repair and replacement of undersized culverts that promote erosion and alter stream channels will improve fish habitat. These restoration activities will also improve the degraded conditions noted above. Repair of failing septic systems, closure of abandoned wells and removal of unused fuel storage tanks will also decrease the potential of pollutants entering the ground or surface waters.

Prioritized Improvement Areas: Prioritizing areas for restoration in the Mud Creek subwatershed is based upon the needs addressed above as well as field assessment data. Additional priorities may arise from a closer assessment of the impaired reaches. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all restoration projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4 and 5.

Mud Creek Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	B48A	Gravel Brook	Reduced till	Filter strip	Nutrients, Sediment
2	B52	Gravel Brook	Reduced till	Filter strip	Nutrients, Sediment
3	B14-15	Doolin Drain	Reduced till	Filter strip	Nutrients, Sediment
4	B60A	Unnamed tributary	Reduced till	Filter strip	Nutrients, Sediment
5	TBD	Tributaries	Wetland Restoration		Nutrients, Sediment
6	A34-36	Kahler Drain	Reduced till	Filter strip	Nutrients, Sediment
7	A7	Mud Creek	Reduced till	Filter strip	Nutrients, Sediment
8	A5	Mud Creek	Reduced till	Filter strip	Nutrients, Sediment
9	24	Unnamed tributary	Stream stabilization	Fencing	Sediment, Nutrients
10	63	Hilton Drain	Stream stabilization	Fencing	Sediment, Nutrients
11	51	Gravel Brook	Stream stabilization		Sediment
12	2	Tributary	Waste Storage		Nutrients
13	57	Gravel Brook	Road repair		Sediment
14	17	Doolin Drain	Road repair		Sediment
15	51	Gravel Brook	Culvert replacement		Sediment
16	17	Doolin Drain	Culvert replacement		Sediment
17	TBD	All	Repair failed septic systems		E. coli; Nutrients
18	TBD	All	Well closure		Chemical leachate
19	TBD	All	Fuel tank removal		Chemical leachate

Figure 5.13.B – Mud Creek Improvement Areas



5.13 Subwatershed: High Bank Creek **HUC: 040500070209**

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
21809.1	3.51%	53.97%	0.00%	21.89%	7.33%	3.12%	3.26%	10.44%	100%

The upper reach of the High Bank Creek subwatershed is a mixture of residential lake communities, pastureland and row crops. Most of the central portion has been drained to facilitate agricultural use, but remnants of forested floodplain still exist. The lower portion, known for the high banks that give the stream its name, is still protected by a wide forest buffer. Development is limited to rural residential beyond the lake areas, with no industrial complexes. Presettlement vegetation types included oak-hickory forest in the upper reach, with mixed conifer and mixed hardwood swamp around the lakes and along the Mud Creek tributary. The middle and lower reaches were beech-sugar maple forest with areas of forested swamp along the floodplain. Wetland loss has been significant in agricultural areas, around the developed lakes and along the Mud Creek floodplain. Loss of tree canopy and overhanging vegetation threatens the cold water fishery in this subwatershed, as does loss of connection with groundwater recharge areas. Fish passage, limited due to undersized and perched culverts at road crossings, is being improved through a multi-year barrier removal project which includes removal of the Morgan Dam.

Protected Areas: There are no protected lands in the High Bank Creek subwatershed

Special Features: Habitat areas in the subwatershed may support the following threatened, endangered or special concern species: grasshopper sparrow, cisco or lake herring, dwarf bulrush, woodland vole, king rail and Eastern massasagua.

Hydrologic Features:

Tributaries: Mud Creek, Tributary of Fine Lake; Tributary of Culver Lake; Tributary of Long Lake
Drains: Culp Drain; Brown Drain; Lee Drain; Sanford Brook Drain
Lakes: Fine; Culver; Long; Mill; Bristol; Von Syckle; Little Mill; Mud; Little Mud; Bass; Fisher
Dams: Morgan Dam

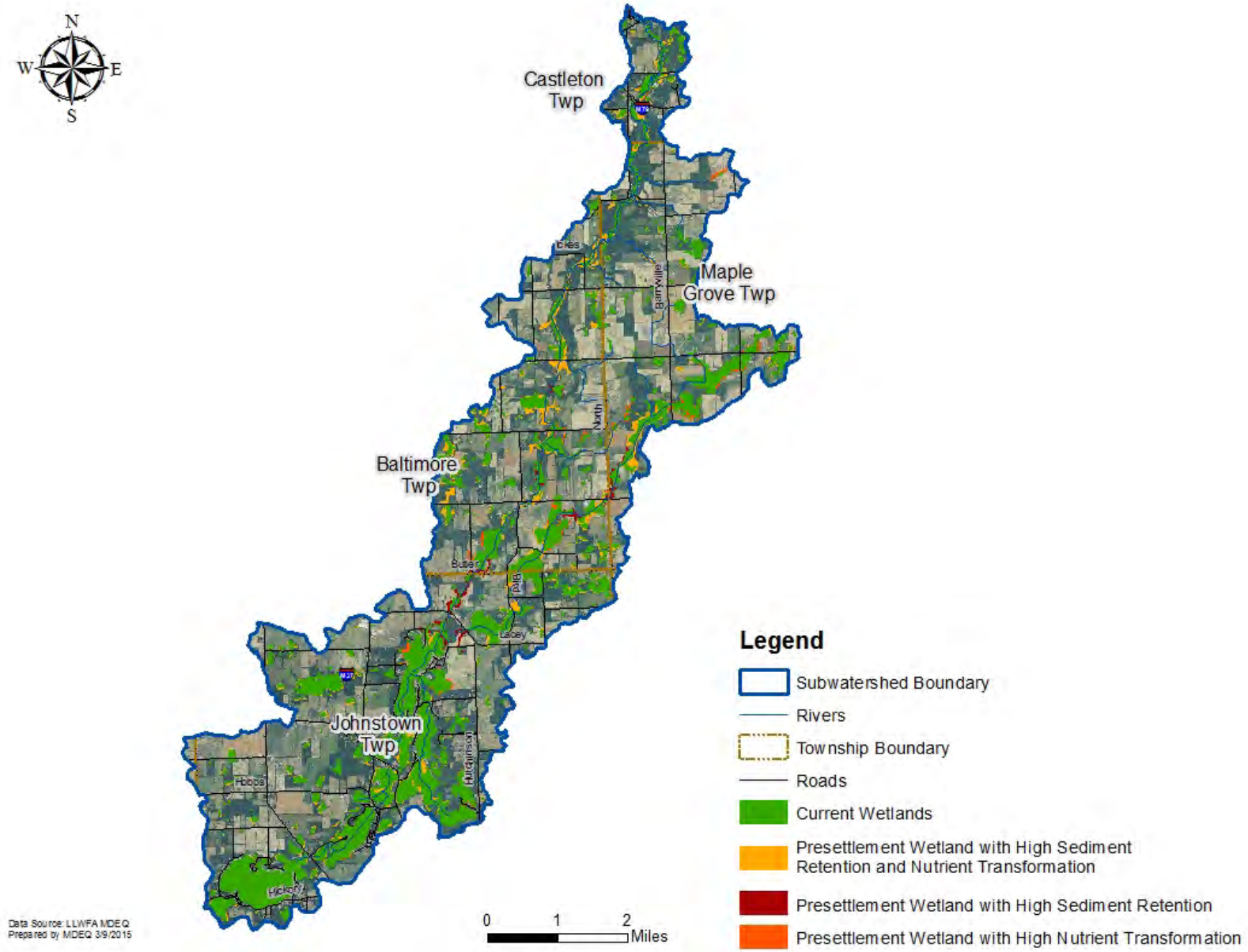
Water Temperature Classification: High Bank Creek is classified as a cold-transitional stream below Bivens Road and a warm-transitional stream from its headwaters to Bivens Road. Fine Lake is a warm lake, but the remaining lakes in the Bristol chain are classified as warm-transitional.

Point Source Contributions:

Facility Name	Permit Number	Latitude	Longitude	Permitted Discharge (Max)
Pleasant View Family Church	GW1010145	42.4986	-85.2319	N/A

Environmental Contamination: There are no listed sites of environmental contamination in the High Bank Creek subwatershed.

Figure 5.14.A – High Bank Creek Potential Wetland Restoration



Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the High Bank Creek subwatershed is supporting most designated uses that have been assessed, excepting fish consumption due to PCB and mercury in fish tissue, and PCB in the water column. Additional information is required to determine whether High Bank Creek and its tributary Mud Creek are supporting the Other Indigenous Aquatic Life and Wildlife use. The only section of the subwatershed assessed regarding its cold water fishery is fully supporting this use.

Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Insufficient Information[1,2] Fully Supporting[3,4,5,6] Not Assessed[7]			
Cold Water Fishery	Not Assessed[1,2,3,4,5,7] Fully Supporting[6]			
Fish Consumption	Not Assessed[6,7]			
Fish Consumption	Not Supporting[1,2,4]	Mercury in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1,2,3]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1,2,3]	PCB in Water Column	Y	2014

[1] AUID 040500070209-01 Includes High Bank Creek
[2] AUID 040500070209-02 Includes Mud Creek
[3] AUID 040500070209-03 Includes High Bank Creek and Thornapple River
[4] AUID 040500070209-04 Includes Fine Lake East of Hickory Corners
[5] AUID 040500070209-05 Includes Bristol Lake 2 miles South of Dowling, MI
[6] AUID 040500070209-06 Includes Long Lake NE of Hickory Corners, Johnstown Twp.
[7]AUID 040500070209-NAL Includes only 'assessed' for Navigation, Agriculture, and Industrial Water Supply

Biological Surveys: Locations surveyed in the High Bank Creek subwatershed are represented below with their applicable community status. Survey results indicate slightly degraded habitat and good macroinvertebrate scores at most locations. The marginal habitat status at Bivens Road is due to high sediment deposition, lack of sinuosity and high flashiness.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
High Bank Creek	1998	Scott Rd	Excellent	Excellent	Acceptable
High Bank Creek	1998	Thornapple Lake Rd	Excellent	Good	Acceptable
High Bank Creek	2002	Dowling Rd	Acceptable	Good	
High Bank Creek	2009	Bivens Rd	Excellent	Marginal	

Macroinvertebrate collections conducted by the Barry Conservation District under the MiCorps program from 2006-2009 indicate declining results at Lacey Road and fair to excellent results at Scott Road. These two locations are wholly different. Lacey Road in the upper reach is channelized, with over one foot of sediment covering the substrate, turbid conditions and unvegetated banks. Scott Road in the lower reach is a sinuous, cobble-bottomed stream with clear water and ample habitat. Lacey Road was dredged prior to the last collection in 2009, perhaps accounting for the decline in diversity and abundance of taxa.

Location	Date Sampled	Group 1 #R	Group 1 #C	Group 2 #R	Group 2 #C	Group 3 #R	Group 3 #C	Group 1 Total	Group 2 Total	Group 3 Total	Total Score	Score Rank
Lacey Rd	10-28-06	2	0	4	0	4	0	10	12	4.4	26	Fair
Scott Rd	10-28-06	10	0	6	3	1	0	10	9.2	1.1	20	Fair
Scott Rd	05-12-07	1	2	1	1	3	0	15.3	6.2	3.3	25	Fair
Lacey Rd	10-27-07	10	5	18	3	2	1	15.3	21.2	3.2	40	Good
Scott Rd	10-27-07	20	5	15	9	2	0	25.3	24.6	2.2	52	Excellent
Scott Rd	5-12-08	10	5	6	6	3	1	15.3	12.4	4.3	32	Fair
Lacey Rd	10-18-08	3	0	6	0	3	0	15	18	3.3	36	Good
Scott Rd	10-18-08	2	0	3	1	2	0	10	12.2	2.2	24	Fair
Lacey Rd	11-04-09	1	0	2	0	3	1	5	6	4.3	15	Poor
Scott Rd	11-04-09	1	2	2	2	3	0	15.6	12.4	3.3	31	Fair

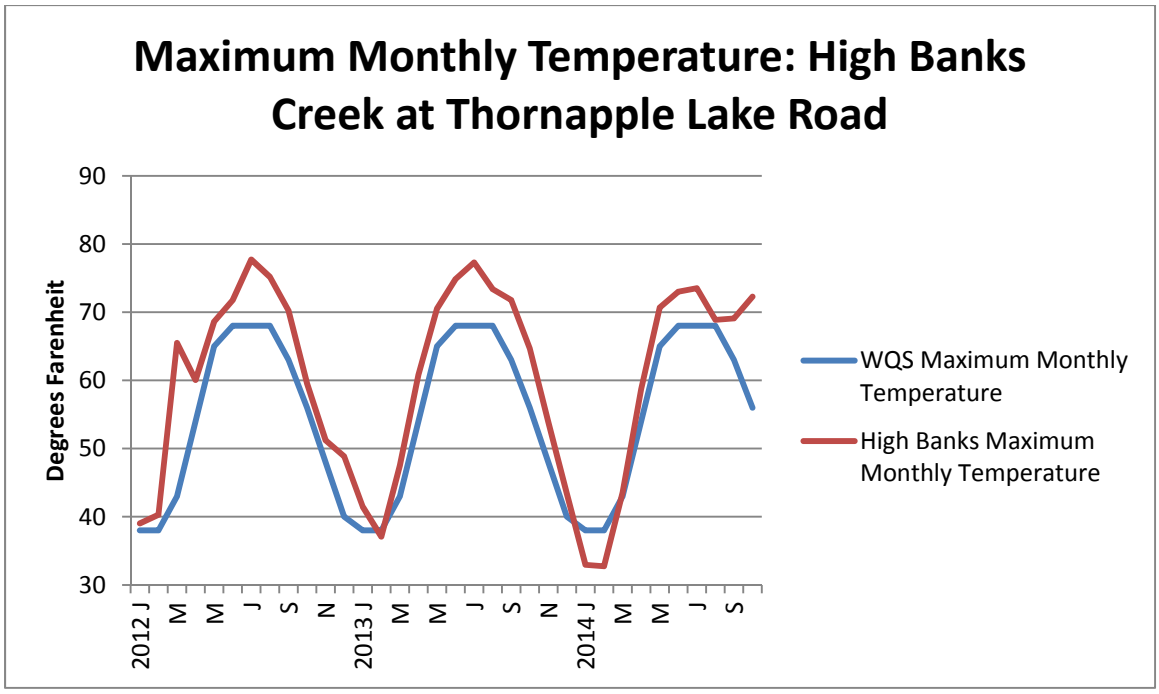
***E.coli* Monitoring:** The Barry Conservation District conducted weekly *E. coli* monitoring at one location on High Bank Creek, at the Thornapple Lake Road crossing, from June to September, 2013 for the purpose of determining whether *E. coli* pollution was an issue in the watershed. Results indicate that High Bank Creek is not meeting water quality standards for both total body contact and partial body contact recreation.

The table below shows results of *E. coli* data collected weekly from June 11 to September 24, 2013. Daily geometric means are compared to the daily maximum for total body contact and partial body contact recreation, with grey shading indicating that the daily maximum for total body contact or the 30-day geometric mean was exceeded. An underline indicates that both the maximum for total body

contact and partial body contact were exceeded. Note that a result of 2420 per 100 ml is the limit of the analysis and should be interpreted as >2420 per 100 ml.

Date	Left	Center	Right	Duplicate	Daily Geometric Mean	30 Day Geometric Mean
6/11/2013	236	308	219		252	
6/18/2013	285	411	308		330	
6/25/2013	1203	980	866	687	915	
7/2/2013	548	613	461	*damaged	537	
7/9/2013	613	649	649	579	622	506
7/16/2013	613	579	365		506	572
7/23/2013	461	365	546		451	605
7/30/2013	649	1553	770		919	590
8/6/2013	649	548	687	435	571	595
8/13/2013	2420	870	2420	870	1451	726
8/20/2013	308	326	238	291	289	628
8/27/2013	1986	1986	1413		1773	729
9/3/2013	548	272	236		328	696
9/10/2013	2420	2420	2420		2420	799
9/17/2013	435	326	365	488	399	747
9/24/2013	435	461	313		397	595

The Barry Conservation District utilized HOBO temperature loggers to monitor temperature on three cold water tributaries in the Thornapple River watershed from January 2012 through October 2014 Two loggers were placed in High Bank Creek – one at Maple Grove Road and one at Thornapple Lake Road. These locations were upstream and downstream of a bridge construction project carried out by the Barry County Road Commission and Barry Conservation District to improve fish passage. These locations were also within (Maple Grove Road) and beyond (Thornapple Lake Road) the designated cold water portion of High Bank Creek. While both loggers were retrieved, the logger at Maple Grove Road contained a corrupted file and the data was not able to be salvaged. Maximum monthly temperature data from High Banks Creek are charted below, with tables expressed in Appendix 4. Monthly temperatures for High Banks Creek at Thornapple Lake Road regularly exceed Michigan's water quality standards for cold water streams. High Banks Creek exceedences reach a maximum of nine degrees Fahrenheit (July 2012 and July 2013).



Impairments: The High Bank Creek subwatershed is not meeting its designated uses for fish consumption due to PCB and mercury levels. Since PCB and mercury contamination result from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB or mercury reduction.

Degradations: *E. coli* levels found in the 2013 Barry Conservation District monitoring program indicate that High Bank Creek's main stem is not meeting water quality standards for both total body contact recreation and partial body contact recreation due to fecal contamination. The fact that the upper reach of High Bank Creek and Mud Creek require further study to determine whether it is supporting the use of other indigenous aquatic life and wildlife is consistent with the findings of the Barry Conservation District macroinvertebrate collections in this channelized portion of the subwatershed. Livestock operations and cropland are located in the upper and middle portion of the subwatershed, in areas along the river and tributaries. Hobby and horse farms are also popular in the central portion of the subwatershed. The potential for nutrient-rich runoff, including *E. coli*, reaching the river and tributaries is high. Residential lakes at the headwaters may also contribute nutrient and other runoff, as very few lake residents utilize vegetative buffers along the shoreline. Lake residents still utilize private septic systems, which may contribute to fecal coliform levels in the creek. Roads and road crossings in the subwatershed are contributors of sediment. Gravel roads in hilly areas are prone to erosion, and a number of culverts are perched or undersized, creating erosion and stream flow issues.

Recommendations: Further study is needed to determine whether High Bank Creek and its tributary Mud Creek are meeting water quality standards for other indigenous aquatic life and wildlife. A follow-up study by the MDEQ is needed to determine whether High Bank Creek is meeting standards for total and partial body contact recreation. Sources of fecal contamination also need to be determined. Improvement efforts in the subwatershed should address agricultural and residential runoff, manure management, and aging septic systems to reduce nutrient loading, sedimentation and potential *E.coli* issues. Reduced tillage and stream buffers in cultivated fields and riparian buffers in residential areas are important to reduce pollutant loads. Road and culvert repair with further reduce sedimentation in

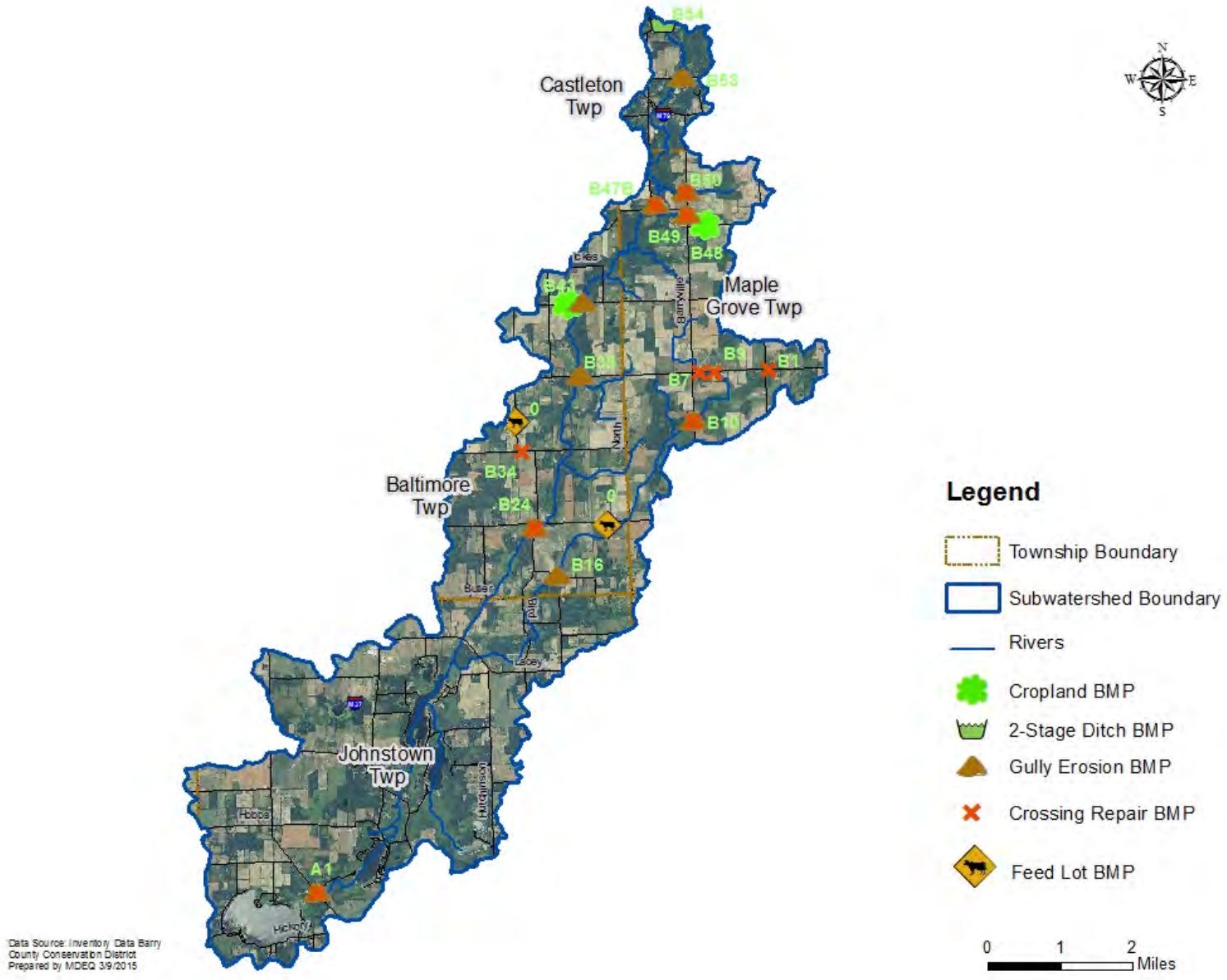
the streams. Restoration of wetlands in channelized areas, especially those prioritized in Figure 5.14.A, will also be effective in filtering nutrients. Opportunities to close abandoned wells and remove abandoned fuel storage tanks should also be sought.

Prioritized Improvement Areas: Prioritizing areas for improvement in the High Bank Creek subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4 and 5.

High Bank Creek Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	B48	High Bank Creek	Reduced till	Filter strip	Nutrients, Sediment
2	B33	High Bank Creek	Waste facility		Nutrients, Sediment
3	B-A	High Bank Creek	Waste facility		Nutrients, Sediment
4	B43	High Bank Creek	Reduced till	Filter strip	Nutrients, Sediment
5	B54	High Bank Creek	Road repair		Sediment
6	B24	High Bank Creek	Culvert repair		Sediment
7	B24	High Bank Creek	Road repair		Sediment
8	B53	High Bank Creek	Road repair		Sediment
9	A1	High Bank Creek	Culvert repair		Sediment
10	A1	High Bank Creek	Road repair		Sediment
11	B10	Mud Creek	Road repair		Sediment
12	B16	Mud Creek	Road repair		Sediment
13	B9	Mud Creek	Culvert repair		Sediment
14	B39	Tributary	Road repair		Sediment
15	B43	Tributary	Road repair		Sediment
16	B47B	Tributary	Road repair		Sediment
17	B49	Tributary	Road repair		Sediment
18	B50	Tributary	Road repair		Sediment
19	B1	Culp Drain	Culvert repair		Sediment
20	B47B	Tributary	Culvert repair		Sediment
21	B34	Tributary	Culvert repair		Sediment
22	B7	Brown Drain	Culvert repair		Sediment
23	B10	Mud Creek	Culvert repair		Sediment
24	B49	Tributary	Culvert repair		Sediment
25	B50	Tributary	Culvert repair		Sediment
26	TBD	All	Repair failed septic systems		*E. coli*; Nutrients
27	TBD	All	Well closure		Chemical leachate
28	TBD	All	Fuel tank removal		Chemical leachate

Figure 5.14.B – High Bank Creek Improvement Areas



5.15 Subwatershed: Cedar Creek **HUC: 040500070210**

Land Use/Cover:

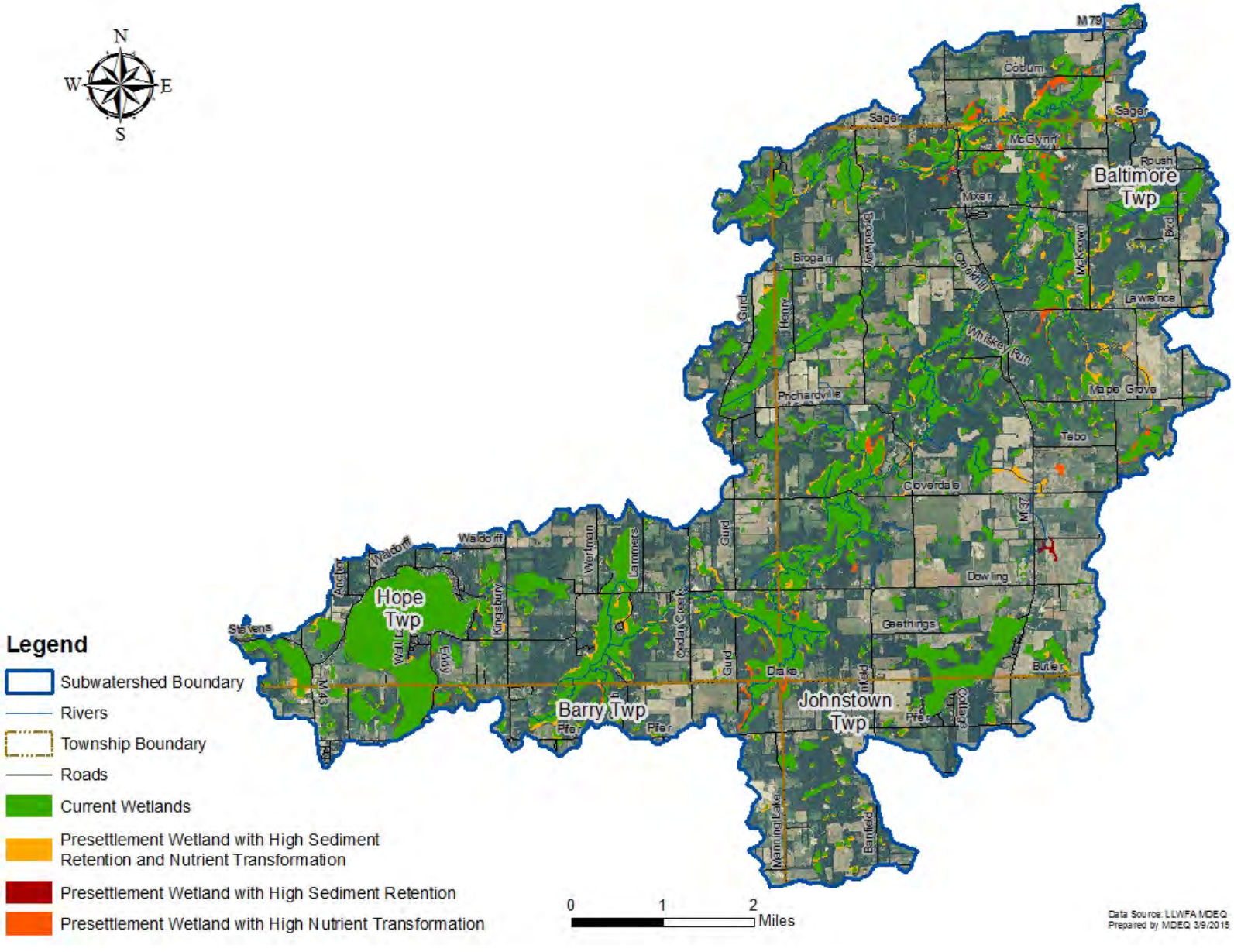
Size in Acres	Imperviou s	Agricultura l	Barre n	Forest	Rang e	Urban/Buil t	Wate r	Wetland s	Total %
29623. 1	3.52%	42.06%	0.00%	30.75 %	9.86 %	3.44%	3.84 %	9.96%	100 %

Land use in the Cedar Creek subwatershed is largely rural residential and agricultural, with row crops and hay dominating the farmed areas. Industrial development is limited to two gravel pits owned by the Barry County Road Commission, one additional pit that is privately owned and light industrial along M-37 in the Dowling area. The mainstem and tributaries of Cedar Creek are protected in many areas by forested floodplain and wetlands unsuitable for building. The north-central part of Baltimore Township, on either side of M-37, has been designated as one of the highest-ranking Potential Conservation Areas in Barry County, due to its fairly unaltered lowland forest and hardwood swamp cover. Additional lands in this subwatershed have been protected by conservation easements. The Baltimore Township Pheasant Cooperative has assisted in installing and managing over 250 acres of native prairie within the subwatershed. Wetland loss, though limited in this subwatershed, is most prevalent in the farmed regions around Dowling and along developing lakes, most notably Wall Lake. Impacts to the Cedar Creek subwatershed are relatively minimal, as development in the lowland areas and extensive wetlands has been naturally checked. Several small dams, remnants of early mills, remain – though only the Wall Lake dam – which controls lake water levels, has a modern function.

Protected Areas: Several private properties along Cedar Creek and its tributaries, as well as the nearly 600 acre Pierce Cedar Creek Institute, are protected by conservation easements through the Southwest Michigan Land Conservancy. Much of the shoreline of Clear Lake is owned by the Battle Creek School District and operated as Clear Lake Camp.

Special Features: The Michigan Natural Features Inventory identifies the following listed species in the Cedar Creek subwatershed: Blanchard's cricket frog, Blanding's turtle, Eastern box turtle, common loon, woodland vole, Eastern massasagua rattlesnake, Henslow's sparrow, Laura's snaketail, beaked agrimony, leadplant, showy orchis, and ginseng. Most of these species are believed to exist in the upper portion of the subwatershed, excepting the Blanding's turtle, massasagua and ginseng, which are found in both the lower and upper subwatershed. The lower subwatershed is also listed as potentially housing a great blue heron rookery. The mainstem of Cedar Creek in the north central portion of Baltimore Township, along M-37 between Cloverdale and Brogan roads, ranks as a high priority conservation area in the Barry County Potential Conservation Areas report prepared by the Michigan Natural Features Inventory due to the unchanged nature of its land cover and the existence of a natural vegetation community. Protection of this area is warranted, as is further study of its elements.

Figure 5.15.A – Cedar Creek Wetland Potential



Hydrologic Features:

Tributaries: Tributary of Mud Lake; Tributary of Stocking Lake; Tributary of Clear Lake; Kellie Creek; North Branch of Cedar Creek; Tributary of Mixer Lake; Tributary of Middle Lake
Drains: small agricultural drains
Lakes: Mud; Stocking; Clear; Big Cedar; Little Cedar; Shallow; Wall; Howard; Casey; Little Pine; Whitefish; Brewster; Pierce; Aurohn; Mixer; Middle (Morrice); Hall; Myers; Newton Lake; Farm Ponds
Dams: Cedar Creek Dam; North Branch Cedar Creek Dam; Topski Dam; Wall Lake Dam; Wargess Dam

Water Temperature Classification: The tributaries and mainstem of Cedar Creek are classified as cold-transitional, and Cedar Creek is a stocked, designated trout stream.

Point Source Contributions: The following facilities are permitted through the Michigan Department of Environmental Quality to discharge into the waters of the Cedar Creek subwatershed:

Facility Name	Permit Number	Latitude	Longitude	Permitted Discharge Maximum if noted:
Goldworthys Towing & Rec	GW1510122	42.52427	-85.2571	
TNR Machine Inc-Dowling	MIS510383	42.5225	-85.308333	Stormwater

Environmental Contamination Sites: The Cedar Creek subwatershed contains three active LUST sites and six brownfield sites. The tables below provide location data from MDEQ databases.

Active Leaking Underground Storage Tank (LUST) Sites

LUST Site Name	Latitude	Longitude	Substance Released
Dowling Body Shop	42.524299	-85.253899	Unknown
Dowling Cookie Store LLC	42.52262667	-85.25329	Gasoline, Gasoline
Todd- Schultz Grocery	42.566603	-85.356683	Not Listed

Brownfield Sites

BEA Number	Address	Latitude	Longitude
Part 201	10160 Bedford Rd	42.50682	-85.26566
Part 213	8942 S M-37	42.5243	-85.2539
Part 213	8975 M-37, Bedford Rd	42.52263	-85.25329
200802208GR	8975 M-37, Bedford Rd	42.52263	-85.25329
Part 213	11190 S Wall Lake Rd	42.48827	-85.41294
Part 201	S Wall Lake Rd	42.49777	-85.40737

Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the waters of the Cedar Creek subwatershed are fully supporting all assessed uses except for fish consumption due to PCB in fish tissue

and the water column. There is insufficient information to determine whether Little Cedar Lake is supporting its cold water fishery designation. Much of the subwatershed, including the mainstem, have not been assessed for their cold water fishery or other indigenous aquatic life and wildlife uses.

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Fully Supporting[1,2] Not Assessed[3,4,5,6]			
Cold Water Fishery	Not Assessed[1,2,5,6] Fully Supporting[3] Insufficient Information[4]			
Fish Consumption	Not Assessed[1,3,4,5,6]			
Fish Consumption	Not Supporting[2]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[2]	PCB in Water Column	Y	2014

[1] AUID 040500070210-02 Includes Clear Lake West of M-37 south of Dowling
[2] AUID 040500070210-03 Includes Cedar Creek, Kellie Creek and North Branch Cedar Creek
[3] AUID 040500070210-04 Includes Big Cedar Lake Entire Lake
[4] AUID 040500070210-05 Includes Little Cedar Lake Entire Lake
[5] AUID 040500070210-NA Includes Waters only 'assessed' for Navigation, Ag and Industrial
[6] AUID 040500070210-NAL Includes Lakes only 'assessed' for Navigation, Ag and Industrial

Biological Surveys: Locations surveyed in the Cedar Creek subwatershed are represented below with their applicable community status. Survey results indicate slightly degraded habitat and acceptable macroinvertebrate scores on Cedar Creek. The habitat score for Kellie Creek on Lawrence Road in 2009 is due to high sediment deposition, lack of sinuosity and lack of variation due to channelization.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Cedar Creek	1998	M-79	Excellent	Excellent	Not rated - no salmonids
Cedar Creek	2002	Dowling Rd	Acceptable	Good	
Cedar Creek	2002	Mixer Rd	Acceptable	Good	
Cedar Creek	2002	McKeown Rd	Acceptable	Good	
Cedar Creek	2009	McKeown Rd	Acceptable	Good	

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Cedar Creek	2009	Lawrence Rd	Acceptable	Marginal	

Macroinvertebrate collections conducted by the Barry Conservation District under the MiCorps program from 2006-2009 indicate good diversity amongst taxa at the McKeown Road site. This location is noted for heavy sedimentation and channel widening due to undersized culverts. There is ample woody debris and other habitat at this location.

Location	Date Sampled	Group 1 #R	Group 1 #C	Group 2 #R	Group 2 #C	Group 3 #R	Group 3 #C	Group 1 Total	Group 2 Total	Group 3 Total	Total Score	Score Rank
McKeown	10-25-06	1	2	4	1	3	0	15.6	15.2	3.3	34	Good
McKeown	05-12-07	4	0	4	1	2	0	20	15.2	2.2	37	Good
McKeown	10-27-07	1	3	5	1	1	0	20.9	18.2	1.1	40	Good
McKeown	10-18-08	1	0	4	1	1	1	5	15.2	1.1	21	Fair
McKeown	10-25-08	2	0	2	3	2	1	10	15.6	3.2	29	Fair
McKeown	11-07-09	3	0	3	3	3	0	15	18.6	3.3	37	Good

Impairments: The Cedar Creek subwatershed is not meeting its designated uses for fish consumption due to PCB levels. Since PCB contamination results from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB or mercury reduction.

Degradations: Overall, Cedar Creek and its tributaries remain fairly well buffered and most of the watershed is undrained. Due to rolling topography, gravel roads in the subwatershed contribute large amounts of sediment to the subwatershed. Streambank erosion is also an issue along Cedar Creek. Fourteen road crossings are also in need of repair or replacement due to plugging, perching or undersizing, which all contribute to erosion and unstable stream banks as well as fish passage problems.

Recommendations: The Little Cedar Lake requires further study to determine whether it is supporting a cold water fishery. The subwatershed also needs to be assessed to determine whether it is meeting partial and total body contact recreation standards. The potential for agricultural runoff should be addressed in identified areas. Road maintenance and culvert replacement will reduce sediment and habitat degradation while improving fish passage in the creek. Protection of wetland, riparian and headwater areas is critical in order to maintain the quality of this designated trout stream. Opportunities to identify and repair failed septic systems, close abandoned wells and remove unused fuel storage tanks should be pursued.

Prioritized Improvement Areas: Prioritizing areas for improvement in the Cedar Creek subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4-5. In addition to improvements which reduce pollutant loads, Cedar Creek also has 14 road-

stream crossing locations that cause erosion and impede fish passage due to plugging and misaligned and undersized culverts, also listed in Appendix 5.

Cedar Creek Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	B2	Kellie Creek	Reduced till	Filter strip	Nutrients, Sediment
2	A19	Cedar Creek	Waste storage facility		Nutrients
3	B21	Cedar Creek	Culvert replacement		Sediment
4	B21	Cedar Creek	Road repair		Sediment
5	A6	Cedar Creek	Culvert replacement		Sediment
6	B22A	Cedar Creek	Streambank stabilizaton		Sediment
7	A19	Cedar Creek	Streambank stabilization		Sediment
8	B6	Kellie Creek	Culvert replacement		Sediment
9	B6	Kellie Creek	Road repair		Sediment
10	A15	Tributary	Culvert replacement		Sediment
11	A15	Tributary	Road repair		Sediment
12	A22	Tributary	Culvert replacement		Sediment
13	A22	Tributary	Road repair		Sediment
14	A28	Tributary	Culvert replacement		Sediment
15	B14	Tributary	Culvert replacement		Sediment
16	A13	Tributary	Culvert replacement		Sediment
17	A18A	Tributary	Culvert replacement		Sediment
18	B7	Tributary	Culvert replacement		Sediment
19	B17	Tributary	Culvert replacement		Sediment
20	B8	Tributary	Culvert replacement		Sediment
21	B2	Kellie Creek	Road repair		Sediment
22	B3	Kellie Creek	Road repair		Sediment
23	B5	Tributary	Road repair		Sediment
24	B7	Tributary	Road repair		Sediment
25	B14	Tributary	Road repair		Sediment
26	B16	North Branch	Road repair		Sediment
27	A16	Cedar Creek	Road repair		Sediment
28	A17	Tributary	Road repair		Sediment
29	A19	Cedar Creek	Road repair		Sediment
30	B20	Cedar Creek	Road repair		Sediment
31	TBD	All	Repair failed septic systems		E. coli; Nutrients
32	TBD	All	Well closure		Chemical leachate
33	TBD	All	Fuel tank removal		Chemical leachate

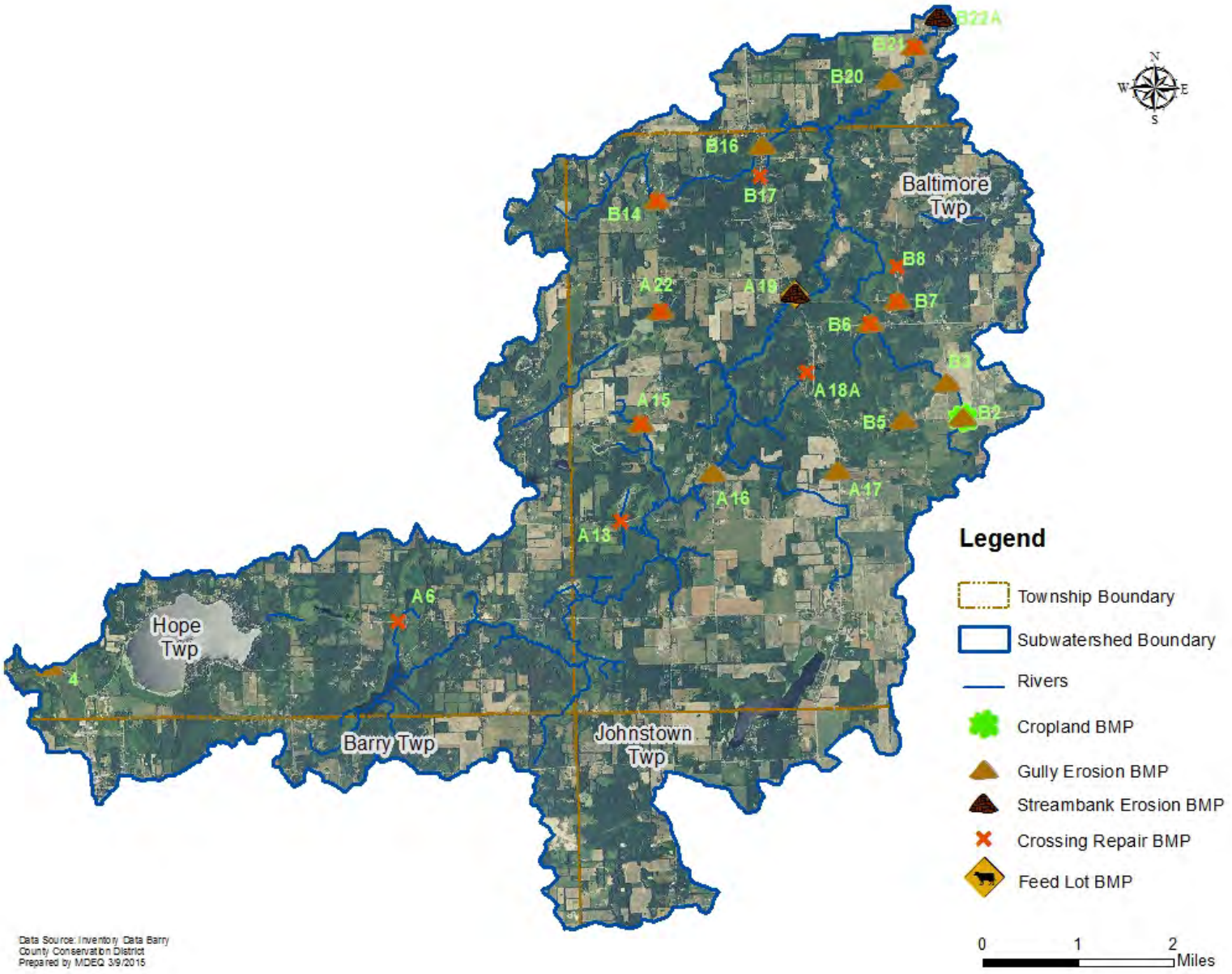
Prioritized Protection Areas: One of the highest ranking potential conservation areas in the watershed is located in the Cedar Creek subwatershed. The north-central part of Baltimore Township, on either side of M-37, is home to pristine wetlands and unimpeded floodplain and upland forest. Protecting this

valuable natural resource through conservation easements will also protect water quality on this important system. Wetland protection is also a priority in the Pritchardville area of the upper subwatershed as well as in the remaining areas of wetlands in the headwaters of Kellie Creek.

Cedar Creek Protection Areas

Rank	Ref #	Waterbody	Practice	Acres	Protection Elements
1	B18	Cedar Creek	Conservation Easement	350	Wetlands, Floodplain forest
2	A16	Cedar Creek	Conservation Easement	200	Wetlands, Associated uplands
3	B6	Kellie Creek	Conservation Easement	150	Wetlands, Floodplain forest

Figure 5.15.B – Cedar Creek Improvement Areas



5.16 Subwatershed: Thornapple Lake – Thornapple River HUC: 040500070211

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
14873	4.00%	50.28%	0.00%	27.81%	8.22%	4.63%	3.50%	5.81%	100%

Current land use in the Thornapple Lake subwatershed is agricultural (row and forage crops) and rural residential, with residential development heaviest along the north shore and Morgan communities of Thornapple Lake and the western limits of the Village of Nashville. There is some commercial development along M-79 and within the Village of Nashville, with very little industrialization. The river corridor and portions of the lake's shoreline maintain a forested wetland buffer. Agricultural lands exist along the subwatershed perimeter, with tributaries largely converted to drains. Recreational channel dredging is also found along the lake at Charlton Estates, Thornapple Lake Estates and Barry's Resort. Wetland loss is greatest at the headwaters of Buckson Creek and north of the Village of Nashville along M-66. Presettlement vegetation in the subwatershed included a large area of mixed hardwood swamp above Thornapple Lake between Mud Creek and Thornapple River - a portion of which remains undisturbed today – and a smaller area of swamp along the lake perimeter just above River Road. The majority of the subwatershed was beech-maple forest, with a lobe of oak-hickory forest extending south of the lake and river from Morgan into the Cedar Creek subwatershed to the west.

Protected Areas: County-owned Charlton Park protects nearly 300 acres of hardwoods, wetlands, swamp and shoreline along Thornapple Lake.

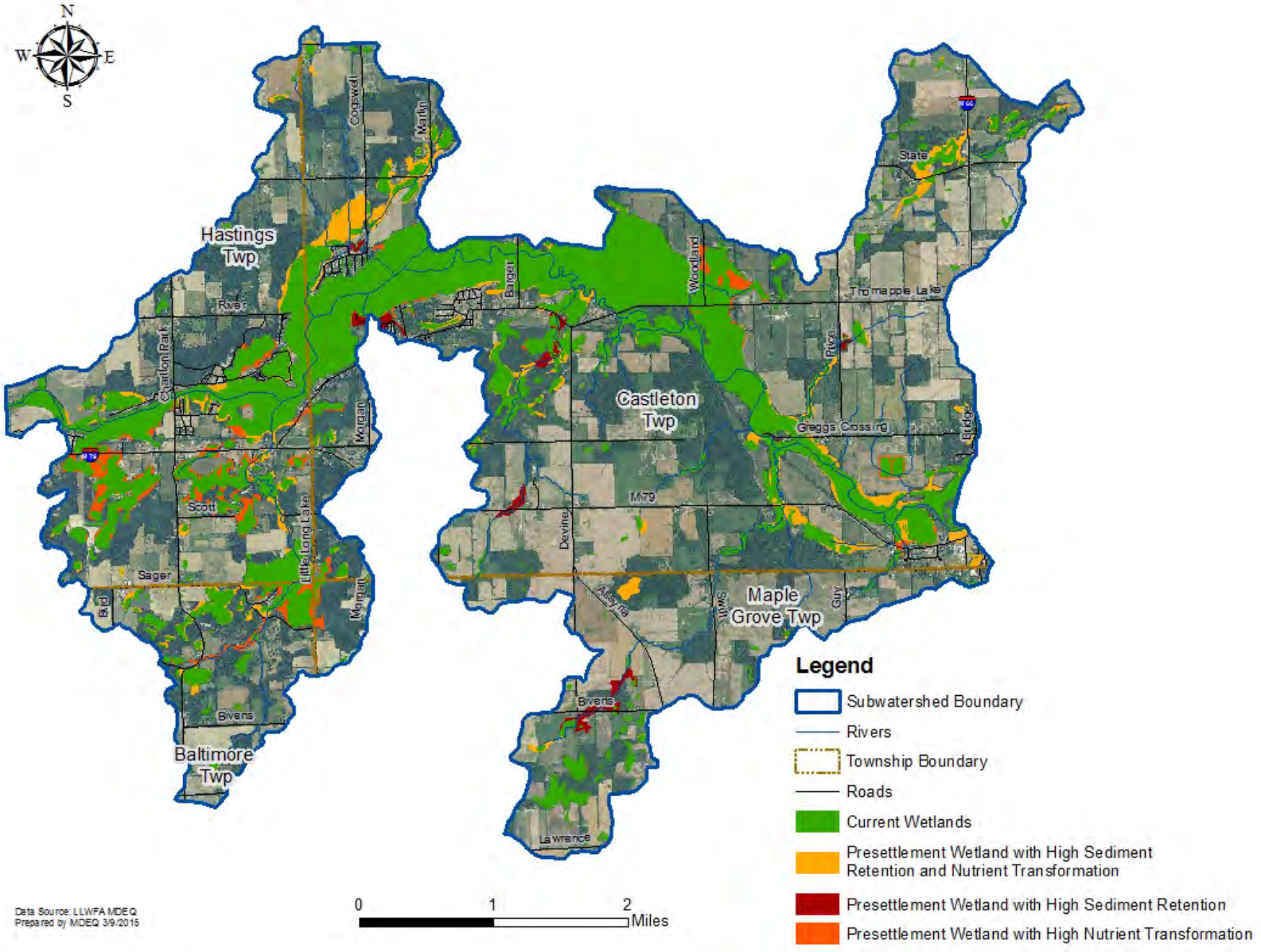
Special Features: The Michigan Natural Features Inventory identifies the following listed species in the Thornapple Lake subwatershed: Blanchard's cricket frog, spotted turtle, Eastern box turtle, and elktoe – a mussel species. The Barry County Potential Conservation Areas report by Michigan Natural Features Inventory ranks the area of mixed hardwood swamp above Thornapple Lake as high priority for conservation.

Hydrologic Features:

Tributaries: Buckson Creek; Tributary below Gregory & Ellison Drain;
Drains: State Road & Extension Drain; Northrup Drain; Ostroth Drain; Paustle Drain; Gregory & Ellison Drain; Crouch & McIntyre Drain; Thornapple River #1 Drain; White Ditch
Lakes: Thornapple; Ellison; Little Long; Gregory Lake
Dams: None
Other: USGS Gage Station #04117500 – Thornapple River near Hastings

Water Temperature Classification: The waters of the Thornapple River and tributaries above Thornapple Lake are classified as warm-transitional, with the lake and river below it considered warm. Buckson Creek, a small tributary which enters the river near Greggs Crossing, is a designated trout stream, though it is not stocked by the DNR because there is no public access.

Figure 5.16.A – Thornapple Lake Wetland Restoration Poteitial



Point Source Contributions: The following facilities are permitted to discharge into the waters of the Thornapple Lake subwatershed:

Facility Name	Permit Number	Latitude	Longitude	Permitted Discharge (Max)
Camp Thornapple	GW1510111	42.61973	-85.18083	Lagoon
Nashville WWTP	MI0020079	42.603888	-85.103888	Lagoon
Thornapple Lake Estates	M00542	42.62696	-85.171	

Active Leaking Underground Storage Tank Sites

LUST Site Name	Latitude	Longitude	Substance Released
Shell Speed-mart	42.602379	-85.093306	Gasoline, Gasoline, Kerosene, Gasoline, Diesel

Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the Thornapple Lake subwatershed is fully supporting assessed uses of navigation, industrial water supply and agriculture. Additional information is needed to determine whether Thornapple Lake is supporting its designated uses as a warm water fishery and for other indigenous aquatic life and wildlife; however, the Thornapple River within this subwatershed is fully supporting both of these uses. No areas have been assessed for total or partial body contact recreation. Like most state waters, the subwatershed is not supporting fish consumption because of the presence of PCB in the water column and both mercury and PCB in fish tissue.

Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Total Body Contact Recreation	Not Assessed [1,3,4,5] Fully Supporting[2]			
Partial Body Contact Recreation	Not Assessed [1,3,4,5] Fully Supporting[2]			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Insufficient Information[1] Fully Supporting[3] Not Assessed[2,4,5]			
Other Indigenous Aquatic Life and Wildlife	Insufficient Information[1] Not Assessed[2,3,4,5]			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Assessed[2,4,5]			
Fish Consumption	Not Supporting[1]	Mercury in Fish Tissue	Y	2014

Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Fish Consumption	Not Supporting[3]	PCB in Water Column PCB in Fish Tissue	Y	2014

[1] AUID 040500070211-01 Includes Thornapple Lake SE of Hastings
[2] AUID 040500070211-02 Includes Thornapple Lake, Charlton Park Beach
[3] AUID 040500070211-03 Includes Thornapple River
[4] AUID 040500070211-04 Includes Long Lake West of Nashville, south of Thornapple Lake
[5] AUID 040500070211-NA, NAL Includes Lakes and waters only 'assessed' for Navigation, Ag and Industrial

Biological Surveys: Locations surveyed in the Thornapple Lake subwatershed are represented below with their applicable community status. Survey results indicate good to excellent habitat and excellent macroinvertebrate status at most locations. The McKeown Road site, downstream of Thornapple Lake, may be affected by declining water quality in the lake, which collects sediment and nutrients from upstream. Fish collection downstream of the Nashville Wastewater Treatment Plant was minimal, with only 40 fish in the survey. The presence of redhorse species indicated that although the quantity was low, the water quality was acceptable.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Thornapple Lake	1998	d/s Nashville WWTP	Excellent	Good	Poor
Thornapple Lake	1998	McKeown Rd	Acceptable	Excellent	Acceptable
Thornapple Lake	2002	Greggs Crossing Rd	Excellent	Good	Excellent
Thornapple Lake	2004	Greggs Crossing Rd	Excellent	Excellent	

***E.coli* Monitoring:** The Barry Conservation District conducted weekly *E. coli* monitoring at two locations on the Thornapple River at Thornapple Lake: Barger Road, above the lake, and McKeown Road, below the lake. Monitoring continued from June to September, 2013 for the purpose of determining whether *E. coli* pollution was an issue in the watershed. Results indicate that the Thornapple River at Barger Road is not meeting Michigan's standards for both total body contact and partial body contact recreation, but the river is supporting both of these designated uses at McKeown Road, according to Michigan's Water Quality Standards (WQS). The table below shows results of *E. coli* data collected weekly from June 13 to September 26, 2013. Daily geometric means are compared to the daily maximum for total body contact and partial body contact recreation, with grey shading indicating that the daily maximum for total body contact or the 30-day geometric mean was exceeded. An underline indicates that both the maximum for total body contact and partial body contact were exceeded. Note that a result of 2420 per 100 ml is the limit of the analysis and should be interpreted as >2420 per 100 ml.

Thornapple River at Barger Road

Date	Left	Center	Right	Duplicate	Daily Geometric Mean	30 Day Geometric Mean
6/13/2013	2420	2420	2420	2420	2420	
6/20/2013	34	46	52	86	51	
6/27/2013	86	93	61		79	
7/3/2013	140	115	194		146	
7/11/2013	345	308	345		332	229
7/18/2013	194	166	135	238	179	124
7/25/2013	131	109	108	127	118	151
8/1/2013	162	146	148	178	158	170
8/8/2013	172	185	228		194	178
8/15/2013	112	185	201		161	158
8/22/2013	285	345	260		295	173
8/29/2013	457	479	416	378	450	204
9/5/2013	210	166	150	140	174	217
9/12/2013	142	166	192	167	165	219
9/19/2013	133	135	135		134	208
9/26/2013	172	184	206		187	213

Thornapple River at McKeown Road

Date	Left	Center	Right	Duplicate	Daily Geometric Mean	30 Day Geometric Mean
6/13/2013	329	630	830	690	587	
6/20/2013	20	30	35	27	27	
6/27/2013	23	21	88		35	
7/3/2013	17	20	51		26	
7/11/2013	27	21	52		31	59
7/18/2013	30	23	32	23	27	29
7/25/2013	33	26	43	19	29	29
8/1/2013	24	38	74	47	42	31
8/8/2013	42	32	77		47	34
8/15/2013	8	10	57		17	31
8/22/2013	12	26	57		26	30
8/29/2013	53	58	150	73	76	36
9/5/2013	34	42	51	32	39	39
9/10/2013	29	34	93	108	56	41
9/19/2013	15	24	67		29	40
9/26/2013	55	31	31		38	43

Impairments: The Thornapple Lake subwatershed is not meeting its designated uses for fish consumption due to PCB and mercury levels. Since PCB and mercury contamination result from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB or mercury reduction.

Degradations: *E. coli* levels found in the 2013 Barry Conservation District monitoring program indicate that within the Thornapple Lake subwatershed, the Thornapple River above the lake is not meeting water quality standards for both total body contact recreation and partial body contact recreation due to fecal contamination. The Barry-Eaton Health Department, which monitors *E.coli* levels at Charlton Park beach on Thornapple Lake has issued four beach advisories and one beach closure from 2012-13 due to *E. coli* levels above water quality standards. Aging residential septic systems that leak or drain into surface waters and agricultural manure application or livestock access are potential sources for this area. Channelization of tributaries in this subwatershed affects water quality by reducing habitat, increasing sedimentation and increasing flashiness. The subwatershed includes a diversity of land uses, from village and lake residential to agricultural to commercial-light industrial. Thornapple Lake and Thornapple River below the lake see heavy recreational use, which increases the potential for aquatic invasive species introduction.

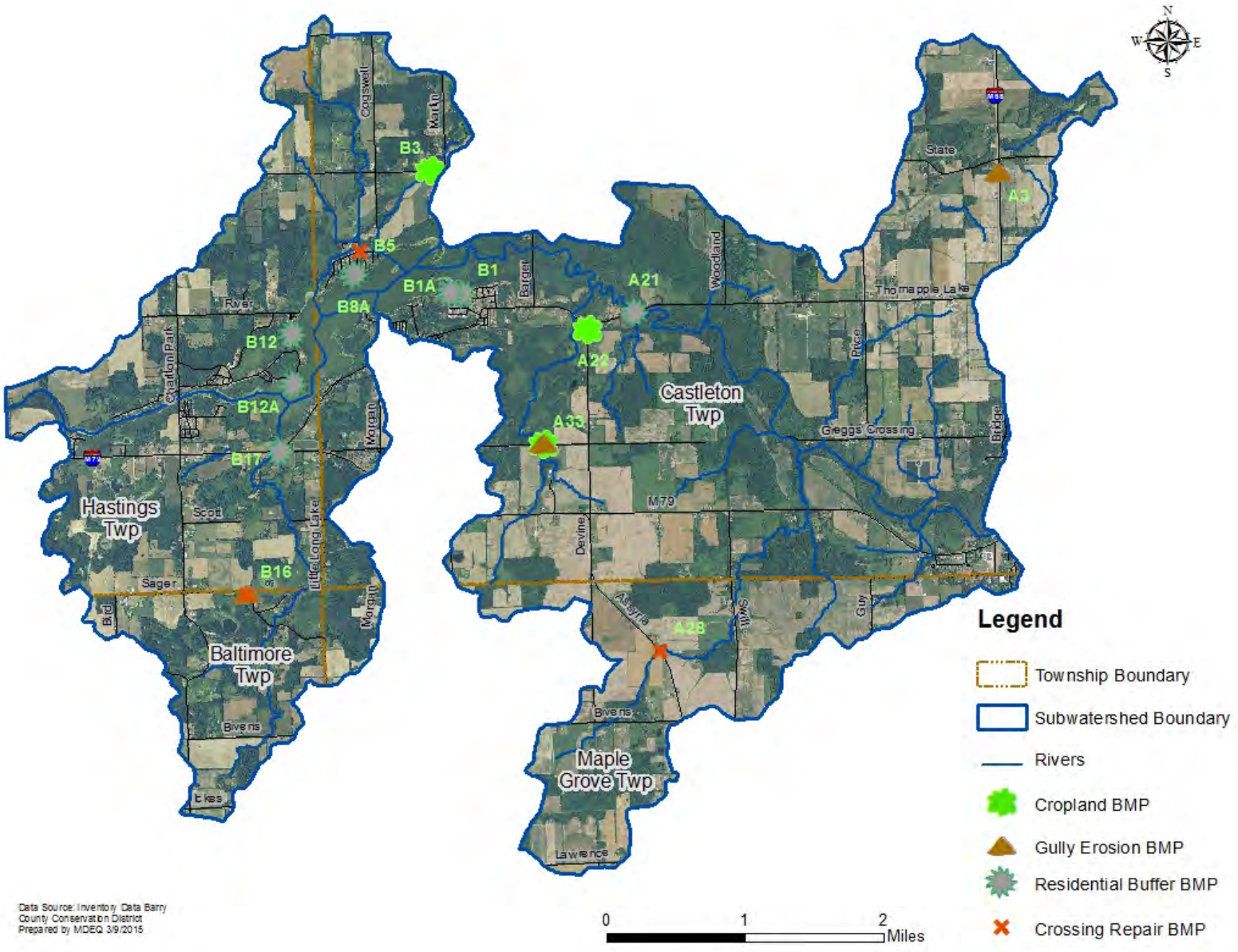
Recommendations: Thornapple Lake requires further study to determine whether it is supporting a warm water fishery. Though a 1998 study ranked the fish community in the Thornapple River downstream of the Nashville wastewater treatment plant as poor, survey notes indicate this ranking was due to the fact that only 40 fish were taken. Among them were somewhat sensitive species that indicated survivability in the river's habitat. Assessments are needed to determine whether the river and lake meet water quality standards for partial and total body contact recreation. Sources of *E. coli* in the lake and river are as yet unknown and will require further study to determine. Improvement activities should address each of these uses. Practices should include shoreline and streambank buffers for agricultural, residential and commercial landscapes to reduce runoff; reduction of livestock access to streams; increased participation in septic system inspections; plans for municipal sewer for lake residents; and road maintenance practices that reduce erosion. Opportunities to close abandoned wells and remove unused fuel storage tanks should also be pursued.

Prioritized Improvement Areas: Prioritizing areas for improvement in the Thornapple Lake subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4 and 5.

Thornapple Lake Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutants
1	A22	Northrup Drain	Reduced till	Filter strip	Nutrients, Sediment
2	B3	Unnamed tributary	Reduced till	Filter strip	Nutrients, Sediment
3	B1A	Thornapple Lake	Residential buffer		Sediment, Nutrients
4	A33	Unnamed tributary	Reduced till	Filter strip	Nutrients, Sediment
5	B1	Thornapple Lake	Residential buffer		Sediment, Nutrients
6	B17	Crouch & McIntyre Drain	Residential buffer		Sediment, Nutrients
7	B12A	Thornapple Lake	Residential buffer		Sediment, Nutrients
8	B8A	Thornapple Lake	Residential buffer		Sediment, Nutrients
9	B12	Thornapple Lake	Residential buffer		Sediment, Nutrients
10	A21	Thornapple River	Residential buffer		Sediment, Nutrients
11	A3	State Road & Extension	Road repair		Sediment
12	A33	Unnamed tributary	Road repair		Sediment
13	B15	Paustle Drain	Road repair		Sediment
14	B16	Unnamed tributary	Road repair		Sediment
15	A28	Ostroth Drain	Culvert replacement		Sediment
16	B16	Unnamed tributary	Culvert replacement		Sediment
17	B5	State Road & Extension	Culvert replacement		Sediment
18	TBD	All	Repair failed septic systems		E. coli; Nutrients
19	TBD	All	Well closure		Chemical leachate
20	TBD	All	Fuel tank removal		Chemical leachate

Figure 5.16.B – Thornapple Lake Improvement Areas



5.17 Subwatershed: Fall Creek **HUC: 040500070401**

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
15870	4.05%	36.56%	0.00%	29.34%	10.58%	6.11%	4.65%	12.76%	100%

Fall Creek subwatershed maintains large areas of forested floodplain and wetland in its headwaters region and along the mainstem, providing water quality protection. A multitude of smaller lakes are currently protected from development by large-tract landowners. Urbanized areas include the southern portion of the City of Hastings along South Broadway Street as well as residential lake development around Wilkinson, Long and No. 21 lakes. Development has drastically altered the lower reach of Fall Creek. The City of Hastings grew up at the confluence of the creek and the river, and for decades in the 19th century, three dams powered sawmills near the creek's mouth. In the 20th century, the creek was tiled between Green Street and the river and now flows beneath roads and parking lots in the downtown area. Residential development has necessitated six culverts on the creek within a one-mile stretch on the city's south side. Additionally, historic industry and aging underground storage tanks have left large tracts of brownfield areas along the creek. Though significant wetland areas still exist, wetland loss is most prevalent in the city and in areas drained for agricultural use.

Protected Areas: Approximately 130 acres of private land just southwest of the City of Hastings and 170 acres south of Shultz Road are protected through conservation easements held by the Southwest Michigan Land Conservancy.

Special Features: According to the Michigan Natural Features Inventory, the Fall Creek subwatershed may be home to Blanchard's cricket frog, Blanding's turtle, common loon, water willow, Eastern massasauga rattlesnake, and the ellipse mussel as well as one or more great blue heron rookeries.

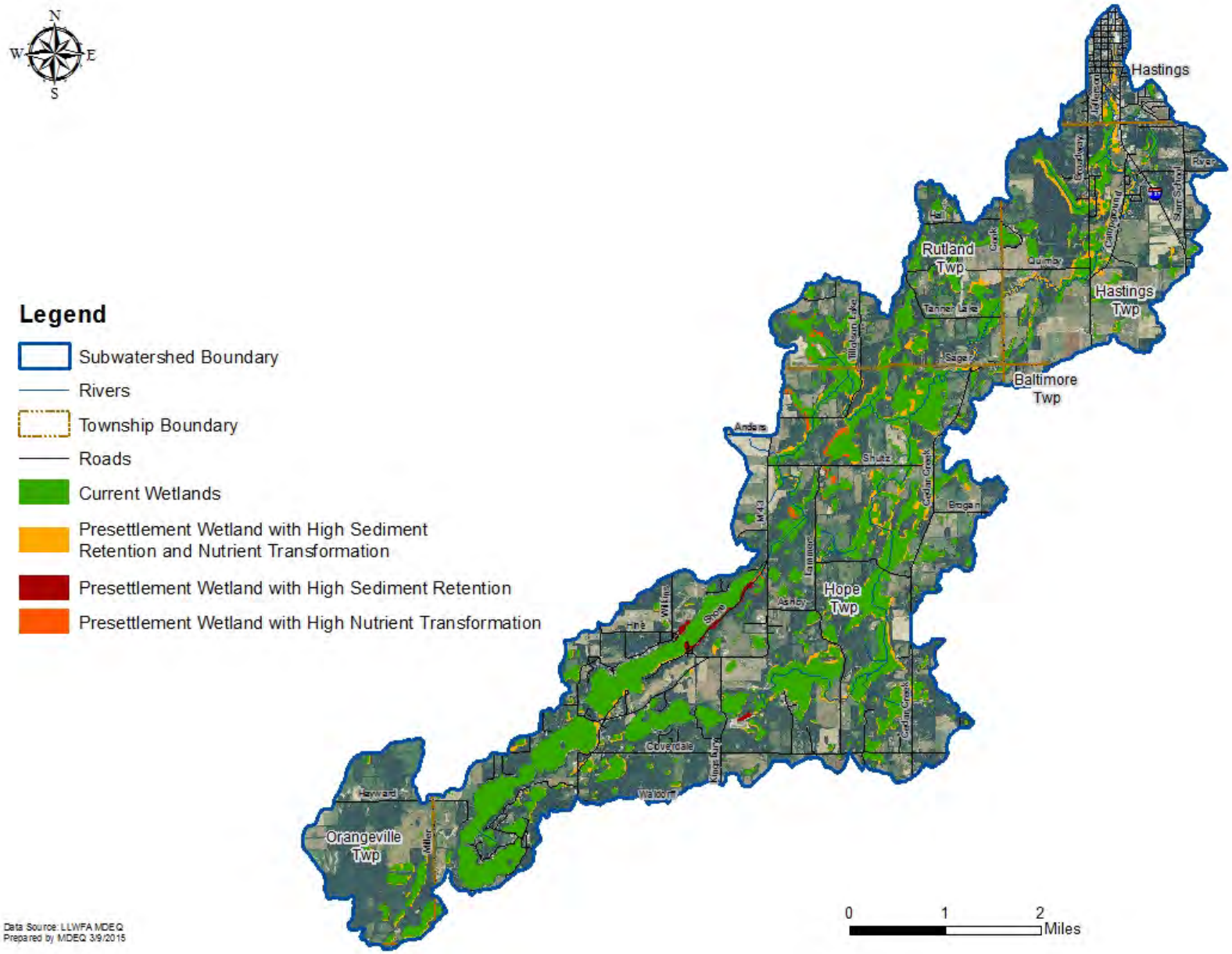
Hydrologic Features:

Tributaries: unnamed
Drains: Schultz Drain
Lakes: Jones; Wilkinson; Cloverdale; Long; Horseshoe; Tanner; Tillotson; Twin Lakes; Cox; Larabee; Bawker; Gesler; Lake #21
Dams: Long Lake Pike Rearing Pond Dam

Water Temperature Classification: Wilkinson Lake, at the headwaters of the Fall Creek system, is a warm lake, while Cloverdale and Long lakes, as well as Fall Creek, are classified as warm-transitional waters.

Point Source Contributions: There are no permitted discharges into the Fall Creek subwatershed.

Figure 5.17.A – Fall Creek Potential Wetland Restoration



Environmental Contamination Sites: The Fall Creek subwatershed contains ten active LUST sites and 20 brownfield sites. The tables below provide location data from MDEQ databases.

Active Leaking Underground Storage Tank (LUST) Sites

LUST Site Name	Latitude	Longitude	Substance Released
Hastings Building Products #1	42.645616	-85.285941	Unknown
Hastings Building Products #1	42.645616	-85.285941	Gasoline
City of Hastings	42.64767	-85.28768	Unknown
Hastings, City of (DPW Garage)	42.647915	-85.284395	Not Listed
R & J #4	42.629185	-85.283153	Kerosene
R & J #4	42.629185	-85.283153	Diesel
R & J #4	42.629185	-85.283153	Unknown
Terry Cappon Oil Co Inc.	42.62992	-85.28252	Unknown
Terry Cappon Oil Co Inc.	42.62992	-85.28252	Unknown
Shell Speed-mart	42.646222	-85.286688	Unknown

Brownfield Sites

BEA Number	Address	Latitude	Longitude
200702148GR	127 S Michigan Ave	42.648489	-85.286119
201103069GR	1420 Hanover St, M-37	42.633875	-85.28375
200802218GR	1729 S M-37 Hwy	42.625662	-85.280617
199900588GR	227 E State St	42.64899	-85.28498
200501728GR	307 E Green St	42.64598	-85.284407
200601908GR	370 N Grove St	42.503131	-85.408567
Part 213	201 E Orchard St	42.4997	-85.40532
Part 213	307 E Green St	42.6462	-85.28439
Part 213	201 S Jefferson	42.64767	-85.28768
Part 201	Broadway & State St NW	42.64921	-85.29144
Part 201	Wall Lake Rd	42.54203	-85.3901
Part 213	301 E Court St	42.64792	-85.2844
200401375GR	227 E State St	42.64873	-85.289561
Part 123	370 N Grove St	42.50222	-85.40903
Part 213	1729 S M-37 Hwy	42.62919	-85.28315
Part 201	E & W Orchard St & Brickyard Rd	42.50009	-85.40825
Part 213	227 E State St	42.64881	-85.28571
Part 213	1601 S M-37 Hwy	42.62992	-85.28252
Part 213	4998 S Wall Lake	42.5666	-85.35668
Part 213	134 E Court St	42.64762	-85.28705

Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, most designated uses assessed in the Fall Creek subwatershed are fully supported. Its status as a cold water fishery and warm water

fishery has not been assessed. As in the rest of the watershed, fish consumption is not supported due to PCB in fish tissue and the water column.

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Fully Supporting[1,2,3] Not Assessed[4]			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Assessed[2,3,4]			
Fish Consumption	Not Supporting[1]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1]	PCB in Water Column	Y	2014

[1] AUID 040500070401-01 Includes Fall Creek
[2] AUID 040500070401-02 Includes Cloverdale Lake West of Wall Lake Rd at Cloverdale
[3] AUID 040500070401-03 Includes Long Lake North of Cloverdale and Wall Lk Rd., Hope Twp
[4] AUID 040500070401-NAL Includes Lakes only 'assessed' for Navigation, Ag and Industrial Water Supply

Biological Surveys: Locations surveyed in the Fall Creek subwatershed are represented below with their applicable community status. Survey results from 2002 at Cook Road, south of Hastings, are excellent. The 2009 survey at Shriner Street in Hastings shows only marginal habitat status and less diversity in the macroinvertebrate community due to siltation covering natural substrate and to historic channel alterations.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Fall Creek	2002	Cook Rd	Excellent	Excellent	Acceptable
Fall Creek	2009	Shriner St	Acceptable	Marginal	

Macroinvertebrate collections conducted by the Barry Conservation District under the MiCorps program from 2006-2009 indicate good to excellent macroinvertebrate scores at the sampling location on Shriner Road in Hastings. Water is clear, cobble is present in some areas, and there is ample woody debris and habitat, though there is little riparian vegetation in some areas due to landscape practices.

Location	Date	Group	Group	Group	Group	Group	Group	Group	Group	Group	Total	Score
	Sampled	1 #R	1 #C	2 #R	2 #C	3 #R	3 #C	1 Total	2 Total	3 Total	Score	Rank
Camp-ground	10-28-06	2	2	7	1	4	0	20.6	24.2	4.4	49	Excellent
Shriner	10-28-06	4	0	6	1	2	1	20	21.2	3.2	44	Good
Shriner	05-12-07	3	1	6	2	3	1	20.3	24.4	4.3	49	Excellent
Shriner	05-12-08	4	0	4	3	2	1	20	21.6	3.2	45	Good
Shriner	10-22-08	4	1	4	3	3	1	25.3	21.6	4.3	51	Excellent
Shriner	11-07-09	1	3	4	3	4	0	20.4	21.6	4.4	46	Good

***E.coli* Monitoring:** The Barry Conservation District conducted weekly *E. coli* monitoring at one location on Fall Creek, at the Schriner Road crossing, from June to September, 2014 for the purpose of determining whether *E. coli* pollution was an issue in the watershed. Results indicate that Fall Creek is not meeting water quality standards for both total body contact and partial body contact recreation.

The table below shows results of *E. coli* data collected weekly from June 3 to September 16, 2014. Daily geometric means are compared to the daily maximum for total body contact and partial body contact recreation, with grey shading indicating that the daily maximum for total body contact or the 30-day geometric mean was exceeded. An underline indicates that both the maximum for total body contact and partial body contact were exceeded. Note that a result of 2420 per 100 ml is the limit of the analysis and should be interpreted as >2420 per 100 ml.

Date	Right	Center	Left	Duplicate	Daily Geometric Mean	30 Day Geometric Mean
6/3/2014	167	199	291		213	
6/10/2014	77	121	80		91	
6/17/2014	345	240	238	276	272	
6/24/2014	2420	1733	1986	2420	2119	
7/1/2014	411	276	345	365	346	362
7/8/2014	1046	866	1120		1005	469
7/15/2014	579	770	770	980	762	673
7/22/2014	435	435	291	387	382	723
7/29/2014	387	325	1986	488	591	552
8/5/2014	461	387	649		487	600
8/12/2014	457	613	411		486	532
8/19/2014	1203	312	816	689	678	518
8/26/2014	1733	1203	1733	1733	1582	711
9/2/2014	548	517	517	488	517	690
9/9/2014	238	461	344		335	648
9/16/2014	326	326	249		298	598

Impairments: The Fall Creek subwatershed is not meeting its designated uses for fish consumption due to PCB levels. Since PCB contamination results from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB reduction.

Degradations: Results of *E. coli* monitoring on Fall Creek indicate that it is not meeting water quality standards for partial and total body contact recreation. There are a large number of environmental contamination sites in the subwatershed. City stormwater inlets permit residential runoff to reach Fall Creek. Agriculture, including hobby farm operations, creates the potential for nutrient-rich runoff reaching Fall Creek.

Recommendations: Further assessment is needed to determine whether partial and total body contact recreation is impaired in Fall Creek. Assessment of the cold water fishery is also important. Efforts by the City of Hastings to improve brownfield sites in the Fall Creek subwatershed should continue. A long-range plan to daylight the mouth of the creek should also be pursued, with caution taken to assure that runoff from contaminated soils does not reach the creek. Raising awareness about chemical and fertilizer runoff is important. Improvement efforts in the Fall Creek subwatershed should focus on continued clean-up of brownfield areas, reducing stormwater impacts, and reducing nutrient and sediment loading. Riparian buffers in residential areas along the creek and residential lakes, and stream buffers in cultivated fields and pastures, are important to reduce pollutant loads. Unpaved roads in the subwatershed contributing sediment loads at crossings should be repaired to decrease runoff. Several culverts are also creating erosion due to misalignment and are in need of replacement. Restoration of the creek's channel throughout the City using natural channel design techniques will also be effective in reducing erosion and improving stream habitat. Extending municipal sewer to heavily residential lakes in the subwatershed is also recommended. Opportunities to close abandoned wells, repair failing septic systems and remove unused fuel storage tanks should also be pursued.

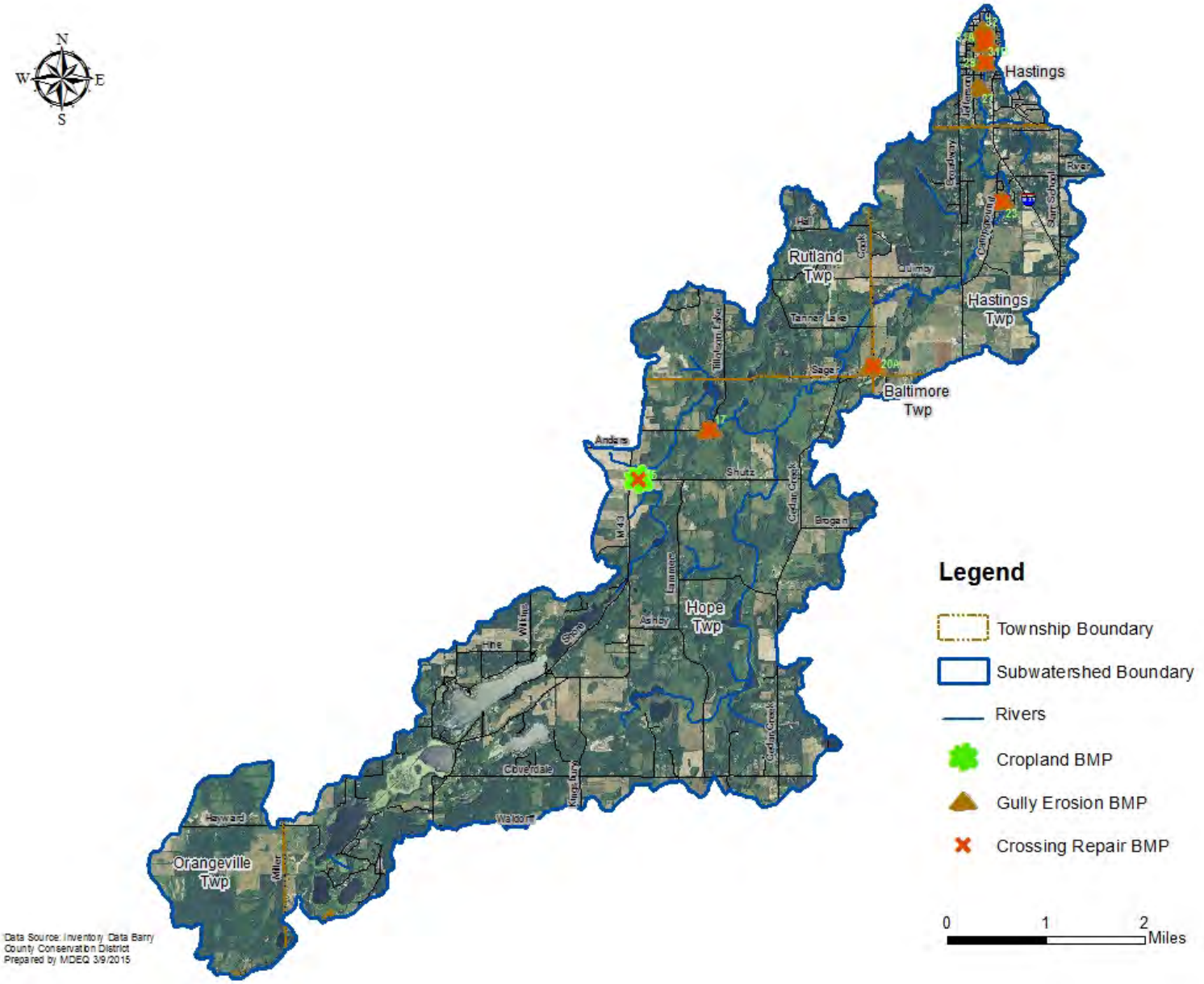
Prioritized Improvement Areas: Prioritizing areas for improvement in the Fall Creek subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4 and 5.

Fall Creek Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	15	Fall Creek	Reduced till	Filter strip	Nutrients, Sediment
2	31A	Fall Creek	Residential buffer		Sediment, Nutrients
3	31-32	Fall Creek	Stream restoration		
	23	Fall Creek	Culvert replacement		Sediment
	23	Fall Creek	Road repair		Sediment
	29	Fall Creek	Culvert replacement		Sediment
	29	Fall Creek	Road repair		Sediment
	31B	Fall Creek	Culvert replacement		Sediment

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
	31B	Fall Creek	Road repair		Sediment
	31A	Fall Creek	Culvert replacement		Sediment
	15	Fall Creek	Culvert replacement		Sediment
	17	Schultz Drain	Culvert replacement		Sediment
	17	Fall Creek	Road repair		Sediment
	20A	Tributary	Culvert replacement		Sediment
	4	Fall Creek	Road repair		Sediment
	20A	Tributary	Road repair		Sediment
	27	Fall Creek	Road repair		Sediment
	32	Fall Creek	Road repair		Sediment
6	TBD	All	Repair failed septic systems		*E. coli*; Nutrients
7	TBD	All	Well closure		Chemical leachate
8	TBD	All	Fuel tank removal		Chemical leachate

Figure 5.17.B – Fall Creek Improvement Areas



5.18 Subwatershed: Butler Creek – Thornapple River **HUC: 040500070402**

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
18104.9	7.45%	46.19%	0.00%	25.05%	11.73%	12.26%	0.23%	4.54%	100%

The Butler Creek subwatershed contains most of the City of Hastings, excepting the central southern portion, which is part of Fall Creek. The city is highly developed, with large shopping areas, several factories, and high density residential. This, coupled with the main highways of M-43 and M-37, accounts for the high percentage of impervious surface in the subwatershed. Row crops, hay and pasture dominate the eastern portion of the subwatershed outside the city limits. The western lobe includes development along the M-37 corridor, the Hastings Country Club golf course, the former River Bend golf course (now farmed), and a portion of the Hastings Airport. Hilly topography south of M-37 in the Yeckley and Tanner Lake Road area has limited development and protected forested cover. Maps of presettlement vegetation indicate beech-sugar maple forest was dominant in the eastern part of the subwatershed above the river and in the Tanner Lake Road region. The rest of the subwatershed was predominately oak-hickory forest. Areas of wetland loss include the headwaters of Pratt and Butler creeks, which have been drained for agricultural use, and the river floodplain along the River Bend property. The subwatershed has also been impacted by stormwater drain systems within the city and developed areas which replace and/or reroute streams and increase the flashiness of the river system. Future development of the M-37 corridor may impact the three cold water tributaries in this subwatershed and their fairly intact wetland systems.

Protected Areas: The City of Hastings, Barry County and Hastings Township own parks and open space along the mainstem of the river in this subwatershed, including Tyden Park, the Hastings Riverwalk linear trail, Bliss Riverfront Park, McKeown Bridge Park and the Riverside Cemetary. Those developed for park use provide river access for fishing and boating. Those that remain undeveloped consist of important forested floodplain and upland forest. The City of Hastings also owns Sweezy's Pond and Fish Hatchery Park, which are both along an unnamed tributary. City parks can improve riparian buffers to these water resources to help protect water quality.

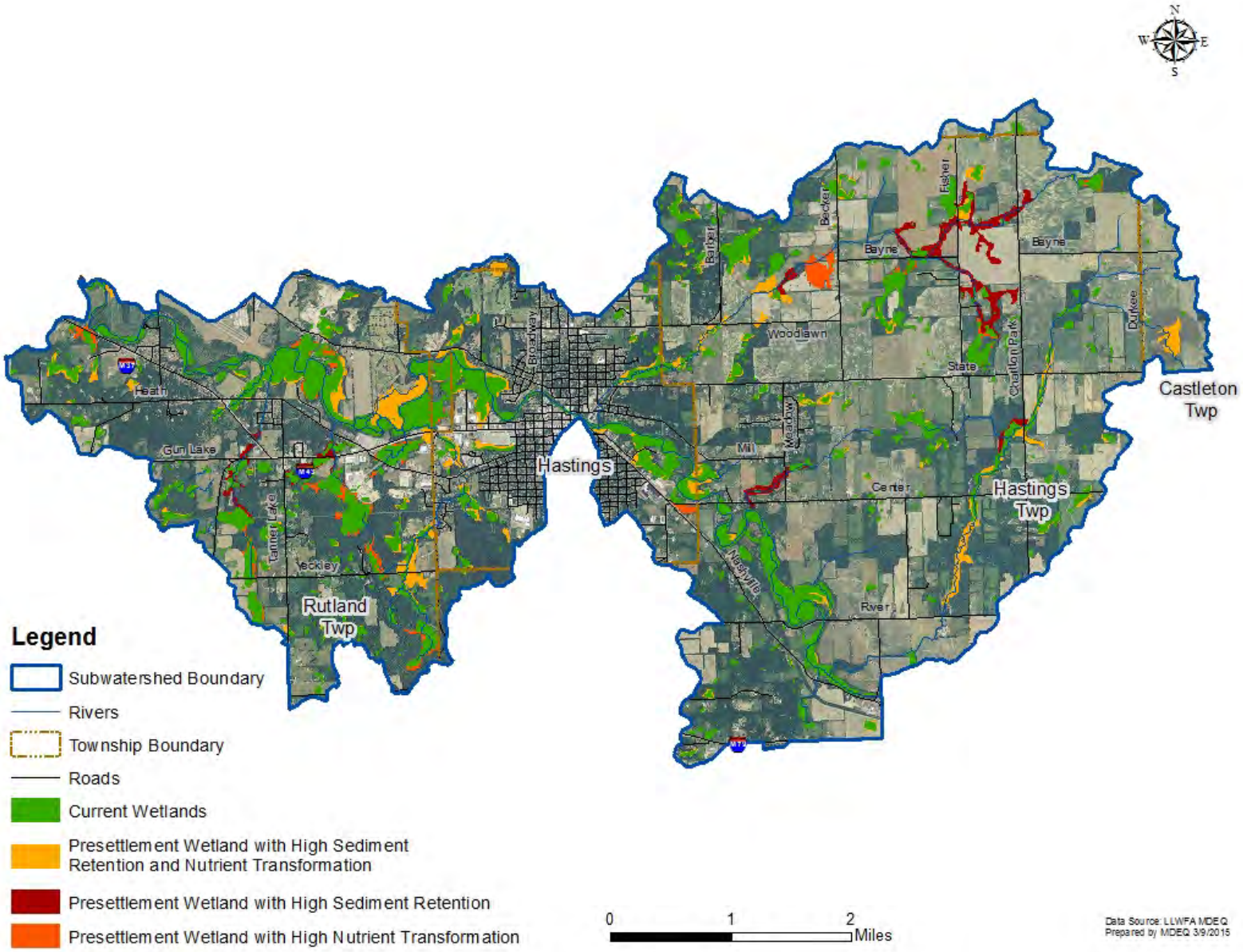
Special Features: No special features or listed species are cataloged in the Michigan Natural Features Inventory for this subwatershed.

Hydrologic Features:

Tributaries: Pratt Creek; Butler Creek; Dead Horse Creek
Drains: Holmes Drain; Barnum Drain; Ragla Drain; Clary & Whitney Ditch
Lakes: none
Dams: Hastings Hatchery Dam

Water Temperature Classification: The temperature classifications for waters of the Butler Creek include Butler Creek and the Thornapple River as warm water, Pratt Creek as a warm-transitional stream, and Dead Horse Creek and two unnamed tributaries (known as Spring Creek and Hatchery Creek) flowing northward to the river as cold streams.

Figure 5.18.A – Butler Creek Potential Wetland Restoration



Point Source Contributions: The following facilities are permitted through the Michigan Department of Environmental Quality to discharge into the waters of the Butler Creek subwatershed:

Facility Name	Permit Number	Latitude	Longitude	Permitted Discharge Maximum if noted
BCN Tech Service	MIS510553	42.6406	-85.2739	Stormwater
Flexfab	MIS510340	42.6456	-85.3442	Stormwater
Hastings City-Barry Co Air	NEC157498	42.673056	-85.354722	
Hastings Fiberglass Prdt	NEC157499	42.6425	-85.3103	
Hastings Mfg Co	MIS510338	42.650833	-85.283333	Stormwater
Padnos-Hastings	MIS510346	42.508333	-85.508333	Stormwater
Viking Corp-Hastings	MIS510451	42.65	-85.3056	Stormwater

Environmental Contamination Sites: The Butler Creek subwatershed contains twelve active LUST sites and 51 brownfield sites. The tables below provide location data from MDEQ databases.

Active Leaking Underground Storage Tank (LUST) Sites

LUST Site Name	Latitude	Longitude	Substance Released
Taco Bell/Phillips 66	42.649457	-85.300893	Gasoline
Taco Bell/Phillips 66	42.649457	-85.300893	Gasoline, Gasoline
State Employees Credit Union	42.648715	-85.286219	Used Oil
Hastings Manufacturing Co.	42.651871	-85.282075	Unknown
Hastings Manufacturing Co.	42.651871	-85.282075	Gasoline
Thorn & High St.	42.652043	-85.286	Used Oil
Caulkens Citgo	42.646197	-85.284388	Not Listed
Hastings Amoco # 0089	42.64880337	-85.59077907	Not Listed
Kelly Hasselback	42.653455	-85.256777	Not Listed
Blankenstein Pont, Olds, GMC	42.651015	-85.286412	Unknown
State & Apple	42.648812	-85.285712	Gasoline
Pennock Hospital	42.643162	-85.309109	Gasoline

Brownfield Sites

BEA Number	Address	Latitude	Longitude
200000779GR	1000 Blk E State St.	42.64379	-85.27151
200100954GR	1004 E State St.	42.64026	-85.27285
200601898GR	1004 E State St.	42.64026	-85.27285
200601899GR	1004 E State St.	42.64026	-85.27285
200802400GR	1035 E State St.	42.64026	-85.27285
200802366GR	126 N Broadway St & 301 State St	42.64921	-85.29144
200802367GR	126 N Broadway St & 301 State St	42.64921	-85.29144
201102900GR	1272 W Green St	42.643011	-85.307053
201102901GR	1272 W Green St	42.643011	-85.307053
200802217GR	1335 N Broadway St	42.660267	-85.290699
200702141GR	202 E State St	42.646913	-85.281681

BEA Number	Address	Latitude	Longitude
200802220GR	2198 W M-43 Hwy	42.645735	-85.331332
200601920GR	221 W State St	42.64873	-85.289476
200601919GR	241 W State St	42.64873	-85.28976
201203243GR	2620 W M-179 Hwy	42.645766	-85.340365
201203244GR	2620 W M-179 Hwy	42.645766	-85.340365
201303400GR	301 W State St & 126 N Broadway	42.648724	-85.290734
201303499GR	325,541,545 N Hanover St	42.652842	-85.283219
201102911GR	328 N Michigan Ave	42.650942	-85.286183
201102894GR	333 W State St	42.64921	-85.29144
201102886GR	629 W State St	42.648694	-85.296037
199600047PL	635 W State St	42.64922	-85.29582
200201041GR	725 W State St	42.648683	-85.298353
200401522GR	725 W State St	42.648683	-85.298353
Part 213	313 N Broadway St	42.65083	-85.29011
Part 213	328 N Michigan Ave	42.65102	-85.28641
Part 201	1869 N Broadway (M-43)	42.6812	-85.29419
Part 201	904 E Center	42.64666	-85.28415
Part 201	1004 E State St.	42.64026	-85.27285
199800424GR	328 N Michigan Ave	42.650942	-85.286183
199800431GR	328 N Michigan Ave	42.650942	-85.286183
200301307GR	835 W State St	42.644147	-85.276478
Part 213	1335 Broadway	42.64616	-85.33136
Part 213	301 W State Rd	42.64616	-85.29078
Part 213	429 S Michigan Ave	42.64562	-85.28594
Part 201	429 S Michigan Ave	42.64552	-85.28427
Part 201	W State Rd	42.6597	-85.30729
200601790GR	325 N Hanover St	42.65034	-85.28233
Part 213	325 N Hanover St	42.65187	-85.28208
Part 201	325 N Hanover St	42.65034	-85.28233
Part 213	135 E Green St	42.64622	-85.28669
Part 201	1000 E State St	42.64379	-85.27151
Part 213	1700 E State St	42.65346	-85.25678
200802255GR	M37-M-43	42.645608	-85.33536
200802278GR	M37-M-43	42.645608	-85.33536
Part 213	1009 W Green St	42.64316	-85.30911
Part 213	202 E State St	42.64872	-85.28622
Part 213	1021 W State St	42.64946	-85.30089
Part 213	835 W State St	42.64876	-85.29822
Part 213	Thorn and High St	42.65204	-85.286
Part 201	210 N Industrial Park Dr	42.64914	-85.30322

Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the Butler Creek subwatershed is supporting most designated uses that have been assessed, excepting fish consumption due to PCB and mercury in fish tissue, and PCB in the water column. Additional information is required to determine whether the Butler and Pratt Creek tributaries are supporting the Other Indigenous Aquatic Life and Wildlife use.

Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Fully Supporting[1,2] Not Assessed[3,4,5]			
Other Indigenous Aquatic Life and Wildlife	Fully Supporting[1,2] Insufficient Information[3,4] Not Assessed[5]			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Assessed[5]			
Fish Consumption	Not Supporting[1,2,3,4]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[3,4]	Mercury in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1,2,3,4]	PCB in Water Column	Y	2014

[1] AUID 040500070402-01 Includes Thornapple River
[2] AUID 040500070402-02 Includes Thornapple River
[3] AUID 040500070402-03 Includes Butler Creek
[4] AUID 040500070402-04 Includes Pratt Creek and Unnamed Tributary to Pratt Creek
[5] AUID 040500070402-NA and NAL Includes Waters and Lakes only 'assessed' for Navigation, Ag and Industrial Water Supply

Biological Surveys: Surveys include macroinvertebrate community, habitat and occasionally fish community. Locations surveyed in the Butler Creek subwatershed are represented below with their applicable community status. Survey results indicate a mainly healthy river in this subwatershed.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Butler Creek	1998	u/s Hastings WWTP	Excellent	Not surveyed	
Butler Creek	1998	d/s Hastings WWTP	Acceptable	Not surveyed	
Butler Creek	2002	u/s Hastings WWTP	Excellent	Good	
Butler Creek	2002	d/s Hastings WWTP	Acceptable	Good	
Butler Creek	2004	d/s Hastings WWTP	Excellent	Excellent	
Butler Creek	2004	u/s Hastings WWTP	Excellent	Good	
Butler Creek	2009	M-37	Acceptable	Good	
Butler Creek	2009	Broadway St	Excellent	Good	
Butler Creek	2009	Center Rd	Excellent	Excellent	

***E.coli* Monitoring:** The Barry Conservation District conducted weekly *E. coli* monitoring at two locations in the Butler Creek subwatershed, at the McKeown Road crossing of Pratt Creek and the Mill Street crossing of Butler Creek, from June to September, 2014 for the purpose of determining whether *E. coli* pollution was an issue in the watershed. Results indicate that Butler and Pratt Creeks are not meeting water quality standards for both total body contact and partial body contact recreation.

The table below shows results of *E. coli* data collected weekly from June 3 to September 16, 2014. Daily geometric means are compared to the daily maximum for total body contact and partial body contact recreation, with grey shading indicating that the daily maximum for total body contact or the 30-day geometric mean was exceeded. An underline indicates that both the maximum for total body contact and partial body contact were exceeded. Note that a result of 2420 per 100 ml is the limit of the analysis and should be interpreted as >2420 per 100 ml.

Pratt Creek at McKeown Road

Date	Right	Center	Left	Duplicate	Daily Geometric Mean	30 Day Geometric Mean
6/3/2014	1046	1046	816	816	924	
6/10/2014	195	156	121	149	153	
6/17/2014	435	613	501	435	491	
6/24/2014	2420	2420	2420	2420	2420	
7/1/2014	816	1733	1553		1300	716
7/8/2014	2420	2420	2420	2420	2420	877
7/15/2014	579	1300	687	579	740	1222
7/22/2014	548	687	613	1986	823	1362

Date	Right	Center	Left	Duplicate	Daily Geometric Mean	30 Day Geometric Mean
7/29/2014	1986	1986	2420		2121	1291
8/5/2014	1203	1414	1414	1414	1358	1303
8/12/2014	461	727	517	816	613	976
8/19/2014	312	2420	1120	2420	1196	1080
8/26/2014	2420	2420	2420		2420	1312
9/2/2014	1414	1120	1203		1240	1200
9/9/2014	1203	1300	1203	1553	1307	1190
9/16/2014	326	291	488	435	377	1068

Butler Creek at Mill Street

Date	Right	Center	Left	Duplicate	Daily Geometric Mean	30 Day Geometric Mean
6/3/2014	548	649	579	649	605	
6/10/2014	126	208	241	208	190	
6/17/2014	980	649	980		854	
6/24/2014	2420	2420	2420		2420	
7/1/2014	1046	1120	866	921	983	695
7/8/2014	2420	2420	2420	2420	2420	947
7/15/2014	2420	2420	2420		2420	1629
7/22/2014	1120	921	1120		1049	1689
7/29/2014	816	1120	1203	1414	1117	1451
8/5/2014	461	2420	727	816	902	1424
8/12/2014	816	816	866	921	854	1129
8/19/2014	2420	472	980		1038	981
8/26/2014	2420	2420	2420	2420	2420	1174
9/2/2014	816	727	980	1046	883	1117
9/9/2014	411	548	613	411	488	982
9/16/2014	130	238	238		195	773

Impairments: The Butler Creek subwatershed is not meeting its designated uses for fish consumption due to PCB and mercury levels. Since PCB and mercury contamination result from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB or mercury reduction.

Degradations: *E. coli* monitoring conducted in 2014 indicates that both Pratt Creek and Butler Creek are not meeting water quality standards for partial and total body contact recreation. Industry and commercial businesses have left a large number of environmental contamination sites in and around the City of Hastings. Residential and commercial development along the river in the City and its outskirts has nearly eliminated riparian buffers except for in parks and municipal properties. An extensive and

aging stormwater system in the City increases flashiness in the river and its tributaries and carries residential runoff directly to the river. The high percentage of impervious surface in the City center increases flashiness, depletes groundwater and contributes to polluted runoff. The potential for nutrient-rich residential and agricultural runoff reaching the river and tributaries is high. Unpaved roads in the subwatershed also contribute large sediment loads due to wash-outs at road-stream crossings.

Recommendations: Butler Creek, which flows into the river from the City of Hastings, and Pratt Creek, which inlets at McKeown Road, require further study to determine whether they are supporting the use of other indigenous aquatic life and wildlife. Likewise, an assessment of *E. coli* levels needs to be conducted to determine whether Pratt and Butler Creeks are meeting water quality standards for partial and total body contact recreation. Sources of fecal contamination in these creeks need to be determined. Future planning should include infiltration areas and retention basins to allow filtering and groundwater replenishment. Improvement efforts in the Butler Creek subwatershed should address agricultural and residential runoff, and aging stormwater systems to reduce nutrient and other pollutant loading, sedimentation and potential *E.coli* issues. The City should continue its practice of restoring brownfield areas in this subwatershed. Stream buffers in cultivated fields and riparian buffers in residential areas along the river and streams are important to reduce pollutant loads. Alternatives to road management which will reduce erosion and sedimentation are also important. Location and repair of failing septic systems will reduce *E. coli* levels. Closure of abandoned wells and removal of unused fuel storage tanks will reduce the potential for chemical pollutants reaching waterways.

Prioritized Improvement Areas

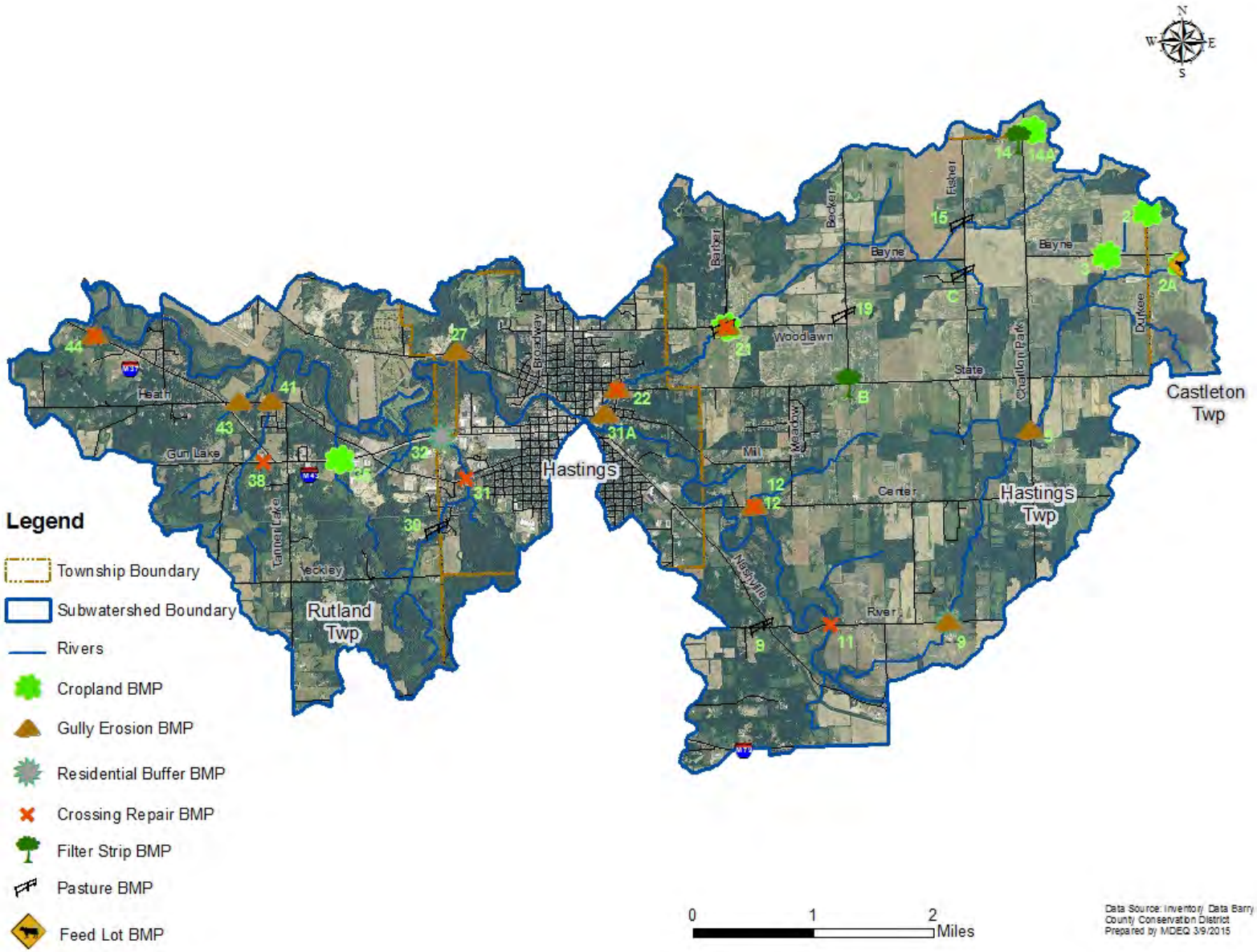
Prioritizing areas for improvement in the Butler Creek subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4 and 5. In addition to restoration projects which reduce pollutant loads, Butler Creek also has seven road-stream crossing locations that cause erosion and impede fish passage due to misaligned and undersized culverts, also listed in Appendix 4 and 5.

Butler Creek Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	2	Pratt Creek	Reduced till	Filter strip	Nutrients, Sediment
2	3	Pratt Creek	Reduced till	Filter strip	Nutrients, Sediment
3	14A	Butler Creek	Reduced till	Filter strip	Nutrients, Sediment
4	2, 2A	Pratt Creek	Waste Storage		Nutrients, Sediment
5	9	Pratt Creek	Stream stabilization	Fencing	Sediment, Nutrients
6	35	Tributary	Reduced till	Filter strip	Nutrients, Sediment
7	2A	Pratt Creek	Reduced till	Filter strip	Nutrients, Sediment
8	21	Butler Creek	Stream stabilization	Fencing	Sediment, Nutrients
9	21	Butler Creek	Reduced till	Filter strip	Sediment, Nutrients
10	19	Butler Creek	Stream stabilization	Fencing	Sediment, Nutrients
11	14	Butler Creek	Filter strip		Nutrients, Sediment

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
12	30	Butler Creek	Stream stabilization	Fencing	Sediment, Nutrients
13	C	Butler Creek	Stream stabilization	Fencing	Sediment, Nutrients
14	15	Butler Creek	Stream stabilization	Fencing	Sediment, Nutrients
15	B	Butler Creek	Filter strip		Nutrients, Sediment
16	9	Pratt Creek	Residential buffer		Sediment, Nutrients
17	32	Tributary	Residential buffer		Sediment, Nutrients
18	12	Tributary	Culvert replacement		Sediment, Fish Passage
19	22	Butler Creek	Culvert replacement		Sediment, Fish Passage
20	44	Tributary	Culvert replacement		Sediment, Fish Passage
21	11	Thornapple River	Bridge repair		Sediment, Fish Passage
22	31	Tributary	Culvert replacement		Sediment, Fish Passage
23	21	Butler Creek	Culvert replacement		Sediment, Fish Passage
24	38	Tributary	Culvert replacement		Sediment, Fish Passage
25	5	Pratt Creek	Road repair		Sediment
26	9	Pratt Creek	Road repair		Sediment
27	12	Tributary	Road repair		Sediment
28	21	Butler Creek	Road repair		Sediment
29	22	Butler Creek	Road repair		Sediment
30	23	Butler Creek	Road repair		Sediment
31	27	Tributary	Road repair		Sediment
32	41	Tributary	Road repair		Sediment
33	43	Thornapple River	Road repair		Sediment
34	44	Tributary	Road repair		Sediment
35	TBD	All	Repair failed septic systems		*E. coli*; Nutrients
36	TBD	All	Well closure		Chemical leachate
37	TBD	All	Fuel tank removal		Chemical leachate

Figure 5.18.B – Butler Creek Improvement Areas



5.19 Subwatershed: Glass Creek **HUC: 040500070403**

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
23511.1	2.36%	30.14%	0.00%	45.64%	9.86%	1.94%	2.79%	9.64%	100%

The Barry State Game Area (BSGA) covers a large portion of the Glass Creek subwatershed, contributing to the high percentage of forested acres. Row crops, hay, dairy and livestock comprise the majority of agricultural use in the subwatershed. Areas within the BSGA, as well as the Federal Edger Wildlife Habitat Protection Area, the Michigan Audubon Warner Sanctuary and the Hidden Pond Preserve, owned by the Southwest Michigan Land Conservancy (SWMLC), have been planted to tall or short grass prairie and make up a portion of the rangeland land use. The majority of the subwatershed is considered the highest-ranking of the Barry County Potential Conservation Areas, according to the Michigan Natural Features Inventory 2007 report. The forested areas in and around the BSGA are listed as an Important Bird Area (IBA) by the Audubon Society and are being managed to maintain habitat for cerulean warbler and other listed bird species. Historic alterations in drainage for agricultural purposes are being restored in some areas of the BSGA to protect and enhance a prairie fen and associated wetlands. Wetland restoration has also occurred on the SWMLC property and the Edger property. Areas of wetland loss include the Kelly and Hine drains, portions of the creek's floodplain, and developed area around Guernsey Lake. Development is mainly rural-residential, with heavier residential around several lakes in the headwaters and in the lower reaches near M-37. Lake development and riparian management practices around the lakes impact water quality within the subwatershed.

Protected Areas: Protected areas in the Glass Creek subwatershed include the BSGA, Audubon's Warner and Otis Sanctuaries, Hidden Pond Preserve and approximately 500 additional acres of private land with conservation easements through the SWMLC. The Barry State Game Area Protection Project is an ongoing partnership between conservation organizations and private landowners to expand protection of high quality waters and natural areas around the BSGA and to restore natural communities within the area.

Special Features: Due to the high percentage of protected lands in the subwatershed, a high number of Federal and State listed species are identified in the area by the Michigan Natural Features Inventory. These include:

- Blanchard's cricket frog
- Spotted turtle
- Blanding's turtle
- Eastern box turtle
- Bald eagle
- Henslow's sparrow
- Common loon
- Prairie Indian plantain
- Horsetail spike-rush
- Black-fruited spike-rush
- Scirpus-like rush
- False boneset
- Umbrella grass
- goldenseal
- Dwarf bulrush
- Tall beak-rush
- Bald-rush
- Barrens buckmoth
- Ottoe skipper
- Tamarack tree cricket
- Pugnose shiner
- Watercress snail
- Eastern massasauga

The Glass Creek subwatershed is also listed as a location of coastal plain marsh, dry-mesic southern forest and prairie fen natural communities.

Hydrologic Features:

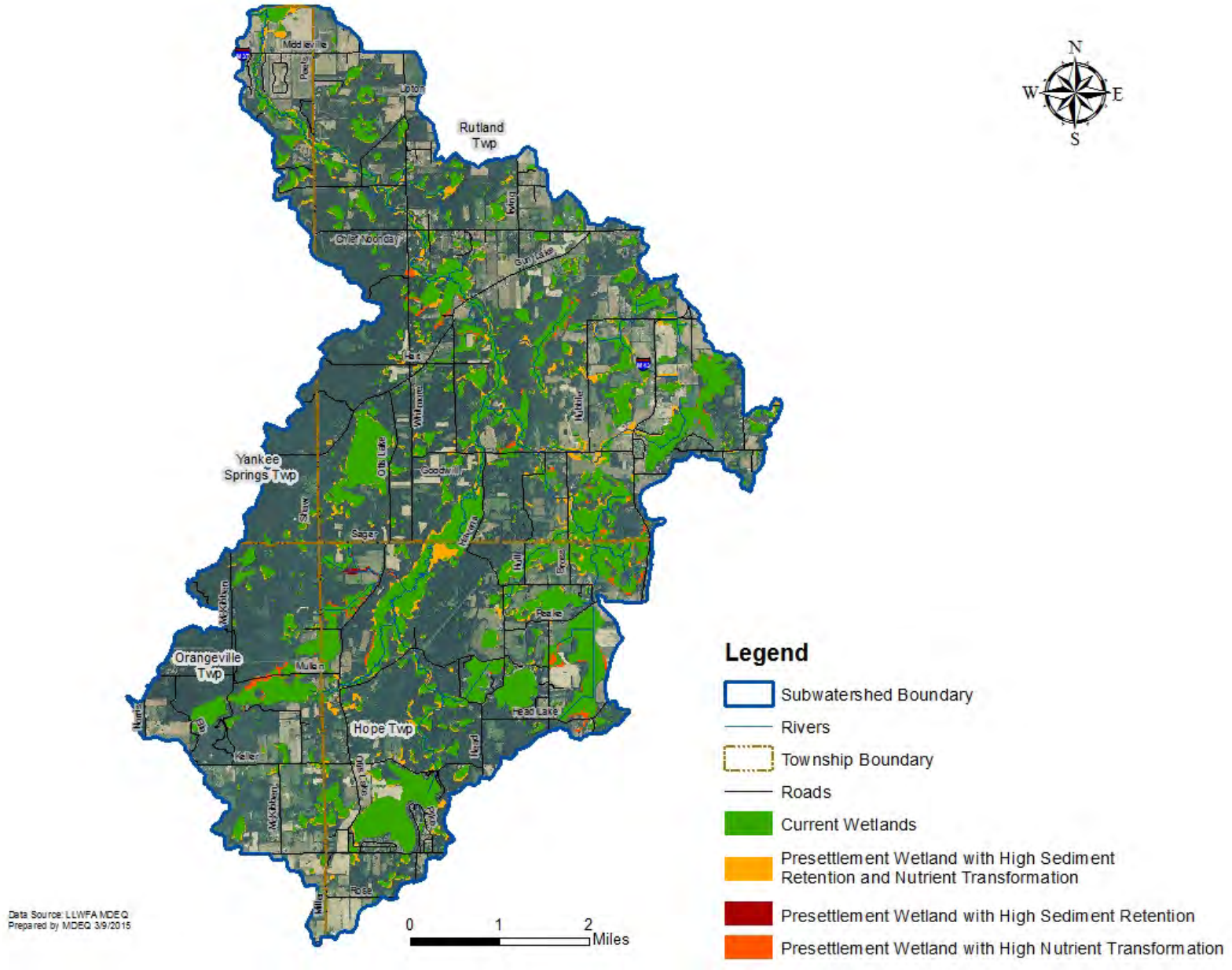
Tributaries: Tributary of Werner Lake; Tributary of Glass Creek; Tributary of Otis Lake; Tributary of Head Lake; Tributary of Perch Lake; Tributary of Podunk Lake
Drains: Farm Drain; Hine Drain; Kelly Drain; Rogers Drain
Lakes: Guernsey; Pine; Werner; Otis; Perch; Podunk; Purdy; Laubaugh; Loomis; Head; Hubbell; Stewart; Smith Pond
Dams: Hubbell Dam; Schutz Dam; Smith Pond Dam; Albion Dam; Podunk Lake Dam; Deadwood Pond Dam

Water Temperature Classification: Glass Creek and its tributaries are cold-transitional streams.

Point Source Contributions: There are no permitted point-source discharges into the waters of the Glass Creek subwatershed.

Environmental Contamination Sites: There are no listed sites of environmental contamination in the Glass Creek subwatershed.

Figure 5.19.A – Glass Creek Potential Wetland Restoration



Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the Glass Creek subwatershed is fully supporting assessed designated uses. Waters of the subwatershed have not been assessed for partial or total body contact recreation. Lakes within the subwatershed have not been assessed for cold water fisheries or other indigenous aquatic life and wildlife. Fish consumption is not supported due to PCB in fish tissue and the water column.

Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Fully Supporting[1] Not Assessed[2]			
Cold Water Fishery	Fully Supporting[1] Not Assessed[2]			
Fish Consumption	Not Assessed[2]			
Fish Consumption	Not Supporting[1]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1]	PCB in Water Column	Y	2014

[1] AUID 040500070403-01 Includes Glass Creek
[2] AUID 040500070403-NAL Includes Lakes only 'assessed' for Navigation, Ag and Industrial Water Supply

Biological Surveys: Locations surveyed in the Glass Creek subwatershed are represented below with their applicable community status. Survey results indicate that Glass Creek is a fairly healthy stream with exposed cobble, overhanging vegetation, woody debris and riffle-pool sequences which provide habitat for macroinvertebrate and fish communities.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Glass Creek	2002	Goodwill Rd	Acceptable	Good	
Glass Creek	2002	Oak Rd	Excellent	Good	Not rated - no salmonids
Glass Creek	2009	M-37	Acceptable	Excellent	

Macroinvertebrate collections conducted by the Barry Conservation District under the MiCorps program from 2008-2009 indicate lack of abundance in collections, with relatively few macroinvertebrates collected, though habitat conditions appeared appropriate for all three community groups.

Location	Date	Group	Group	Group	Group	Group	Group	Group	Group	Group	Total	Score
	Sampled	1 #R	1 #C	2 #R	2 #C	3 #R	3 #C	1 Total	2 Total	3 Total	Score	Rank
Goodwill Rd.	5-03-08	1	0	2	1	0	0	5	9.2	0	14	Poor
Goodwill Rd	10-18-08	1	0	3	0	1	0	5	9	1.1	15	Poor
Goodwill Rd	11-07-09	2	0	3	2	2	1	10	15.4	3.2	29	Fair

***E.coli* Monitoring:** The Barry Conservation District conducted weekly *E. coli* monitoring at one location on Glass Creek, at the Peets Road crossing, from June to September, 2014 for the purpose of determining whether *E. coli* pollution was an issue in the watershed. Results indicate that Glass Creek is meeting water quality standards for partial body contact recreation, but it is not meeting water quality standards for total body contact recreation.

The table below shows results of *E. coli* data collected weekly from June 5 to September 18, 2014. Daily geometric means are compared to the daily maximum for total body contact and partial body contact recreation, with grey shading indicating that the daily maximum for total body contact or the 30-day geometric mean was exceeded. An underline indicates that both the maximum for total body contact and partial body contact were exceeded. Note that a result of 2420 per 100 ml is the limit of the analysis and should be interpreted as >2420 per 100 ml.

Date	Right	Center	Left	Duplicate	Daily Geometric Mean	30 Day Geometric Mean
6/5/2014	155	111	99	111	117	
6/12/2014	126	201	184	162	166	
6/19/2014	205	248	261		237	
6/26/2014	125	141	108	121	123	
7/3/2014	102	113	127	81	104	139
7/10/2014	65	77	89	60	72	125
7/17/2014	108	86	119		103	114
7/24/2014	206	214	194		205	111
7/31/2014	205	238	192	261	222	127
8/7/2014	127	166	142	225	161	140
8/14/2014	140	261	126	153	163	168
8/21/2014	579	461	435		488	217
8/28/2014	192	119	135	192	156	204
9/4/2014	261	308	387	361	326	222
9/11/2014	162	236	222		204	235
9/18/20014	80	148	114	99	108	214

Impairments: The Glass Creek subwatershed is not meeting its designated uses for fish consumption due to PCB levels. Since PCB contamination results from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB reduction.

Degradations: Glass Creek is the highest quality subwatershed in the watershed management area, largely due to the protection it receives from state land, and more recently, conservation easements on private lands made through the Barry State Game Area Protection Project. However, *E. coli* levels determined by 2014 monitoring indicate that Glass Creek is not meeting water quality standards for total body contact recreation. Concentrated residential areas around headwater lakes in the subwatershed may be unknowingly contributing septic system pollutants from aging or undersized systems. Residential riparian management also impacts nutrient levels in the lakes and streams. Livestock operations in the subwatershed are located on or near streams and lakes. Road crossings are a major contributor of sediment to the system both from gully erosion on unpaved roads and also 15 culverts that are perched or undersized.

Recommendations: *E. coli* levels should be assessed in the subwatershed to determine whether it is meeting water quality standards for total and partial body contact recreation. Sources of fecal contamination need to be identified. Management efforts in this subwatershed should be largely directed toward preservation of important wetland and riparian areas, with attention also given to reduction of nutrient and sediment loads. Improvement efforts in the Glass Creek subwatershed should address agricultural and residential runoff and aging septic systems to reduce nutrient loading, sedimentation and potential *E.coli* sources. Stream buffers in cultivated fields and riparian buffers in residential areas along the lakeshores and streams are important to reduce pollutant loads. Restoration of wetlands in drained areas will also be effective in filtering nutrients and improving groundwater recharge. Removal of unused fuel storage tanks and closure of abandoned wells will reduce the potential for ground and surface water contamination.

Prioritized Improvement Areas: Prioritizing areas for improvement in the Glass Creek subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4.

Glass Creek Improvement Areas:

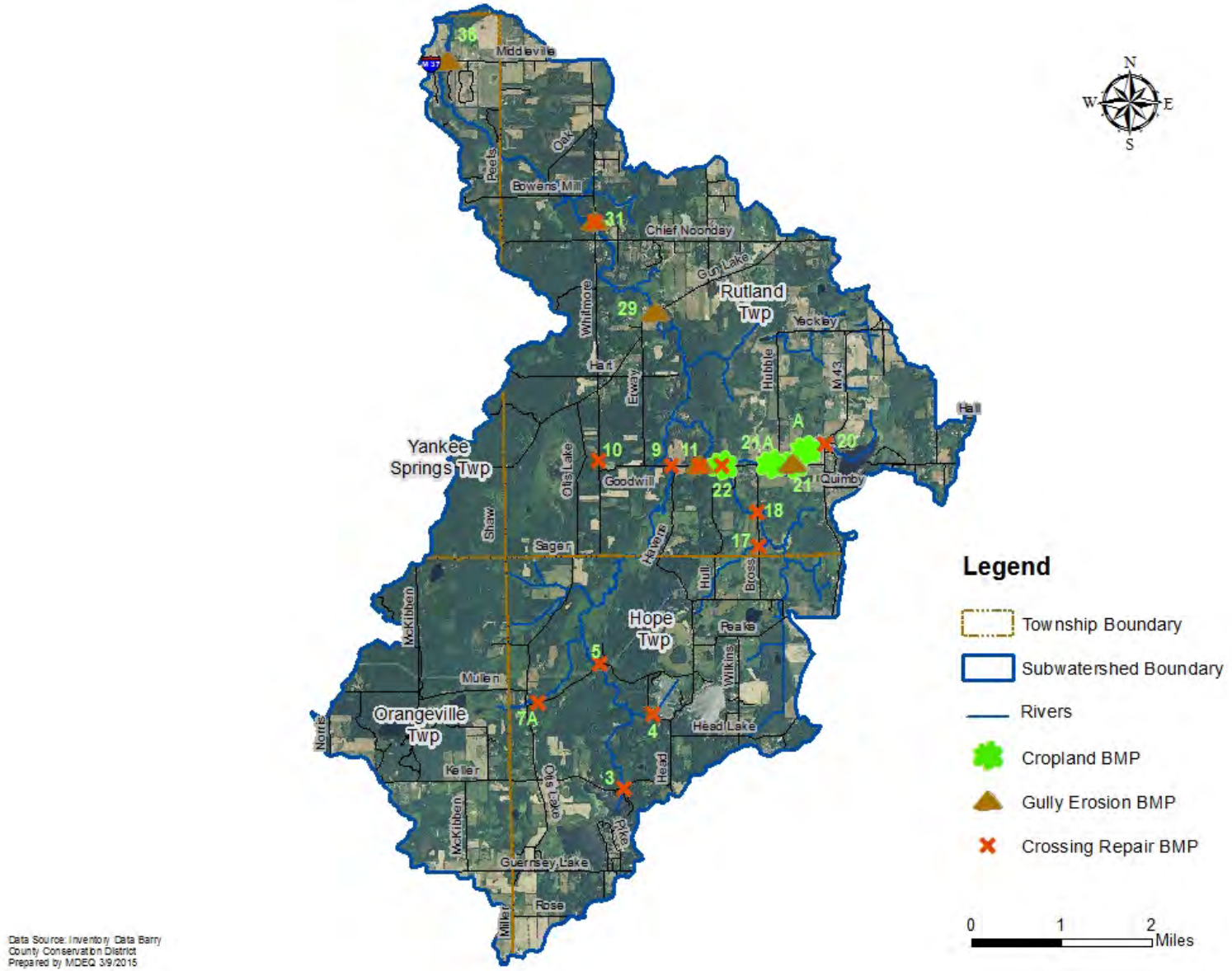
Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	21	Kelly Drain	Reduced till	Filter strip	Nutrients, Sediment
2	A	Kelly Drain	Reduced till	Filter strip	Nutrients, Sediment
3	22	Kelly Drain	Reduced till	Filter strip	Nutrients, Sediment
4	21A	Kelly Drain	Grassed waterway		Nutrients, Sediment
5	7A	Glass Creek	Culvert repair		Sediment
6	9	Glass Creek	Culvert repair		Sediment
7	11	Tributary	Culvert repair		Sediment
8	22A	Tributary	Culvert repair		Sediment
9	10	Tributary	Culvert repair		Sediment
10	3	Glass Creek	Culvert repair		Sediment
11	4	Tributary	Culvert repair		Sediment
12	5	Glass Creek	Culvert repair		Sediment
13	17	Tributary	Culvert repair		Sediment
14	18	Tributary	Culvert repair		Sediment
15	20	Tributary	Culvert repair		Sediment
16	31	Glass Creek	Culvert repair		Sediment
17	11	Tributary	Road repair		Sediment
18	21	Kelly Drain	Road repair		Sediment
19	29	Glass Creek	Road repair		Sediment
20	36	Glass Creek	Road repair		Sediment
21	31	Glass Creek	Road repair		Sediment
22	TBD	All	Repair failed septic systems		*E. coli*; Nutrients
23	TBD	All	Well closure		Chemical leachate
24	TBD	All	Fuel tank removal		Chemical leachate

Prioritized Protection Areas: The highest-ranking potential conservation area in the watershed is located in the Glass Creek subwatershed. The area is located within the Barry State Game Area. Inholdings within this area as well as private properties along its perimeter are high priority areas for conservation easements to protect water quality. Wetlands that support the waters of Glass Creek, whether intact or in need of restoration, are also critical to the protection of the system. The Glass Creek Protection Area coincides with the Barry State Game Area Protection Plan area.

Glass Creek Protection Areas

Rank	Ref #	Waterbody	Practice	Acres	Protection Elements
1	17	Glass Creek	Conservation Easement	200	Wetlands, Floodplain forest
2	16	Glass Creek	Wetland Restoration	100	Wetlands, Associated uplands
3	33	Glass Creek	Conservation Easement	150	Wetlands, Floodplain forest
4	14	Hine Drain	Wetland Restoration	80	Wetlands, Associated uplands
3	24	Kelly Creek	Wetland Restoration	60	Wetlands, Associated uplands

Figure 5.19.B – Glass Creek Improvement Areas



5.20 Subwatershed: Algonquin Lake – Thornapple River **HUC: 040500070404**

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
24879.6	4.14%	45.67%	0.00%	34.17%	7.86%	4.40%	2.34%	5.55%	100%

In the Algonquin Lake subwatershed, land use is generally agricultural row crops, with a large dairy operation located just west of Algonquin Lake. Extensive forestland, part of the Middleville State Game Area, characterizes the northwest, with additional privately owned forested acres just north of Algonquin Lake. Urbanized areas include the northern tip of the City of Hastings, Algonquin Lake, Leach Lake and Middle Lake. Light to medium industrial development is also present along M-43 and M-37 in the subwatershed. Subdivisions are located along the M-37 corridor and along State Road. The Hastings Landfill, operated on approximately 325 acres by Waste Management, is located on the west side of M-43. The Barry County Fairgrounds and the northern half of the Hastings City Airport are within the subwatershed boundaries. Presettlement vegetation was predominately oak-hickory forest, with some areas of beech-sugar maple forest. Former areas of mixed oak savannah are now prime farmland above and below the west end of Woodruff Road. Areas of mixed conifer swamp populated the headwaters of Bull Creek around what is now Fighter Road, and emergent marsh areas were located south of Kiser Road and north of Wing Road. The most significant areas of wetland loss in the subwatershed are those now drained by the Bull and Edwards Drain (Bull Creek) and the Ryan Drain (Sugar Creek). In addition, former wetland areas around three small lakes were altered with the construction of the Algonquin Lake Dam, which created a single lake that is now highly developed. The Algonquin Lake subwatershed will continue to feel the effects of development along the M-37, M-43 and State Road corridors, and likely along the shores of Middle and Leach lakes.

Protected Areas: Portions of the Middleville State Game Area (approximately 2200 acres) are located in the northwest quadrant of the subwatershed. The Carter Lake Preserve is owned and managed by the Southwest Michigan Land Conservancy. Approximately 150 acres of conservation easements are also located within the subwatershed.

Special Features: Habitat areas in the subwatershed may support the following threatened, endangered or special concern species: Blanchard's cricket frog, Eastern box turtle, hooded warbler, Henslow's sparrow, cerulean warbler, showy orchis, starhead topminnow, green violet, goldenseal, false boneset, and American lotus. The subwatershed is also identified as a location of mesic southern forest.

Hydrologic Features:

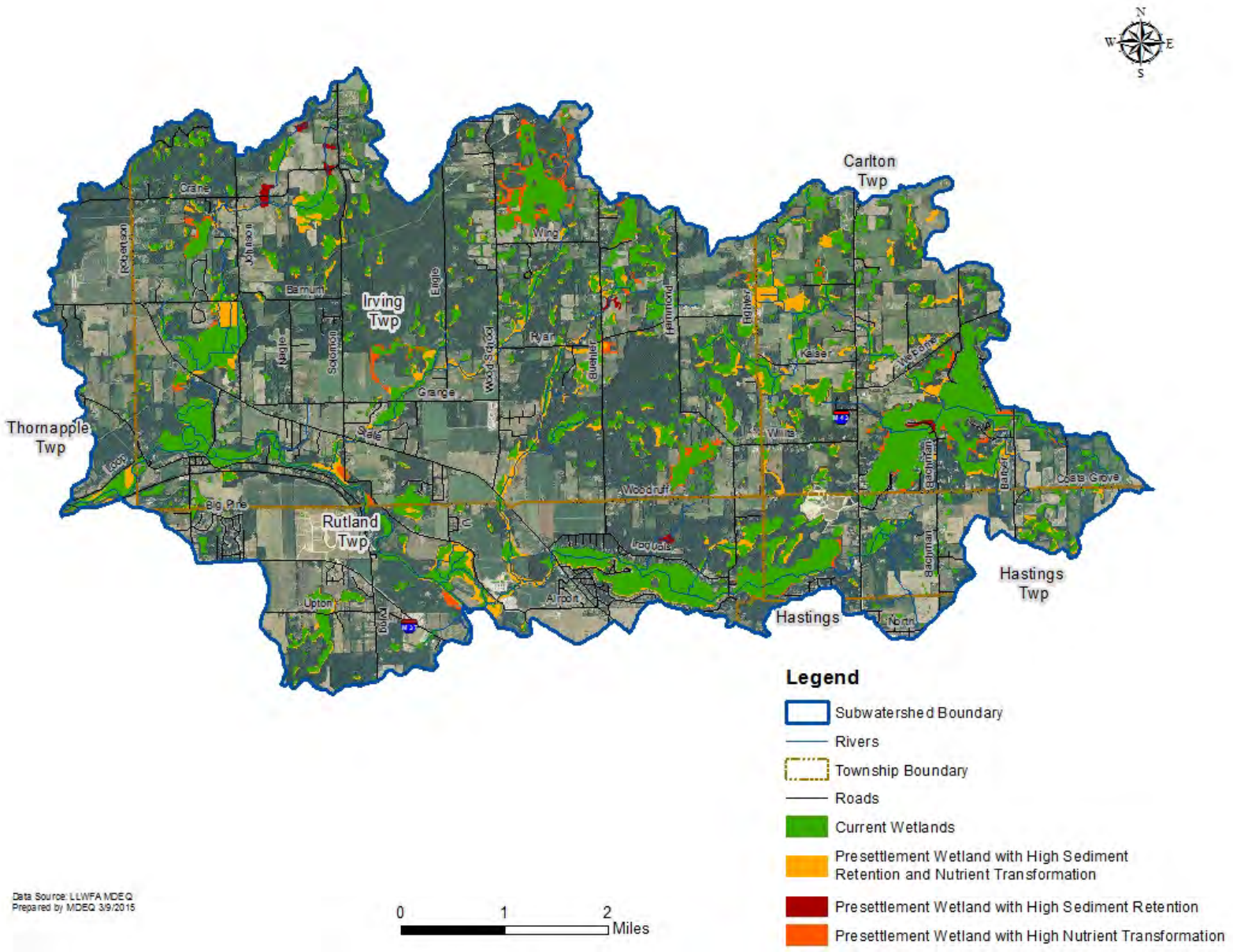
Tributaries: Bull Creek; Tributary of Middle Lake; Tributary of Leach Lake; Sand Creek; Algonquin/Carter Passage; Sugar Creek; Black Creek; North Branch of Black Creek; Tributary of Athawa Lake

Drains: Spencer Drain; Bull & Edwards Drain; Ryan Drain

Lakes: Athawa; Middle; Leach; Carter; Algonquin; Robinson Pond

Dams: Irving Dam; Algonquin Lake Dam; Robinson Dam; Little Twin Lake Dam

Figure 5.20.A – Algonquin Lake Potential Wetland Restoration



Water Temperature Classification: Waters in the Algonquin Lake subwatershed are classified as warm-transitional excepting the mainstem of the Thornapple River, which is classified as a warm river.

Point Source Contributions: The following facilities are permitted through the Michigan Department of Environmental Quality to discharge to the waters in the Algonquin Lake subwatershed:

Facility Name	Permit Number	Latitude	Longitude	Permitted Discharge Maximum (if noted)
Barry Expo Center	GW1510060	42.68034	-85.3904	
Hastings Sanitary Service	MI0050199	42.68075	-85.30304	
Hastings WWTP	MI0020575	42.650277	-85.298055	SS 750lbs/day-Ammonia Nitrogen (N)250lbs/day-Mercury .00033lbs/day--Stormwater
Tom Otto Turkey Farm Inc	GW1510137	42.71292	-85.43956	

Environmental Contamination Sites: There are no brownfield, LUST or hazardous waste sites listed by the MDEQ in the Algonquin Lake subwatershed.

Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the Algonquin Lake subwatershed is fully supporting assessed uses of navigation, industrial water supply and agriculture. A fishery assessment has not been completed. While tributaries in the subwatershed are fully supporting other indigenous aquatic life and wildlife, additional data is needed to make a determination of use support on this section of the Thornapple River. Like most state waters, the subwatershed is not supporting fish consumption because of the presence of PCB in the water column and both mercury and PCB in fish tissue.

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Insufficient Information[1] Fully Supporting[2,3,4] Not Assessed[5]			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Assessed[2,3,4,5]			
Fish Consumption	Not Supporting[1]	Mercury in Fish Tissue	Y	2014

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule
Fish Consumption	Not Supporting[1]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1]	PCB in Water Column	Y	2014

[1] AUID 040500070404-01 Includes Thornapple River
[2] AUID 040500070404-02 Includes Carter Lake NW of Hastings
[3] AUID 040500070404-03 Includes Leach Lakenorth of Hastings north of Coats Grove Rd
[4] AUID 040500070404-04 Includes Middle lake 3 miles north of Hastings
[5]AUID 040500070404-NAL Includes Lakes only 'assessed' for Navigation, Agriculture, and Industrial Water Supply

Biological Surveys:

Macroinvertebrate collections conducted by the Barry Conservation District under the MiCorps program from 2006-2008 indicate fair to poor ratings for the community on two tributaries of the subwatershed. Sugar Creek at State Road is the outlet for the Ryan Drain, which serves an agricultural area north of Algonquin Lake. Sand Creek at Solomon Road comprises drainage from Algonquin Lake and also Sugar Creek. The crossing at Solomon Road is located within Sand Creek Dairy. Water quality at these two locations may be affected by heavy siltation, lack of woody debris and other habitat, and other causes that require further study.

Location	Date Sampled	Group 1 #R	Group 1 #C	Group 2 #R	Group 2 #C	Group 3 #R	Group 3 #C	Group 1 Total	Group 2 Total	Group 3 Total	Total Score	Score Rank
Solomon	05-02-08	1	0	6	0	3	0	5	18	3.3	26	Fair
State Rd	05-01-08	2	0	0	2	1	0	10	6.4	1.1	18	Poor
Solomon	10-18-08	0	0	3	2	2	0	0	15.4	2.2	18	Poor
State Rd	10-18-08	1	0	3	1	4	0	5	12.2	4.4	22	Fair
Solomon	11-07-09	2	0	5	2	1	0	5	21.4	1.1	28	Fair
State Rd	11-07-09	2	0	1	1	1	0	10	6.2	1.1	17	Poor
Solomon	05-29-10	1	0	5	1	3	0	5	18.2	3.3	27	Fair
State Rd	05-29-10	2	0	5	2	5	0	10	21.4	5.5	37	Good

***E.coli* Monitoring:** The Barry Conservation District conducted weekly *E. coli* monitoring at one location on Sand Creek in the Algonquin Lake subwatershed, at the Solomon Road crossing, from June to September, 2014 for the purpose of determining whether *E. coli* pollution was an issue in the watershed. Results indicate that Sand Creek is not meeting water quality standards for both total body contact and partial body contact recreation.

The table below shows results of *E. coli* data collected weekly from June 5 to September 18, 2014. Daily geometric means are compared to the daily maximum for total body contact and partial body contact recreation, with grey shading indicating that the daily maximum for total body contact or the 30-day geometric mean was exceeded. An underline indicates that both the maximum for total body contact and partial body contact were exceeded. Note that a result of 2420 per 100 ml is the limit of the analysis and should be interpreted as >2420 per 100 ml.

Date	Right	Center	Left	Duplicate	Daily Geometric Mean	30 Day Geometric Mean
6/5/2014	548	579	613	308	495	
6/12/2014	727	770	980	980	856	
6/19/2014	1203	866	1203	921	1037	
6/26/2014	517	816	613		637	
7/3/2014	378	291	238		297	631
7/10/2014	261	579	285	345	349	584
7/17/2014	326	276	214	308	278	455
7/24/2014	325	461	461	687	467	381
7/31/2014	579	435	687		557	372
8/7/2014	1733	2420	1553	2420	1993	549
8/14/2014	1553	548	517	613	721	640
8/21/2014	1986	1414	1414	1203	1478	910
8/28/2014	204	231	194		209	826
9/4/2014	2420	2420	2420		2420	1055
9/11/2014	517	435	1120	921	694	835
9/18/2014	488	361	488	291	398	731

Impairments: The Algonquin Lake subwatershed is not meeting its designated uses for fish consumption due to PCB and mercury levels. Since PCB and mercury contamination result from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB or mercury reduction.

Degradations: A CAFO dairy operation manages extensive cropland and forage land in the subwatershed, and manure is spread in areas along the river and tributaries. Two other large livestock operations are located in the subwatershed. Other, smaller farming operations spread manure on fields. The potential for nutrient-rich runoff reaching the river and tributaries is high. Heavily residential Algonquin, Leach and Middle Lakes may also contribute nutrient and other runoff, as very few lake residents utilize vegetative buffers along the shoreline. Algonquin Lake is regularly treated for nuisance aquatic weeds, which indicates nutrient enrichment and may also affect dissolved oxygen levels in the lake and its outlet. While Leach and Middle Lakes recently connected with the City of Hastings wastewater system, Algonquin Lake residents still utilize private septic systems.

Recommendations: The Thornapple River within the subwatershed requires further study to determine whether it is supporting the use of other indigenous aquatic life and wildlife. Two tributaries, Sugar Creek and Sand Creek, show low levels of sensitive macroinvertebrate species, suggesting possible water quality issues. *E. coli* levels need to be assessed to determine whether they meet water quality standards for total and partial body contact recreation. Sources of fecal contamination need to be determined. Improvement efforts in the Algonquin Lake subwatershed should address agricultural and residential runoff, manure management, and aging septic systems to reduce nutrient loading, sedimentation and potential E.coli issues. Stream buffers in cultivated fields and riparian buffers in residential areas along the lakeshores and streams are important to reduce pollutant loads. Restoration of wetlands in channelized areas, especially those indicated as priorities in

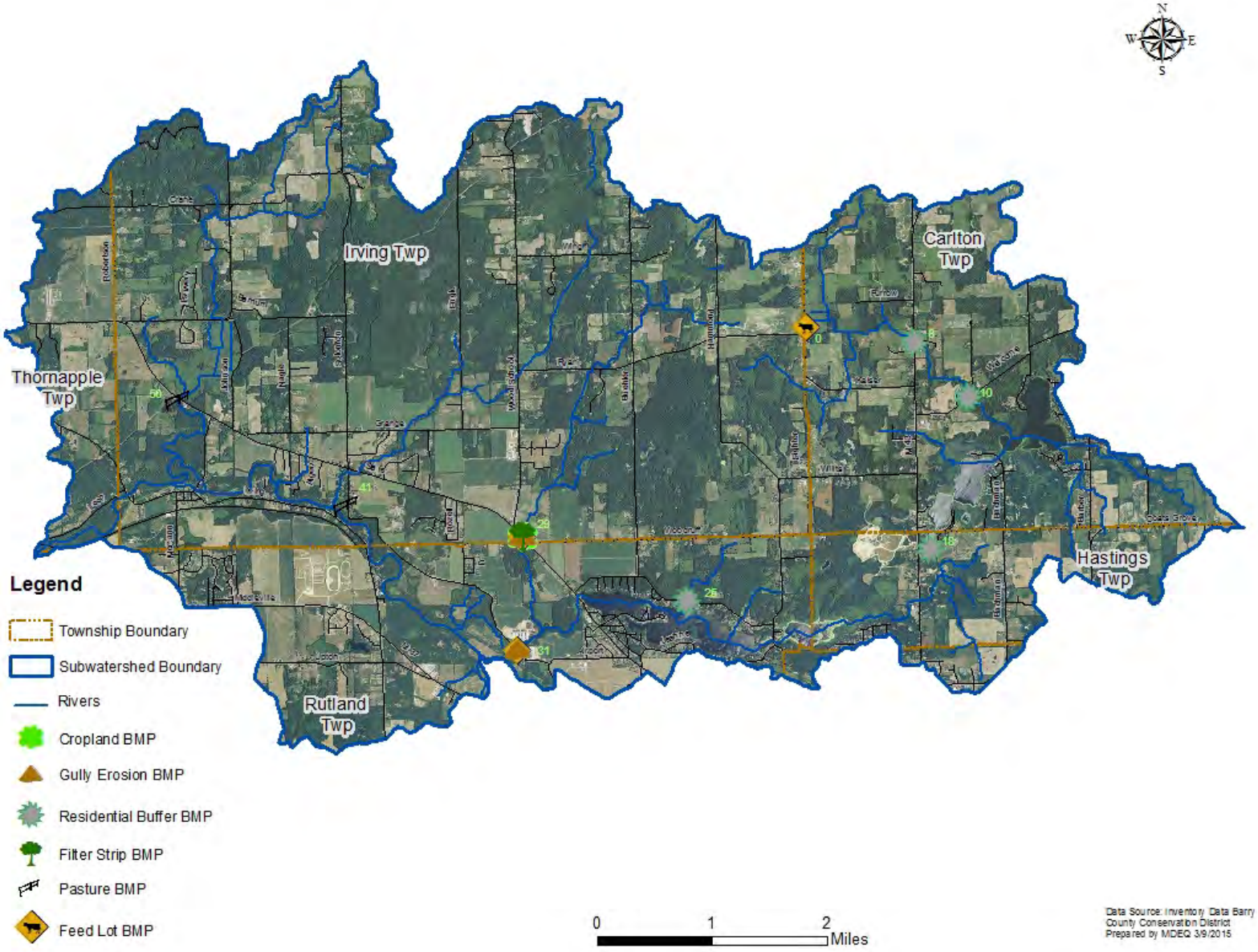
Figure 5.19.A, will also be effective in filtering nutrients. Opportunities to close abandoned wells and remove unused fuel storage tanks should also be pursued.

Prioritized Improvement Areas: Prioritizing areas for improvement in the Algonquin Lake subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4 and 5.

Algonquin Lake Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	29	Sugar Creek	Reduced till	Filter strip	Nutrients, Sediment
2	29	Sugar Creek	Filter strip #2		Nutrients, Sediment
3	50	Black Creek	Stream stabilization	Fencing	Sediment, Nutrients
4	41	Tributary	Stream stabilization	Fencing	Sediment, Nutrients
5	31	Sand Creek	Waste facility		Nutrients
6	5A	Ryan Drain	Waste facility		Nutrients
7	8	Bull Creek	Filter strip		Nutrients, Sediment
8	25	Algonquin Lake	Filter strip		Nutrients, Sediment
9	18	Leach Lake	Filter strip		Nutrients, Sediment
10	10	Middle Lake	Filter strip		Nutrients. Sediment
11	29	Sugar Creek	Road repair		Sediment
12	29	Sugar Creek	Road repair #2		Sediment
13	31	Sand Creek	Road repair		Sediment
14	TBD	All	Repair failed septic systems		*E. coli;* Nutrients
15	TBD	All	Well closure		Chemical leachate
16	TBD	All	Fuel tank removal		Chemical leachate

Figure 5.20.B Algonquin Lake Improvement Areas



5.21 Subwatershed: Duncan Creek **HUC: 040500070405**

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
15049.5	4.29%	76.10%	0.00%	12.07%	5.02%	4.32%	1.05%	1.44%	100%

The Duncan Creek subwatershed is the northernmost heavily agricultural area in the watershed, with row and forage crops making up the majority of farmland. Soil types classify the subwatershed's land as prime farmland and prime farmland if drained. Urban business and residential growth continues along the M-37 corridor between the villages of Middleville and Caledonia. In both the 2000 and 2010 census, this area was one of the fastest growing in the region, serving as a bedroom community to the industrial area of Kentwood in Grand Rapids. Heavily residential areas are found around Duncan Lake and in subdivisions scattered throughout the subwatershed. The addition of the Finkbeiner Bridge over the Thornapple River in 2011 is calculated to spur industrial growth to the east of the river and is likely to develop a new east-west corridor when the Finkbeiner expansion extends through Allegan County to US 131. Wetland loss is most evident in the headwaters areas, which have been drained for agricultural use. Both agricultural and residential land use have impacted water quality in Duncan Creek, most notably above and within Duncan Lake.

Protected Areas: There are no protected lands in the Duncan Creek subwatershed.

Special Features: Listed species: Missouri Rock-cress (Arabis misouriensis var. deamii) – State special concern plant; Bigmouth shiner (Notropis dorsalis) – State special concern fish. The floodplain area around the mouth of Duncan Creek (east of M-37) ranks as a high priority conservation area in the Barry County Potential Conservation Areas report prepared by the Michigan Natural Features Inventory due to the unchanged nature of its land cover and the existence of a natural vegetation community. Protection of this area is warranted, as is further study of its elements.

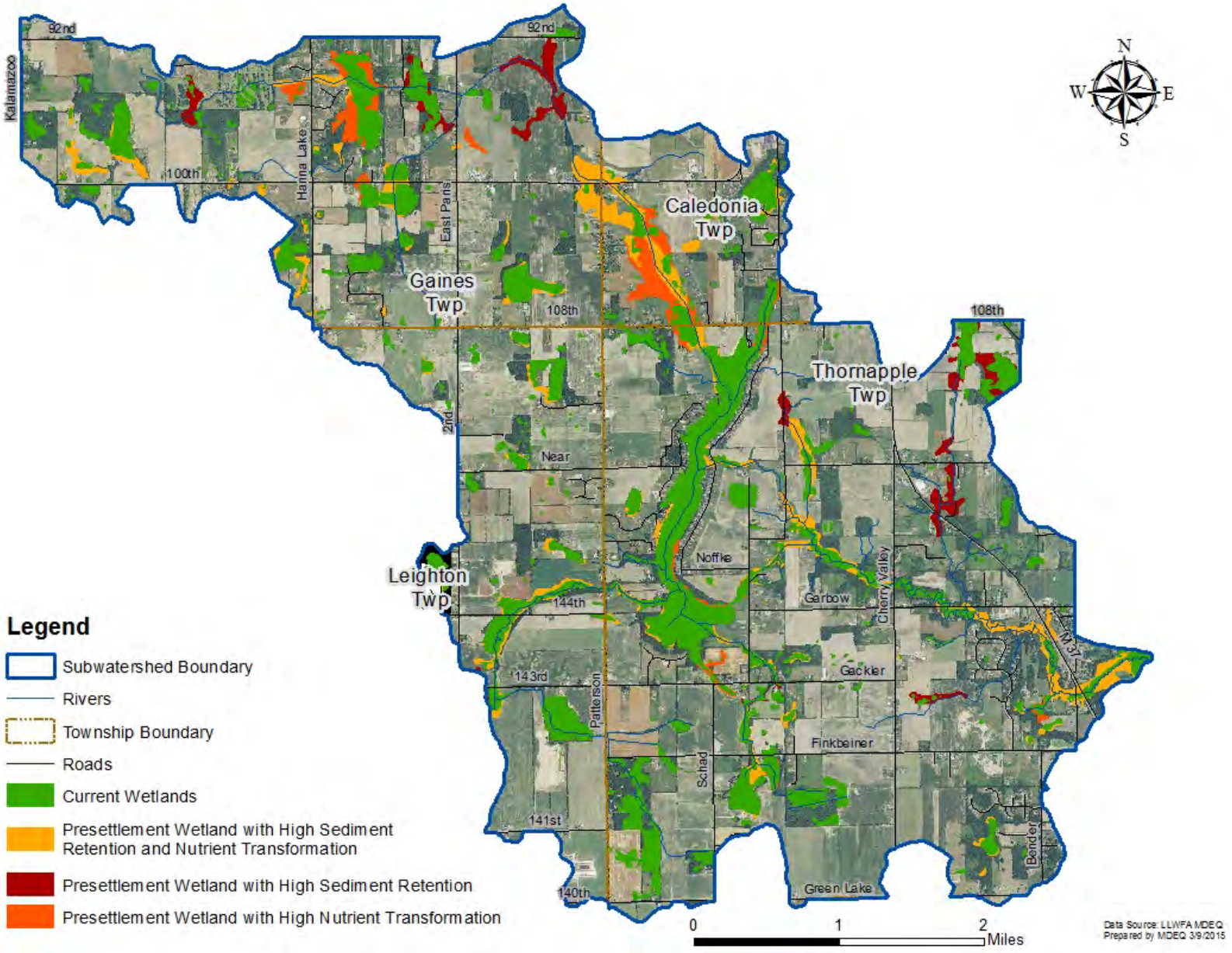
Hydrologic Features:

Tributaries: Unnamed
Drains: Wilson Drain
Lakes: Duncan Lake, Hanna Lake, Schad Pond
Dams: Duncan Lake Creek Dam

Water Temperature Classification: The waters of the Duncan Creek subwatershed are classified as warm transitional streams.

Groundwater: The Barry-Eaton District Health Department has classified a large portion of the subwatershed as a Known Area of Groundwater Concern due to high (above 10 ppm.) levels of nitrate in well samples in the area. Exceedences of WQS standards for nitrate levels for drinking water are clustered around the intersection of Green Lake and Schad Roads, in Section 16 of Thornapple Township, and in the Duncan Lake residential area. Additional points of exceedence are found throughout the subwatershed.

Figure 5.21.A – Duncan Creek Potential Wetland Restoration



NPDES Permit Sites: Thornapple Township maintains the Thornapple Township – Duncan Lake WWSL at 11421 Parmalee Rd. in Middleville, which is permitted to discharge into waters of the Duncan Creek subwatershed.

Facility Name	Permit Number	Latitude	Longitude	Permitted Discharge Type and Maximum if noted
Thornapple TWP WWSL	MIG580104	42.739444	-85.515	Lagoons

Environmental Contamination Sites: Thomas A. Crane maintains a 500 gallon underground gasoline storage tank for farm use at 6795 Cherry Valley Rd. in Middleville. Caledonia High School maintains a 500 gallon underground diesel tank at 9757 Duncan Lake Ave. SE in Caledonia.

Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, Duncan Creek is supporting most assessed designated uses. It is not supporting fish consumption because of the presence of PCB in the water column and fish tissue in samples from assessed areas including Duncan Creek, Duncan Lake outlet and Hanna Lake outlet and tributary. Mercury in fish tissue was also detected in fish from the Duncan Lake outlet and Hanna Lake outlet areas. The "insufficient information" on the other indigenous aquatic life and wildlife designated use for the Duncan Lake outlet, Wilson Drain and Hanna Lake areas represents the need for additional DEQ data to make a determination.

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Fully Supporting [2,4] Insufficient Information[1,3] Not Assessed [5]			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Assessed [2,5]			
Fish Consumption	Not Supporting [1,3]	Mercury in Fish Tissue	Y	2014
Fish Consumption	Not Supporting [1,3,4]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting [1,3,4]	PCB in Water Column	Y	2014

[1] AUID 040500070405-01 Includes Duncan Lake Outlet and Wilson Drain
[2] AUID 040500070405-02 Includes Duncan Lake
[3] AUID 040500070405-03 Includes Hanna Lake Outlet and unnamed tributary to Hanna Lake
[4] AUID 040500070405-04 Includes Duncan Creek
[5] AUID 040500070405-NA and NAL Includes unassessed rivers, streams and lakes in the subwatershed

Biological Surveys: Locations surveyed in the Duncan Creek subwatershed are represented below with their applicable community status. Survey results indicate good habitat and acceptable macroinvertebrate scores on Duncan Creek, excepting the 108th Street crossing, which is on a channelized portion of the creek and has a highly altered channel.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Duncan Creek	2004	Stimpson Rd	Acceptable	Excellent	
Duncan Creek	2004	108th St	N/A excessive silt	Marginal	
Duncan Creek	2009	Stimpson Rd	Acceptable	Good	
Duncan Creek	2009	Cherry Valley Rd	Acceptable	Good	
Duncan Creek	2009	Duncan Lake Rd	Acceptable	Good	

Macroinvertebrate Survey: Macroinvertebrate collections were conducted in two locations on Duncan Creek by the Barry Conservation District under the MiCorps program in 2008-9. The 108th Street location is above Duncan Lake in a channelized portion of the stream. This site showed lower concentrations of Group 1 – sensitive species and higher numbers of Group 3 – tolerant species than the second site on Finkbeiner Road, which was not channelized. Heavy siltation and lack of woody debris in the 108th Street site likely contribute to the difference in macroinvertebrate communities in the two sites.

Location	Date Sampled	Group 1 #R	Group 1 #C	Group 2 #R	Group 2 #C	Group 3 #R	Group 3 #C	Group 1 Total	Group 2 Total	Group 3 Total	Total Score	Score Rank
108th St.	05-03-08	2	0	6	0	1	2	10	18	3.1	31	Fair
Finkbeiner Rd.	05-03-08	4	0	4	2	1	2	20	18.4	3.1	42	Good
108th St.	10-26-08	2	0	2	3	2	1	10	15.6	3.2	29	Fair
Finkbeiner Rd.	10-26-08	1	1	3	4	4	0	10.3	21.8	4.4	37	Good
108th St.	11-04-09	2	0	5	2	3	1	10	21.4	4.3	36	Good
Finkbeiner Rd.	11-04-09	3	0	4	2	2	0	15	18.4	2.2	36	Good

CLMP Monitoring: A *Duncan Lake Water Quality Monitoring Report* was compiled in 2012 by Progressive AE for Thornapple Township. The report summarized data collected by Progressive AE from 1987-1991 and by volunteers through the Cooperative Lakes Monitoring Program through 2011. Seven parameters: dissolved oxygen, total phosphorus, pH, total alkalinity, chlorophyll-*a* and Secchi transparency were monitored over this time period. Based on monitoring results, the study concludes that Duncan Lake is eutrophic, with "very high total phosphorous and chlorophyll-*a* levels, low Secchi transparency, and deep-water dissolved oxygen depletion during the summer months" (7). Levels of pH

and alkalinity were within the normal range for southern Michigan lakes. Data from the Duncan Lake monitoring program can be found at http://www.micorps.net/data/view/search/lake/raw.php .

***E.coli* Monitoring:** The Barry Conservation District conducted weekly *E. coli* monitoring at one location on Duncan Creek, at the 108th Street crossing, from June to September, 2013 for the purpose of determining whether *E. coli* pollution was an issue in the watershed. Results indicate that Duncan Creek is exceeding water quality standards for both total body contact and partial body contact recreation.
The table below shows results of *E. coli* data collected weekly from June 13 to September 26, 2013. Daily geometric means are compared to the daily maximum for total body contact and partial body contact recreation, with grey shading indicating that the daily maximum for total body contact or the 30-day geometric mean was exceeded. An underline indicates that both the maximum for total body contact and partial body contact were exceeded. Note that a result of 2420 per 100 ml is the limit of the analysis and should be interpreted as >2420 per 100 ml.

	Sample Results (per 100 ml)				Daily Geometric Mean	30-Day Geometric Mean
Date	Left	Center	Right	Duplicate		
6/13/2013	2420	2420	2420		2420	
6/20/2013	980	613	866		804	
6/27/2013	488	387	517	649	502	
7/3/2013	1203	1203	687	687	909	
7/11/2013	488	548	548		527	835
7/18/2013	345	517	461		435	617
7/25/2013	236	517	260		317	516
8/1/2013	345	345	238	248	290	460
8/8/2013	2420	2420	2420		2420	529
8/15/2013	579	727	649		649	550
8/22/2013	291	129	250	361	241	467
8/29/2013	249	416	222		284	438
9/5/2013	365	435	435		410	455
9/12/2013	525	457	361		442	499
9/19/2013	285	240	48		149	321
9/26/2013	99	125	126		116	245

Crossing Surveys: Road-stream crossing surveys conducted on nine sites in the Duncan Creek subwatershed by the Barry Conservation District in 2006-2007 indicate fair habitat quality, with instream structure in most locations, but the channels are characterized by heavy siltation or sandy substrate. Riparian buffers were minimal in the agricultural, residential and lakefront areas. An additional windshield survey of critical areas in the subwatershed was conducted in 2012 in conjunction with a fish passage barrier study by the Barry Conservation District. The windshield survey catalogued visible sources of non-point pollution. Locations where erosion was present were measured in the field to calculate total sediment contributions. Stream lengths at cattle access sites and sites with inadequate buffers were measured using aerial photographs. The general condition and functionality of all culverts and bridges were surveyed as a part of a fish passage barrier study. Undersized, perched, plugged or

damaged culverts were considered as critical areas when they impeded fish passage or caused severe erosion, impoundment or scour pools.

Impairments: The Duncan Creek watershed is not meeting its designated uses for fish consumption due to PCB and mercury levels and for partial and total body contact recreation. Since PCB and mercury contamination result from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB or mercury reduction.

Degradations: *E. coli* levels found in the 2013 Barry Conservation District monitoring program indicate that Duncan Creek's main stem is not meeting water quality standards for both total body contact recreation and partial body contact recreation due to fecal contamination. Excessive substrate imbeddedness in the creek and high phosphorous levels in the lake itself, which acts as a detention basin for the creek, suggest that nutrient-laden runoff is a main concern in the watershed. Channelization in the headwaters areas and loss of critical wetlands for filtration increase the likelihood of polluted runoff reaching the lake and affecting water quality in this recreation area. Riparian management along the heavily-residential lakeshore may also permit lawn fertilizer and pet waste to enter the lake. Of additional concern is the likelihood of failed septic systems or illicit sewer connections carrying untreated sewage from rural residential areas into the creek or its tributaries. Severe bank erosion on two separate sites in the watershed suggests increased flashiness during storm events.

Recommendations: Further study is needed to determine whether Duncan Creek is meeting water quality standards for total and partial body contact recreation. Sources of fecal contaminations require identification. Further study is also needed to determine whether Wilson Drain and the Hanna Lake tributary are meeting standards for other indigenous aquatic life and wildlife. Improvements in the Duncan Creek subwatershed should address runoff, erosion and flow regimes to reduce nutrient loading, sedimentation and bank erosion. Stream buffers in cultivated fields and riparian buffers in residential areas along the lakeshore and streams are important to reduce pollutant loads. Addressing aging septic systems, either through extension of municipal sewer or location and repair of failing systems, will help reduce the potential for fecal contamination. Restoration of wetlands above the lake and at the mouth of Duncan Creek will also be effective in providing storage to slow the rate of flow and to filter nutrients. Opportunities to close abandoned wells and remove fuel storage tanks will reduce the potential for chemical contamination.

Improvement Area Assessment:
Prioritizing areas for improvement in Duncan Creek is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all improvement projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s).

Duncan Creek Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	8	Tributary	Reduced tillage	Filter strip	Nutrients, Sediment
	8	Tributary	Waste storage		Nutrients
	8	Tributary	Road repair		Sediment
2	7	Duncan Creek	Reduced tillage	Filter strip	Nutrients, Sediment
3	6	Duncan Creek	Reduced tillage	Filter strip	Sediment

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
5	27	Tributary	Reduced tillage	Filter strip	Sediment
6	9A	Tributary	Reduced tillage	Filter strip	Nutrients, Sediment
7	17A,B, C, D, E	Duncan Lake	Residential buffer		Nutrients, Sediment
8	16	Wilson Drain	2-stage bank		Sediment
9	24	Duncan Creek	2-stage bank		Sediment
10	23A	Tributary	Reduced tillage	Filter strip	Sediment
11	9	Tributary	Road repair		Sediment
12	17	Tributary	Road repair		Sediment
13	23	Duncan Creek	Road repair		Sediment
14	16A	Wilson Drain	Culvert replacement		Sediment
15	6	Duncan Creek	Streambank stabilization		Nutrients, Sediment
16	TBD	All	Repair failed septic systems		*E. coli*; Nutrients
17	TBD	All	Well closure		Chemical leachate
18	TBD	All	Fuel tank removal		Chemical leachate

Priority 1 – This unnamed channel runs approximately 3000’ through cropland associated with an animal feeding operation. The unbuffered channel is subject to runoff from fertilized fields as well as a feedlot. Best management practices for this site are riparian buffers along both sides of the stream and cover crops on tilled areas or no-till practices to reduce erosion, as well as a waste storage facility.

Priority 2 – Approximately 3350’ of Duncan Creek is intermittently buffered as it passes through cropland. This stream segment just above Duncan Lake has lost a significant amount of floodplain due to land use change. At minimum, riparian buffers are recommended along the channel. If possible, natural channel design can be incorporated to increase the floodplain and improve in-stream habitat.

Priority 3 - This unbuffered segment of Duncan Creek spans approximately 6000’ through tilled fields. Bank erosion downstream of the road crossing is significant, and bank restoration is necessary in this approximately 500’ area. In addition, riparian buffers along both sides of the stream will reduce runoff.

Priority 4 – Another unbuffered segment of Duncan Creek requires approximately 1800’ of buffer to reduce erosion.

Priority 5 – Though a small detention basin is present on the west side of Duncan Lake Road, this field to the east is prone to severe gully erosion during storm events. Installation of a grassed waterway (approximately 2400’) and the use of cover crops will reduce erosion at this site.

Priority 6 – Riparian buffers along approximately 1900’ of this unnamed tributary going through cropland will reduce erosion from this site.

Priority 7 – At least one-third of the Duncan Lake shoreline is maintained as lawn. Bank slope and lack of riparian vegetation foster erosion and runoff of lawn chemicals during rain events. Additional erosion can occur during bankfull events due to the removal of aquatic vegetation. Riparian buffers are recommended along all open lawn areas on the lakeshore. A reduction of aquatic weed treatment/removal is also important to stabilize the shoreline and permit nutrient uptake.

Priority 8 – Severe bank erosion has impacted approximately 350’ of stream in an unchannelized portion of Wilson Drain. Surface overflow and high flow through a culvert have essentially “blown out” the banks of the creek as it enters this wooded valley. Past severe storm events have destabilized the banks which now continue to erode in most rain events. Addressing the field runoff by installing a detention basin, then restoring the stream banks will address this erosion problem.

Priority 9 – A similar severe bank erosion problem plagues this site. Past storm events have destabilized the outer bank on a bend. Bank restoration and possible improvements to a storm detention basin will reduce erosion at this site.
Priority 10 – Approximately 2400' of buffer are required along this unnamed tributary to prevent erosion from cropland.
Priorities 11 through 15 – Each site is a potential location for road repair or culvert replacement, which would aid in reducing sediment.

Rank	Site #	Approximate acres	Location
11	19	16	Field between Duncan Lake and West Duncan Lake Roads
12	17A	30	Field east of Noffke Drive above storm drain
13	26	22	Mouth of Duncan Creek east of M-37
14	26A	7	Mouth of Duncan Creek west of M-37
15	6	29	Field west of East Paris Ave and north of 100th St.

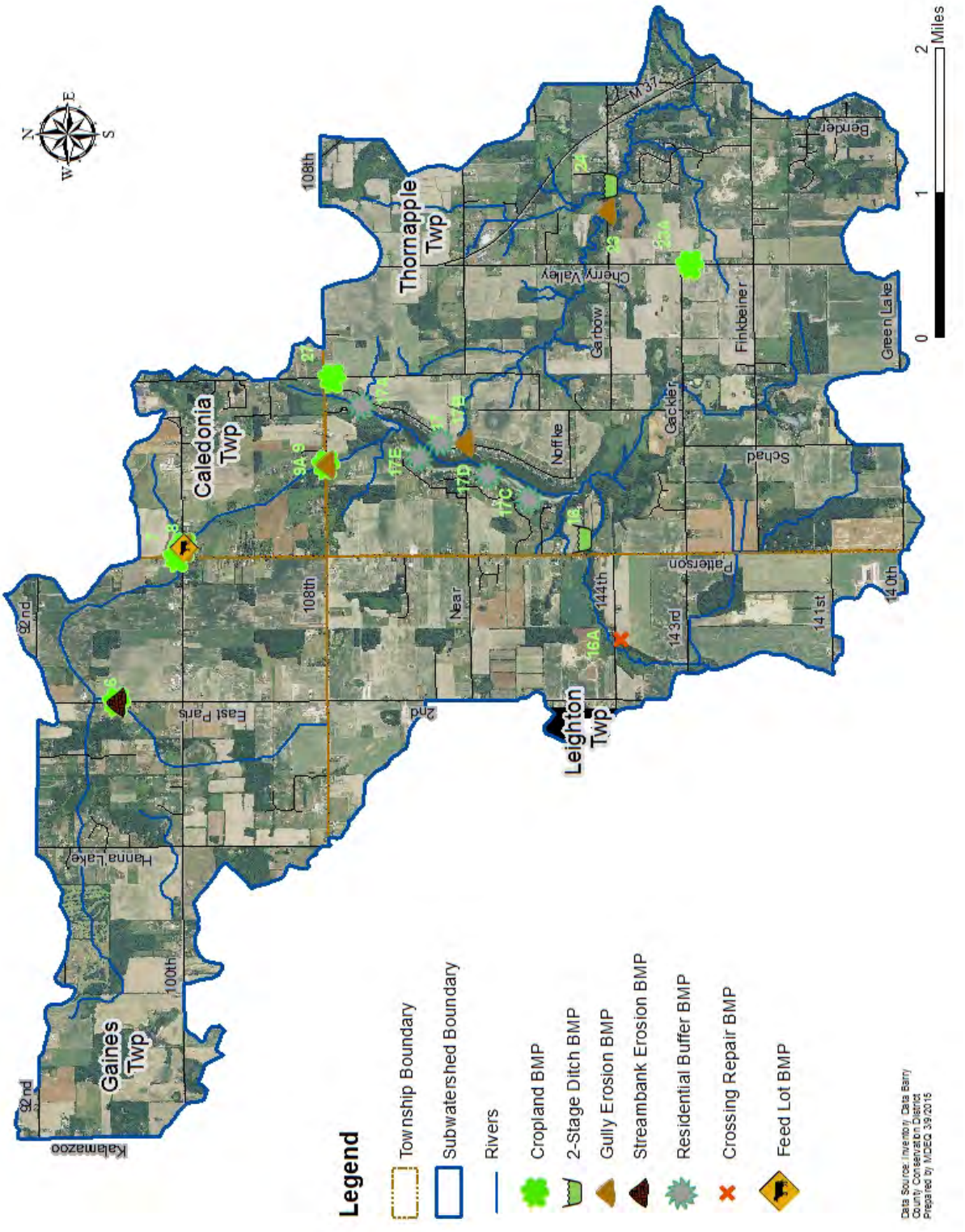


Figure 5.21.B – Duncan Creek Improvement Areas

5.22 Subwatershed: Turner Creek – Thornapple River **HUC: 040500070406**

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
20923	4.33%	34.26%	0.00%	43.53%	11.98%	5.13%	0.71%	4.39%	100%

The lower reach of the Turner Creek subwatershed is within the Yankee Springs State Recreation Area and the Barry State Game Area. Inholdings among the state lands are heavily residential, including lake development around the north ends of Turner and Bassett Lakes and areas off of M-179 and Norris Road. The State Game Area south of M-179 to Gun Lake Road is considered a high priority Potential Conservation Area in Barry County. The subwatershed follows the river to the north beyond the mouth of Basset Creek, encompassing the Village of Middleville and the M-37 corridor north and south of the village. The village and M-37 corridor areas are highly urbanized and include commercial, light- and heavy-industrial uses. Other developed areas include a subdivision along the river north of Parmalee Road and the Loop Road community south of Middleville. Agriculture includes a hog operation, dairies, row and forage crops. Presettlement vegetation is widely varied in the subwatershed and includes mixed oak forest in the upper reach, beech-maple forest along the lower reach of Hill Creek, and oak-hickory forest along the Bassett Creek and river corridors. Big Marsh Drain has eliminated a wet prairie once surrounded by mixed conifer swamp at the headwaters of Hill Creek.

Protected Areas: Nearly the entire lower half of the Turner Creek subwatershed lies within the Barry State Game Area and Yankee Springs Recreation Area, both owned by the State of Michigan and managed by the MDNR. Management practices support water quality, wildlife and many of the listed species that may reside in this area. The Spring Creek Fen, within the Village of Middleville, is also protected by a state-held conservation easement.

Special Features: Due to the high percentage of protected lands in the subwatershed, a high number of Federal and State listed species are identified in the area by the Michigan Natural Features Inventory. These include:

- Blanchard's cricket frog
- Spotted turtle
- Blanding's turtle
- Eastern massasauga
- Eastern box turtle
- Henslow's sparrow
- Cerulean warbler
- Beaked agrimony
- Leadplant
- Purple milkweed
- Prairie Indian plantain
- American chestnut
- Horsetail spike-rush
- Green violet
- False boneset
- Spotted pond weed
- Sprague's pygarctia
- Three-staffed underwing
- Perseus duskywing
- Barrens buckmoth
- Ottoe skipper
- Small heterocampa
- Angular spittlebug
- Newman's brocade
- Mitchell's satyr
- Spartina moth
- Tamarack tree cricket
- Blazing star borer

The subwatershed is also identified as a location of dry-mesic southern forest, prairie fen, wet prairie and wet-mesic prairie.

Hydrologic Features:

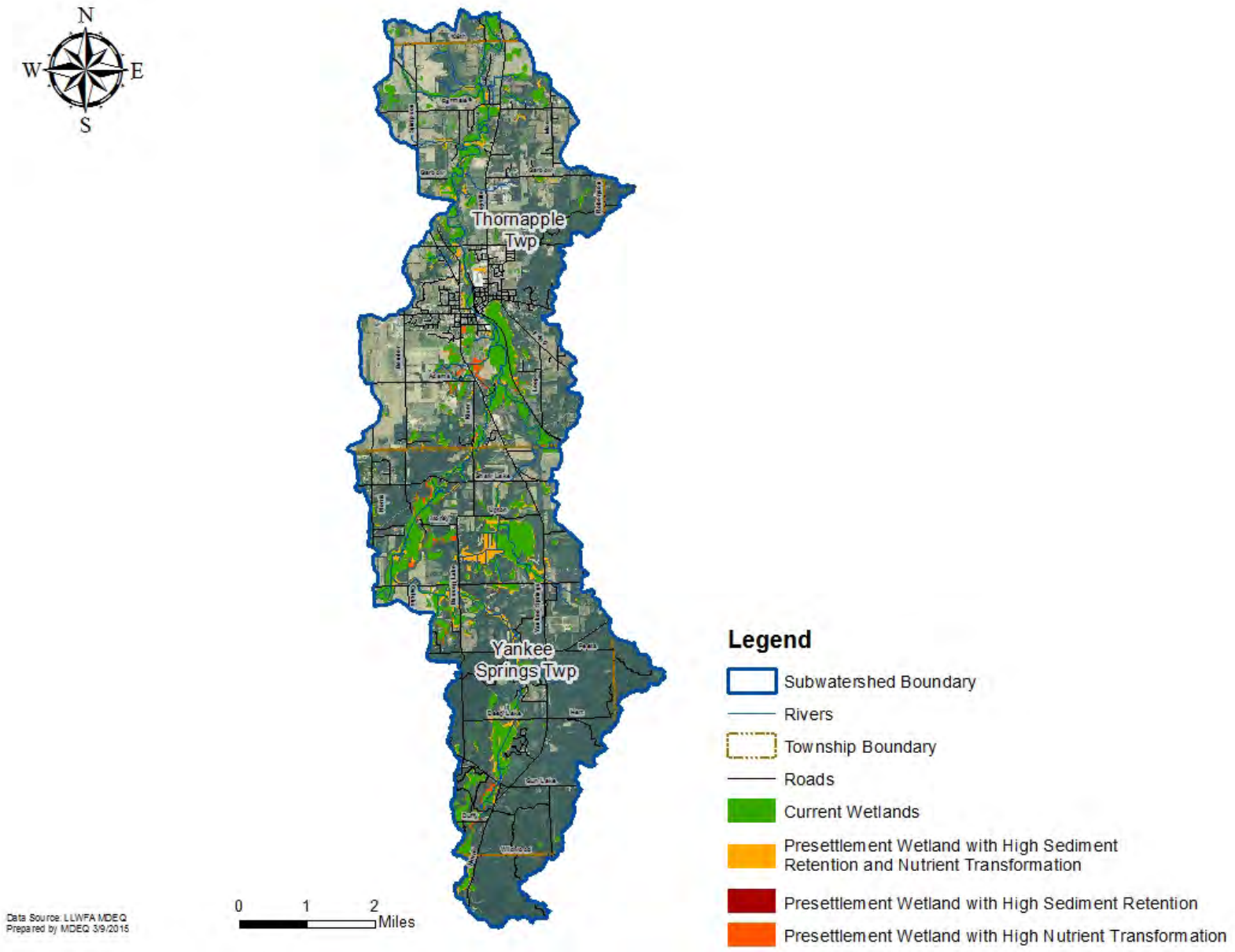
Tributaries: Bassett Creek; Turner Creek; Hill Creek; Spring Creek
Drains: Big Marsh Drain; Townlines Drain
Lakes: Bassett; Turner; Deep; Snow
Dams: Middleville Dam

Water Temperature Classification: Hill Creek is classified as a cold stream, while Turner and Bassett Creeks are considered warm transitional streams. The Thornapple River in this subwatershed is classified as a warm river.

Point Source Contributions: The following facilities are permitted by the MDEQ to discharge into the waters of the Turner Creek subwatershed:

Facility Name	Permit Number	Latitude	Longitude	Permitted Discharge (Max)
Bradford White Corp	MI0004405	42.71722	-85.46389	groundwater
Geukes Market LLC	GW1510027	42.72002	-85.4691	
Middleville WWTP	GW1810191	42.72	-85.454444	Total Inorganic Nitrogen 5.0mg/l-per day- Chloride 250mg/l-per day- Sodium 120mg/l-per day- Total Phosphorus 1.0(monthly)mg/l-Lagoons
Sharp Park Campground	GW1510331	42.62586	-85.44925	
Ottos Poultry Inc	GW1510008	42.73819	-85.45441	
Sharp Park Campground	GWE-0354	42.62586	-85.44925	

Figure 5.22.A – Turner Creek Wetland Restoration Potential



Environmental Contamination Sites: The Turner Creek subwatershed contains four active LUST sites, fourteen brownfield sites and one hazardous waste site. The tables below provide location data from MDEQ databases.

Active Leaking Underground Storage Tank (LUST) Sites

LUST Site Name	Latitude	Longitude	Substance Released
Leasco Truck Rental (Bradford)	42.717955	-85.462963	Diesel
Spencer's Towing	42.710753	-85.356683	Gasoline
Spencer's Towing	42.710753	-85.356683	Waste Oil
Cappons Quick Mart	42.631235	-85.511521	Gasoline, Unknown

Brownfield Sites

BEA Number	Address	Latitude	Longitude
200501597GR	221 W Main St	42.710963	-85.467309
201002799GR	38 State St	42.708513	-85.461841
201203345GR	38 State St	42.708513	-85.461841
201303545GR	500 High St	42.71944	-85.46329
201102963GR	8675 Crane Rd	42.725519	-85.462913
201002688GR	8675 Crane Rd	42.725519	-85.462913
201002857GR	900 E Main St	42.711045	-85.481239
201002858GR	900 E Main St	42.711045	-85.481239
Part 201	200 Lafayette	42.71944	-85.46329
Part 201	3607 Yankee Springs Rd	42.70309	-85.47472
199800395GR	3607 Yankee Springs Rd	42.70309	-85.47472
200201114GR	NW Railroad St & High St	42.713124	-85.465028
Part 213	615 S Broadway	42.70551	-85.46968
Part 212	221 W Main St	42.71075	-85.4673

Hazardous Waste Sites:

Name	Address	City
Paramount Communications, Inc. (Blue Cow, Inc.)	33 State St.	Middleville

Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the Turner Creek subwatershed is fully supporting assessed uses of navigation, industrial water supply and agriculture. A fishery assessment has not been completed. While Turner Creek and Bassett Creek are fully supporting other indigenous aquatic life and wildlife, additional data is needed to make a determination of use support on this section of the Thornapple River and in Hill Creek. The waters of the subwatershed have not been assessed for total and partial body contact recreation. Like most state waters, the subwatershed is not supporting fish consumption because of the presence of PCB in the water column and both mercury and PCB in fish tissue.

Designated Use	Use Support	Cause	Pollutant ?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Insufficient Information[1] Fully Supporting[2,3] Not Assessed[4]			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Assessed[3,4]			
Fish Consumption	Not Supporting[1]	Mercury in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1,2]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1,2] Not Assessed[3,4]	PCB in Water Column	Y	2014

[1] AUID 040500070406-01 Includes Hill Creek and Thornapple River
[2] AUID 040500070406-02 Includes Bassett Creek and Turner Creek
[3] AUID 040500070406-03 Includes Deep Lake, Barry State Game Area NE of Gun Lake
[4] AUID 040500070406-NA and NAL Includes Water and Lakes only 'assessed' for Navigation, Ag and Industrial Water Supply

Biological Surveys: Locations surveyed in the Turner Creek subwatershed are represented below with their applicable community status. Survey results indicate good habitat conditions and an excellent macroinvertebrate community at Shaw Lake Road, on Turner Creek but marginal habitat and unwadable conditions at Upton Road, on Hill Creek. The marginal habitat status for Hill Creek is due to the effects of channelization including high levels of sediment, lack of woody debris and straightening of the stream. Turner Creek is a natural channel well protected by state lands, providing for good water quality and fish population. No rating was provided for the fish community on this trout stream due to the lack of salmonids in the collection.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Turner Creek	2002	Shaw Lake Rd	Excellent	Good	Not rated - no salmonids
Turner Creek	2004	Upton Rd	N/A excessive silt	Marginal	

***E.coli* Monitoring:** The Barry Conservation District conducted weekly *E. coli* monitoring at one location on Turner Creek, at the Kiser Road crossing, from June to September, 2014 for the purpose of determining whether *E. coli* pollution was an issue in the watershed. Results indicate that Turner Creek is meeting water quality standards for partial body contact recreation, but it is not meeting water quality standards for total body contact recreation.

The table below shows results of *E. coli* data collected weekly from June 5 to September 18, 2014. Daily geometric means are compared to the daily maximum for total body contact and partial body contact recreation, with grey shading indicating that the daily maximum for total body contact or the 30-day geometric mean was exceeded. An underline indicates that both the maximum for total body contact and partial body contact were exceeded. Note that a result of 2420 per 100 ml is the limit of the analysis and should be interpreted as >2420 per 100 ml.

Date	Right	Center	Left	Duplicate	Daily Geometric Mean	30 Day Geometric Mean
6/5/2014	93	120	81		97	
6/12/2014	248	118	132		157	
6/19/2014	88	124	119	116	111	
6/26/2014	130	150	145	179	150	
7/3/2014	75	79	71	91	79	114
7/10/2014	68	58	55		60	105
7/17/2014	40	63	67	68	58	87
7/24/2014	345	345	291	276	313	108
7/31/2014	96	133	99	127	113	102
8/7/2014	108	86	80		91	106
8/14/2014	131	155	88		121	119
8/21/2014	488	365	260	313	347	177
8/28/2014	88	96	96	131	102	138
9/4/2014	365	411	345	272	344	177
9/11/2014	115	138	161		137	189
9/18/2014	75	105	73	99	87	172

Impairments: The Turner Creek subwatershed is not meeting its designated uses for fish consumption due to PCB and mercury levels. Since PCB and mercury contamination result from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB or mercury reduction.

Degradations: As noted above, Turner Creek is largely protected by forested state lands, with some livestock and cropping in the lower reach. Residential, commercial and industrial development flanks the Thornapple River in the Village of Middleville. There are a large number of brownfield sites in the subwatershed. Both agricultural and residential runoff affect water quality in the subwatershed. Heavy siltation and marginal habitat in Hill Creek indicate erosion issues as well as effects of channelization on the stream.

Recommendations: The Thornapple River within the subwatershed and Hill Creek require further study to determine whether they are supporting the use of other indigenous aquatic life and wildlife. *E. coli* levels require assessment to determine whether they meet water quality standards for total and partial body contact recreation. Sources of fecal contamination need to be determined. Improvement efforts in the Turner Creek subwatershed should address runoff, manure management, and aging septic systems to reduce nutrient loading, sedimentation and potential *E.coli* issues. Filter strips and riparian buffers will reduce pollutant loads. Clean up and redevelopment of brownfield areas, as well as closure of abandoned wells and removal of unused fuel storage tanks will reduce the potential for pollutants entering the ground or surface waters. Restoration of wetlands in channelized areas, especially those prioritized in Figure 5.22.A, will also be effective in filtering nutrients. Protection of wetland, riparian and headwater areas is critical in order to maintain the quality fisheries of the Turner Creek subwatershed.

Prioritized Improvement Areas: Prioritizing areas for improvement in the Turner Creek subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all management projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4 and 5.

Turner Creek Improvement Areas:

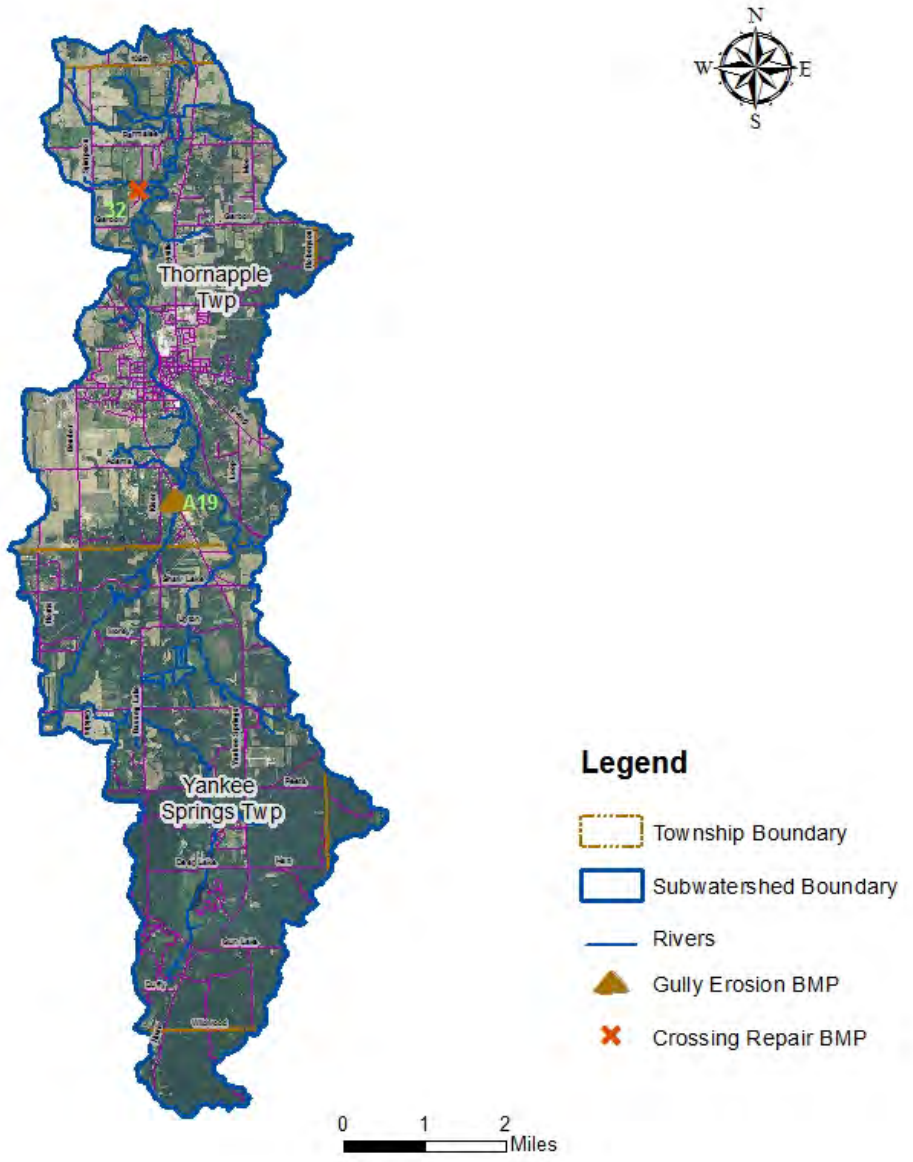
Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	32	Unnamed tributary	Culvert replacement		Sediment
2	A19	Turner Creek	Road repair		Sediment
3	TBD	All	Repair failed septic systems		*E. coli*; Nutrients
4	TBD	All	Well closure		Chemical leachate
5	TBD	All	Fuel tank removal		Chemical leachate

Prioritized Protection Areas: The highest ranking potential conservation area in the watershed extends from the Glass Creek through the Turner Creek subwatersheds. Sheltered by state land, the area south of M-179 and north of Gun Lake Road is home to important wetlands and floodplains. Surrounding this area are several large parcel inholdings whose wetland and floodplain resources should be protected.

Turner Creek Protection Areas

Rank	Ref #	Waterbody	Practice	Acres	Protection(s)
1	T3N R10 W Sec 15-16	Turner Creek	Conservation Easement	200	Wetlands, Floodplain Forest
2	T3N R10 W Sec 10-12	Hill Creek	Conservation Easement	150	Wetlands, Associated uplands

Figure 5.22.B – Turner Creek Improvement Areas



5.23 Subwatershed: McCords Creek – Thornapple River HUC: 040500070407

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
28439.3	6.15%	38.35%	0.00%	22.62%	26.73%	8.78%	1.76%	1.78%	100%

The McCords Creek subwatershed is a developing suburb of Grand Rapids, with increasing residential and commercial growth. Both the Caledonia and Whitneyville areas continue to spread outward, with residential spurs increasing on both sides of the river. With this, commercial development increases along the M-37 corridor and Whitneyville Road. Industrial areas include portions of the M-37 corridor as well as the airport industrial park and the south half of the Gerald R. Ford Airport. Forested slopes still flank areas of the river and support large-lot riverfront residential communities. Areas of row and forage crops are still prevalent in the Alaska area and the eastern portion of the subwatershed. Presettlement vegetation included oak-hickory forest to the east of the river and beech-sugar maple forest to the west. Areas of oak savannah existed north and south of Buck Lake, with emergent marsh bordering the Kettle-Campau Lake and Campbell Lake tributaries. Significant wetland loss areas include the headwaters of McCords Creek and unnamed tributaries and the emergent marsh areas around Kettle and Campau Lakes.

Protected Areas: Kent County owns two parcels on the banks of the Thornapple River in Caledonia Township. A parcel on Emmons Creek and Ruehs Park on the river in Alaska provide recreational access for the public.

Special Features: Habitat areas in the subwatershed may support the following threatened, endangered or special concern species: rock cress, Virginia snakeroot, kitten-tails, hairy-fruited sedge, creeping Whitlow-grass, flattened spike rush, prairie-smoke, green violet, goldenseal, Virginia flax, broad-leaved puccoon, Virginia bluebells, red mulberry, ginseng, yellow-fringed orchid, prairie buttercup, prairie golden asters, round pigtoe mussel and Eastern box turtle. The subwatershed is also identified as a location of hillside prairie, prairie fen and Southern floodplain forest.

Hydrologic Features:

Tributaries: McCords Creek; Unnamed Tributary (Emmons Creek); Unnamed Tributary (Kraft Creek); Unnamed Tributary (Blodgett Creek)
Drains: unnamed
Lakes: Campbell; Riley; Kraft; Campau; Kettle; Buck; Emmons; Barber; Blodgett
Dams: LaBarge Dam
Other: USGS Gage Station #04118000 – Thornapple River near Caledonia

Water Temperature Classification: McCords Creek is a cold transitional stream. The unnamed tributary from Blodgett Lake is a warm-transitional stream. The Thornapple River in this subwatershed is a warm river, and the remaining tributaries are classified as warm streams.

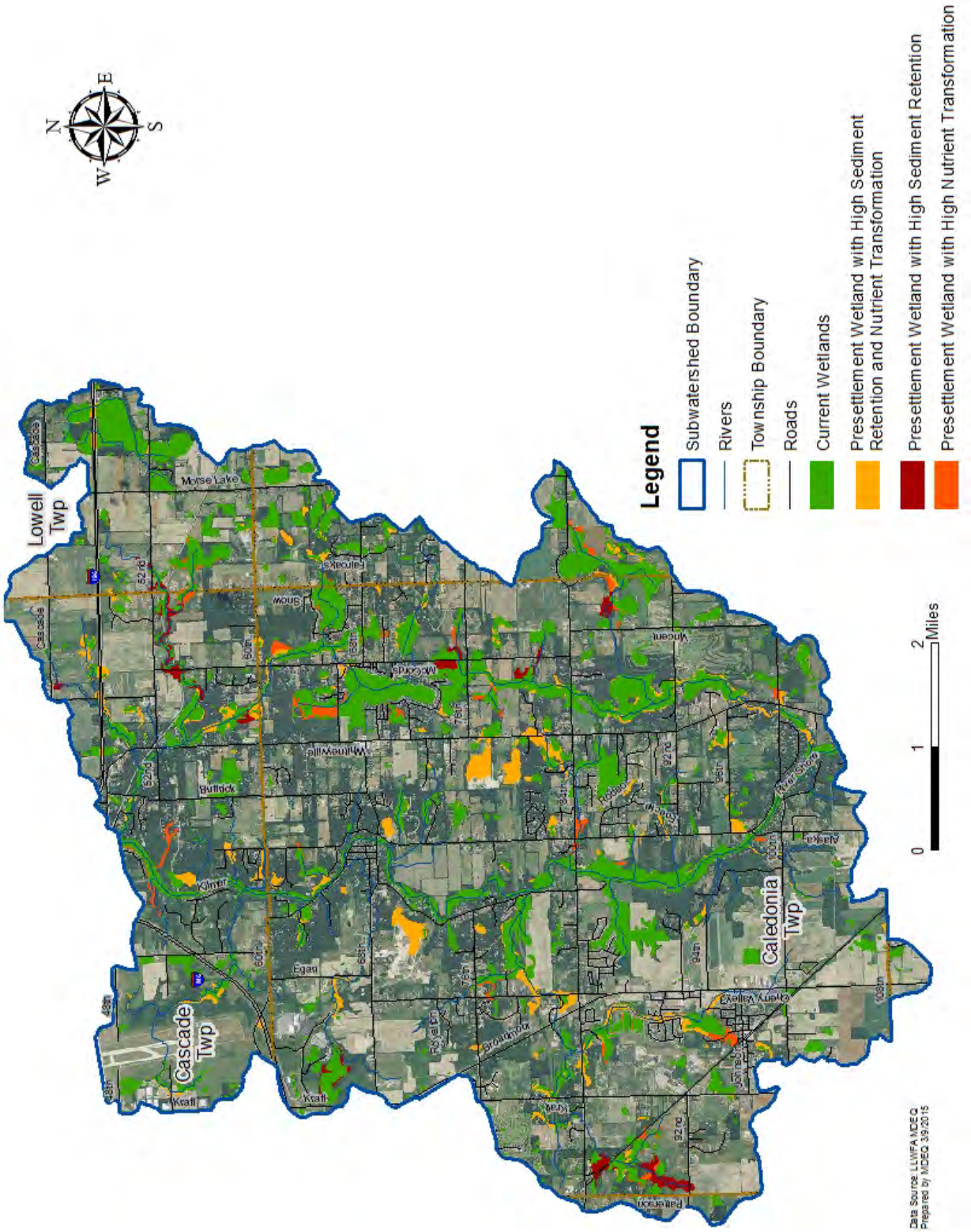


Figure 5.23.A – McCords Creek Potential Wetland Areas

Point Source Contributions: The following facilities are permitted by the MDEQ to discharge into the waters of the McCords Creek subwatershed:

Facility Name	Permit Number	Latitude	Longitude	Permitted Discharge (Max)
Caledonia WWTP	GW1810026	42.80653	-85.51442	Total Inorganic Nitrogen 5.0mg/l perday- Total Phosphorus 2.0mg/l perday--Lagoons
Campau Lake WWTP	GW1810223	42.84682	-85.44123	Lagoons
Cherry Valley Resources	MIS510426	42.8411	-85.5072	Stormwater

Environmental Contamination Sites: The McCords Creek subwatershed contains four active LUST sites, eighteen brownfield sites and one hazardous waste site. The tables below provide location data from MDEQ databases.

Active Leaking Underground Storage Tank (LUST) Sites

LUST Site Name	Latitude	Longitude	Substance Released
EZ Stop	42.785965	-85.507198	Not Listed
Ruehs Park	N.A.	N.A.	Gasoline
Caledonia Tractor & Equipment Co.	42.79365	-85.506623	Used Oil
Caledonia Tractor & Equipment Co.	42.79365	-85.506623	Diesel, Gasoline

Brownfield Sites

BEA Number	Address	Latitude	Longitude
200100821GR	5272 68th St SE	42.836765	-85.53173
200100946GR	6191 Kraft Ave SE	42.850548	-85.527277
200301131GR	6191 Kraft Ave SE	42.850548	-85.527277
201002811GR	7590 68th St	42.839944	-85.478268
201002677GR	9210 Cherry Valley Ave SE	42.79714	-85.505721
200501736GR	9240 Cherry Valley Ave	42.796923	-85.506397
200802312GR	9807 Cherry Vallley SE	42.794267	-85.508394
200802313GR	9807 Cherry Vallley SE	42.797267	-85.508394
Part 213	9633 Cherry Valley SE	42.78952	-85.50737
Part 213	330 Johnson St SE	42.78871	-85.51802
Part 201	Lake, Main, Church & South St	42.7897	-85.51254
Part 213	9210 Cherry Valley Ave SE	42.79365	-85.50662
Part 213	9807 Cherry Vallley SE	42.78597	-85.5072
Part 213	9595 Cherry Valley Ave	42.79047	-85.50758
200401340GR	9210 Cherry Valley	42.79714	-85.505721
Part 213	7590 68th St SW	42.84048	-85.47842
Part 201	6619 Snow Ave	42.84442	-85.42889
Part 213	9266 Cherry Valley Rd	42.79645	-85.50645

Hazardous Waste Sites:

Name	Address	City
Cascade Resource Recovery	6220 52nd St. SE	Grand Rapids

Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the McCords subwatershed is fully supporting assessed uses of navigation, industrial water supply and agriculture. A fishery assessment has not been completed. While this section of the Thornapple River and most tributaries in the subwatershed are fully supporting other indigenous aquatic life and wildlife, additional data is needed to make a determination of use support at the Kraft Lake outlet. Like most state waters, the subwatershed is not supporting fish consumption because of the presence of PCB in the water column and both mercury and PCB in fish tissue.

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Fully Supporting[1,3,4,5,6] Insufficient Information[2] Not Assessed[7]			
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Assessed[5,6,7]			
Fish Consumption	Not Supporting[1,2,3,4]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[2,3,4]	Mercury in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1,2,3,4]	PCB in Water Column	Y	2014

[1] AUID 040500070407-01 Includes Thornapple River
[2] AUID 040500070407-02 Includes Krafts Lake Outlet
[3] AUID 040500070407-03 Includes McCords Creek
[4] AUID 040500070407-04 Includes Unnamed Tributary to Thornapple River
[5] AUID 040500070407-05 Includes Campau Lake, 5 Miles NE of Caledonia
[6] AUID 040500070407-06 Includes Campbell Lake, 5 Miles NE of Caledonia
[7] AUID 040500070407-NA and NAL Includes Waters and Lakes only 'assessed' for Navigation, Ag, and Industrial Water Supply

Biological Surveys: Locations surveyed in the McCords Creek subwatershed are represented below with their applicable community status. Survey results indicate healthy

habitat and macroinvertebrate scores at most locations. Habitat status was not surveyed in non-wadable locations.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
McCords Creek	2004	Buttrick Ave	Excellent	Excellent	
McCords Creek	2004	Thornapple River Dr N	Excellent	Good	
McCords Creek	2004	Thornapple River Dr. S	Acceptable	Good	
McCords Creek	2009	68th St	Marginal	Not surveyed	
McCords Creek	2009	Alaska Ave	Excellent	Not surveyed	
McCords Creek	2009	52nd St	Acceptable	Marginal	

Macroinvertebrate collections conducted by the Barry Conservation District under the MiCorps program from 2008 to 2010 on Emmons Creek indicate the effects of channelization on this tributary, which has limited habitat and affected water quality, affecting both quantity and diversity of macroinvertebrates.

Location	Date Sampled	Group 1 #R	Group 1 #C	Group 2 #R	Group 2 #C	Group 3 #R	Group 3 #C	Group 1 Total	Group 2 Total	Group 3 Total	Total Score	Score Rank
Thornapple River Dr	05-04-08	3	0	2	2	4	1	15	12.4	5.4	33	Fair
Thornapple River Dr	10-19-08	0	0	3	1	2	0	0	12.2	2.2	14	Poor
Thornapple River Dr	11-02-09	1	0	6	1	3	0	5	21.3	3.3	30	Fair
Thornapple River Dr	05-23-10	0	0	3	2	3	1	0	15.2	4.1	19.3	Fair

Impairments: The McCords Creek subwatershed is not meeting its designated uses for fish consumption due to PCB and mercury levels. Since PCB and mercury contamination result from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB or mercury reduction.

Degradations: Industrial and commercial environmental contamination sites are numerous in the Kraft Avenue and Cherry Valley area. Residential development along the river and lakes impacts riparian vegetation and increases runoff. Channelization along Emmons Creek and its headwaters has impacted water quality and habitat on that stream. Stormwater systems increase flashiness in the river and its tributaries and carry residential runoff directly to the river. The high percentage of impervious surface in the subwatershed increases flashiness depletes groundwater and contributes to polluted runoff.

Recommendations: The Kraft Lake outlet requires further study to determine whether it is supporting the use of other indigenous aquatic life and wildlife. Suitability for partial and total body contact recreation needs to be assessed in the subwatershed, as does the warm water

fishery. Future planning should include more infiltration areas and retention basins to allow filtering and groundwater replenishment. There is a good potential for nutrient-rich residential and agricultural runoff reaching the river and tributaries. Improvement efforts in the McCords Creek subwatershed should address urban and agricultural runoff as well as stormwater systems to reduce nutrient and other pollutant loading and sedimentation. Brownfield redevelopment is needed in the Kraft Avenue and Cherry Valley areas. Stream buffers in cultivated fields and pastured acres and riparian buffers in residential areas along the river and streams are important to reduce pollutant loads. When opportunities arise, wetland restoration should be undertaken, especially in areas prioritized in Figure 5.23.A, to improve infiltration and reduce pollutant runoff. A septic inspection ordinance should be considered for Kent County to identify and repair failing systems, which can contribute to fecal contamination of water resources. Closure of abandoned wells and removal of unused fuel storage tanks should also be undertaken when they are identified.

Prioritized Improvement Areas: Prioritizing areas for improvement in the McCords Creek subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all management projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4.

McCords Creek Improvement Areas:

Rank	Ref #	Waterbody	Practice	Practice	Pollutant(s)
1	B15	Tributary	Reduced till	Filter strip	Nutrients, Sediment
2	B39	McCords Creek	Reduced till	Filter strip	Nutrients, Sediment
3	B16	Tributary	Stream stabilization	Fencing	Sediment, Nutrients
4	B42	McCords Creek	Stream stabilization	Fencing	Sediment, Nutrients
5	B32	Tributary	Reduced till	Filter strip	Nutrients, Sediment
6	A6	Tributary	Residential buffer		Nutrients, Sediment
7	A7	Tributary	Residential buffer		Nutrients, Sediment
8	B1	Thornapple River	Residential buffer		Nutrients, Sediment
9	B35	McCords Creek	Residential buffer		Nutrients, Sediment
10	A10	Thornapple River	Stream stabilization		Sediment, Nutrients
11	B4	Tributary	Road repair		Sediment
12	B31	Tributary	Road repair		Sediment
13	B48	Tributary	Road repair		Sediment
14	B4	Tributary	Culvert replacement		Sediment
15	TBD	All	Repair failed septic systems		*E. coli;* Nutrients
16	TBD	All	Well closure		Chemical leachate
17	TBD	All	Fuel tank removal		Chemical leachate

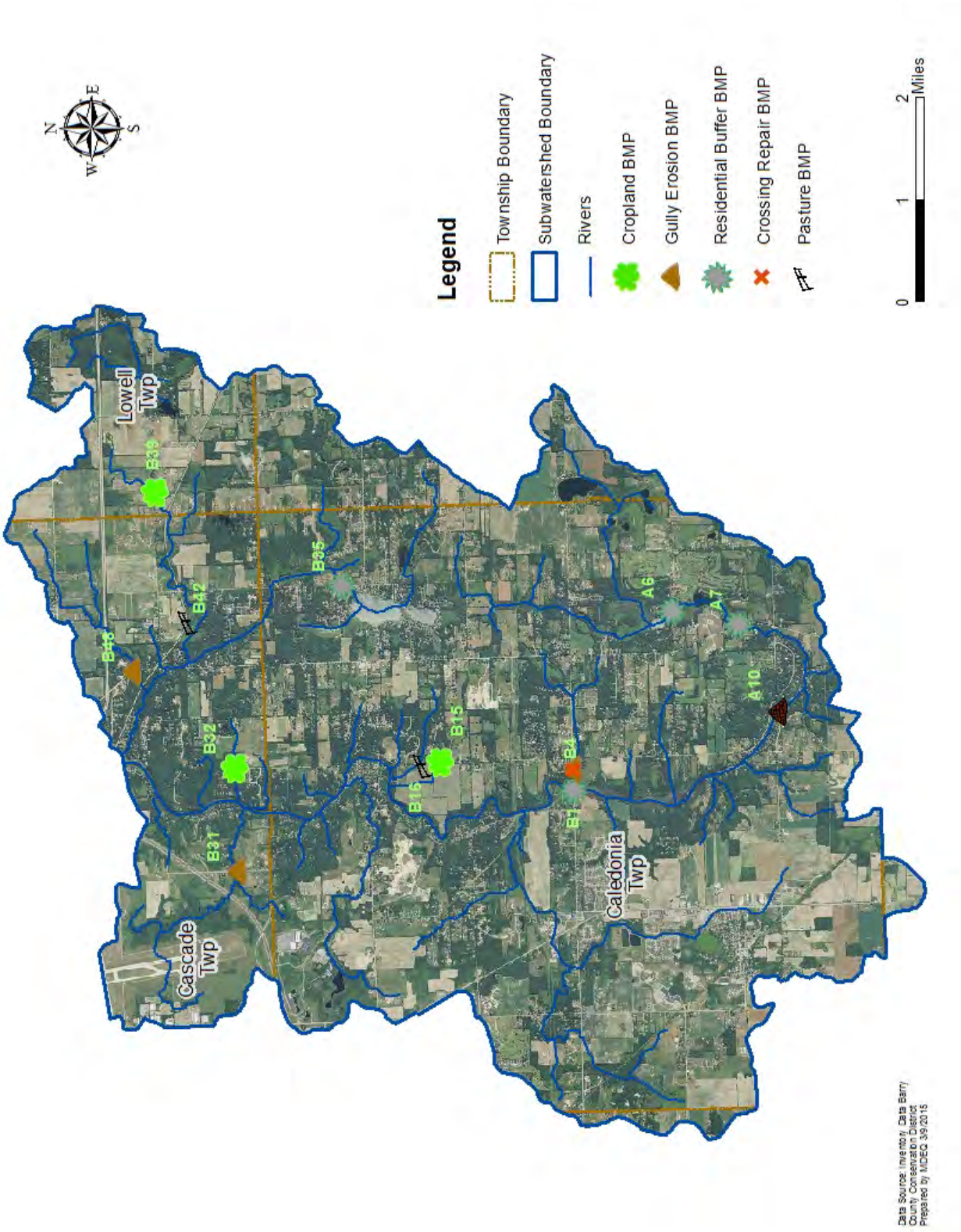


Figure 5.23.B – McCords Creek Improvement Areas

5.24 Subwatershed: Thornapple River **HUC: 040500070408**

Land Use/Cover:

Size in Acres	Impervious	Agricultural	Barren	Forest	Range	Urban/Built	Water	Wetlands	Total %
12815.7	20.41%	11.15%	0.00%	22.22%	24.81%	36.11%	4.33%	1.38%	100%

The Thornapple River subwatershed is the most urbanized area within the watershed, with intense residential development along the river and tributaries. The runways and several structures of the Gerald R. Ford Airport are located within the subwatershed, with runway runoff directed to the waters of the Thornapple. A portion of the airport industrial park is also within the subwatershed. The I-96 freeway crosses the river, and the M-6 interchange is located in the southern portion of the subwatershed. Over a mile of 28th Street a major commercial district extends into the subwatershed. A small agricultural area exists in the southeast corner of the subwatershed. Patches of forest remain in areas of steep terrain amidst the residential areas. Additional green space is maintained by three golf courses within the subwatershed. This portion of the river also contains the Cascade Dam and the Ada Dam, and much of the river is altered due to the dam impoundments. Presettlement vegetation in the subwatershed was mainly oak-hickory forest, with an area of mixed oak savannah along one unnamed tributary, and mixed hardwood swamp at the mouth of the river. Much of the wetland areas have been drained for development, but there is little open space that would permit restoration.

Protected Areas: Ada Township owns parkland along the confluence of the Thornapple and Grand Rivers. Two golf courses are owned by Kent County.

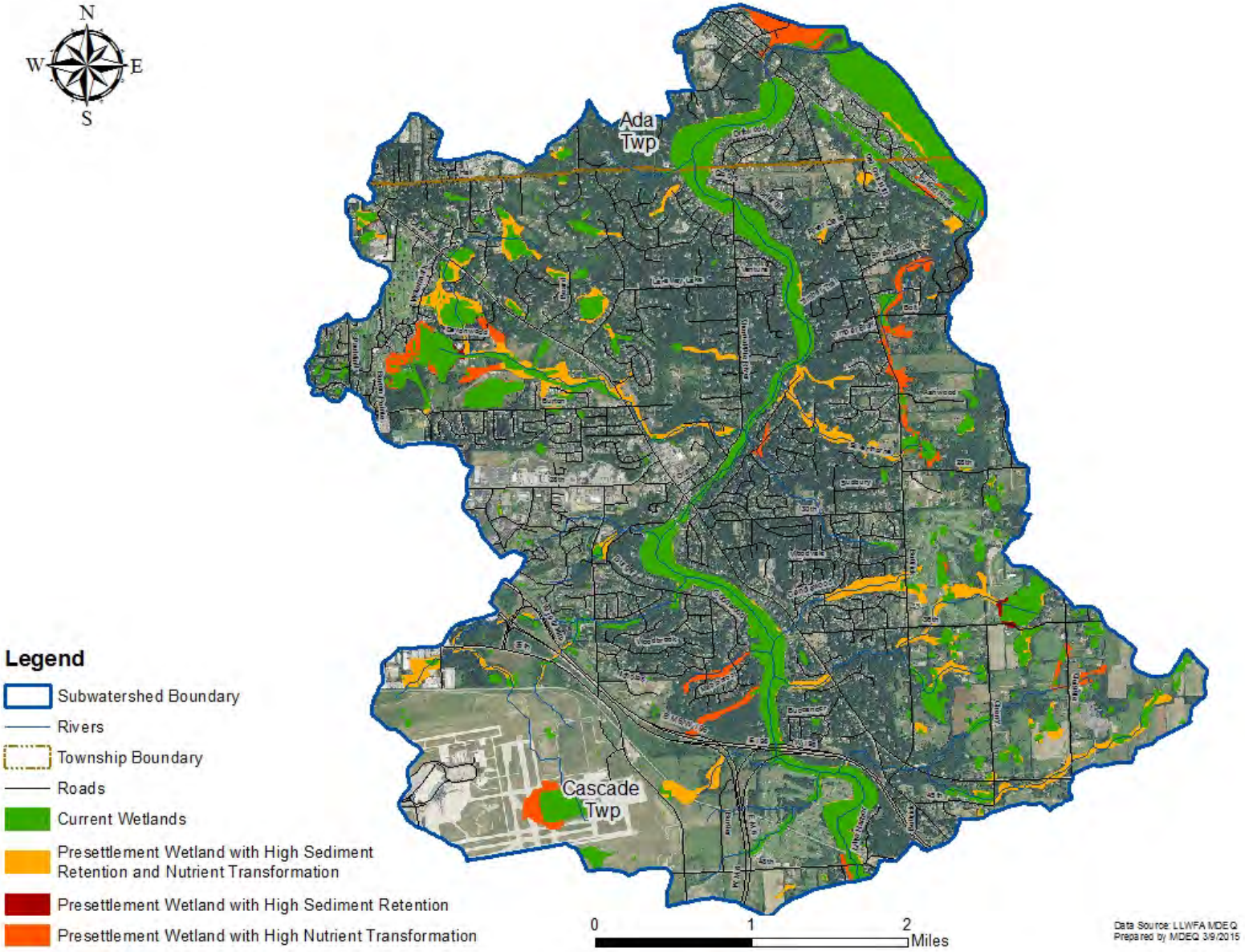
Special Features: According to the Michigan Natural Features Inventory, the Thornapple River subwatershed may be home to a variety of plant species including Missouri rock cress, rock cress, Virginia snakeroot, Western silvery aster, kitten-tails, hairy fruited sedge, creeping whitlow-grass, flattened spike rush, showy orchis, false boneset, Virginia flax, Virginia bluebells, red mulberry, ginseng, yellow fringed orchid, prairie buttercup, and prairie golden alexanders. Other listed species include the bald eagle, Eastern box turtle, and the purple wartyback and round pigtoe mussel. The area may still contain remnants of Midwest-type high prairie.

Hydrologic Features:

Tributaries: unnamed
Drains: unnamed
Lakes: Laraway; Quiggle, Walden, Wood
Dams: Cascade Dam; Ada Dam

Water Temperature Classification: The Thornapple River is classified as a warm river at this location. The unnamed tributary near Tricklewood Drive (a.k.a. Trout Creek) is classified as warm, with the tributary from Walden Lake classified as warm-transitional. The Quiggle Lake tributary and the unnamed tributary south of it are classified as cold-transitional streams.

Figure 5.24.A – Thornapple River Potential Wetland Restoration



Point Source Contributions:

Facility Name	Permit Number	Latitude	Longitude	Permitted Discharge Maximum when Noted
Best Metal Products	MIS510416	42.8994	-85.5444	Not Listed
Compass Auto Group	MIS510291	42.9000	-85.529166	Stormwater
Con-way Freight XGR	MIS510807	42.86763	-85.52064	Stormwater
Concept Industries- GR	MIS510535	42.878333	-85.538333	Stormwater
Gerald R Ford Intl Airport	MI0055735	42.870833	-85.508333	Stormwater
Janesville Acoustics-Kraft	NEC156379	42.90031	-85.52671	Not Listed
Lacks Enterprises Inc-GWCU	MI0057849	42.93444	-85.53528	Copper .17lbs/day- Mercury .000015lbs/day
Paragon Die & Engineering	MIS510144	42.9042	-85.5375	Stormwater

Environmental Contamination Sites: The Thornapple River subwatershed contains two active LUST sites, eleven brownfield sites and two hazardous waste sites. The tables below provide location data from MDEQ databases.

Active Leaking Underground Storage Tank (LUST) Sites

LUST Site Name	Latitude	Longitude	Substance Released
Forest Hills Public Schools	42.920548	-85.505158	Not Listed
United Airlines	42.883137	-85.524358	Not Listed

Brownfield Sites

BEA Number	Address	Latitude	Longitude
201303375GR	6540 E Fulton St	42.953425	-85.48936
201002664GR	660 Ada Dr SE	42.954535	-85.48823
201002663GR	680 Ada Dr SE, 630, 636 Mars Dr SE	42.95233	-85.490368
201002749GR	7065 Ada Dr	42.950447	-85.494537
201103020GR	7580 E Fulton St	42.955299	-85.483042
201203282GR	7586 Fulton St SE	42.956721	-85.486648
201203281GR	7590 Fulton St SE	42.954594	-85.480775
200100959GR	7580 E Fulton St	42.95515	-85.483181
Part 213	552 Ada Dr SE	42.95471	-85.48708
200902420GR	5757 28th St SE	42.915955	-85.525094
Part 201	6025, 6035 28th St SE	42.91375	-85.51935

Hazardous Waste Sites:

Name	Address	City
Amway Corporation	7575 E. Fulton Rd.	Ada
Lacks Industries, Inc.	1601 Galbraith SE	Grand Rapids

Water Quality Issues:

Designated Uses: According to the *2014 Integrated Report*, the Thornapple River subwatershed is fully supporting assessed uses of navigation, industrial water supply and agriculture. A fishery assessment has not been completed. While this section of the Thornapple River and most tributaries in the subwatershed are fully supporting other indigenous aquatic life and wildlife, additional data is needed to make a determination of use support at the unnamed tributary upstream of the Gerald R. Ford Airport. An unnamed tributary near Tricklewood Drive (a.k.a. Trout Creek), which has been affected by chemicals used in deicing at the Gerald R. Ford Airport, is not supporting this use, and a TMDL is scheduled for 2016. Progress is being made toward redirecting this point source pollutant through a filtering system and into the river instead of this small stream. Like most state waters, the subwatershed is not supporting fish consumption because of the presence of PCB in the water column and in fish tissue.

Designated Use	Use Support	Cause	Pollutant?	TMDL Schedule
Total Body Contact Recreation	Not Assessed			
Partial Body Contact Recreation	Not Assessed			
Navigation	Fully Supporting			
Industrial Water Supply	Fully Supporting			
Agriculture	Fully Supporting			
Warm Water Fishery	Not Assessed			
Other Indigenous Aquatic Life and Wildlife	Fully Supporting[1] Not Supporting[2] Insufficient Information[3] Not Assessed[4]	Bacterial Slimes	Y	2016
Cold Water Fishery	Not Assessed			
Fish Consumption	Not Assessed[4]			
Fish Consumption	Not Supporting[1,2,3]	PCB in Fish Tissue	Y	2014
Fish Consumption	Not Supporting[1,2,3]	PCB in Water Column	Y	2014

[1] AUID 040500070408-01 Includes Thornapple River

[2] AUID 040500070408-02 Includes Unnamed Tributary to Thornapple

[3] AUID 040500070408-03 Includes Unnamed Tributary to Thornapple River upstream of Gerald Ford Airport

[4] AUID 040500070408-NA and NAL Includes Water and Lakes only 'assessed' for Navigation, Ag and Industrial Water Supply

Biological Surveys: Only one location has been documented in biological survey tables in the Thornapple River subwatershed since 1991. This location is on an unnamed tributary locally known as Trout Creek, where deicing runoff from the Gerald R. Ford Airport is discharged. Survey results in 2004 indicate a good habitat and acceptable macroinvertebrate score despite evidence of chemical presence. Notes on the 2009 biological survey indicate that

this location was sampled in early May, 2007 and the macroinvertebrate community was rated poor. Excess bacterial/fungal slimes were present and unnatural conditions were evident. This condition was attributed as seasonal, due to the contaminated winter runoff. It is important to note that in 2014, construction is underway that will redirect this runoff through a filtration system and into the Thornapple River.

Subwatershed	Survey Year	Location	Macro-invertebrate Community Status	Habitat Status	Fish Community Status if surveyed
Thornapple River	2004	Tricklewood Dr	Acceptable	Good	

Macroinvertebrate collections conducted by the Barry Conservation District under the MiCorps program from 2008-2010 at the Tricklewood Drive location indicate both lack of abundance and lack of diversity in the macroinvertebrate community. Documentation of bacterial slimes and odors, consistent with the MDEQ report, was also made during sampling sessions.

Location	Date Sampled	Group 1 #R	Group 1 #C	Group 2 #R	Group 2 #C	Group 3 #R	Group 3 #C	Group 1 Total	Group 2 Total	Group 3 Total	Total Score	Score Rank
Tricklewood	5-4-08	0	0	1	0	3	0	0	3	3.3	6.3	Poor
Tricklewood	10-19-08	0	0	2	0	3	0	0	6	3.3	9	Poor
Tricklewood	11-4-08	5	0	4	0	4	0	5	12	4.4	21	Fair
Tricklewood	11-2-09	1	0	4	1	2	1	5	15.2	3.2	23	Fair
Tricklewood	5-23-10	2	0	3	0	5	1	10	9	6.5	26	Fair

Impairments: The Thornapple River subwatershed is not meeting its designated uses for fish consumption due to PCB levels. Since PCB contamination result from atmospheric deposition, it is not within the scope of this management plan to make effective recommendations for PCB reduction. An unnamed tributary known as Trout Creek is not supporting the use of other indigenous aquatic life and wildlife due to bacterial slimes. This condition is attributed to airport de-icer which is channeled to the stream from runway drains at the Gerald R. Ford Airport. A 2013 NPDES permit requires the airport to reduce de-icer levels to this stream and others currently taking the chemical. The airport is constructing a new runoff system that will direct the runoff through a filtration system and into the Thornapple River.

Degradations: A high percentage of impervious surfaces, coupled with industrial and transportation uses in subwatershed contribute to non-point source pollution in the subwatershed. Several permitted discharges already occur, and there are many brownfield sites in the industrial corridor.

Recommendations: The condition of the fishery in the Thornapple River subwatershed needs to be assessed, as does the waterbody's support of total and partial body contact recreation. Continued monitoring of Trout Creek, is needed to determine whether habitat improves as a result of changes in management of de-icer runoff from the Gerald R. Ford Airport. Likewise,

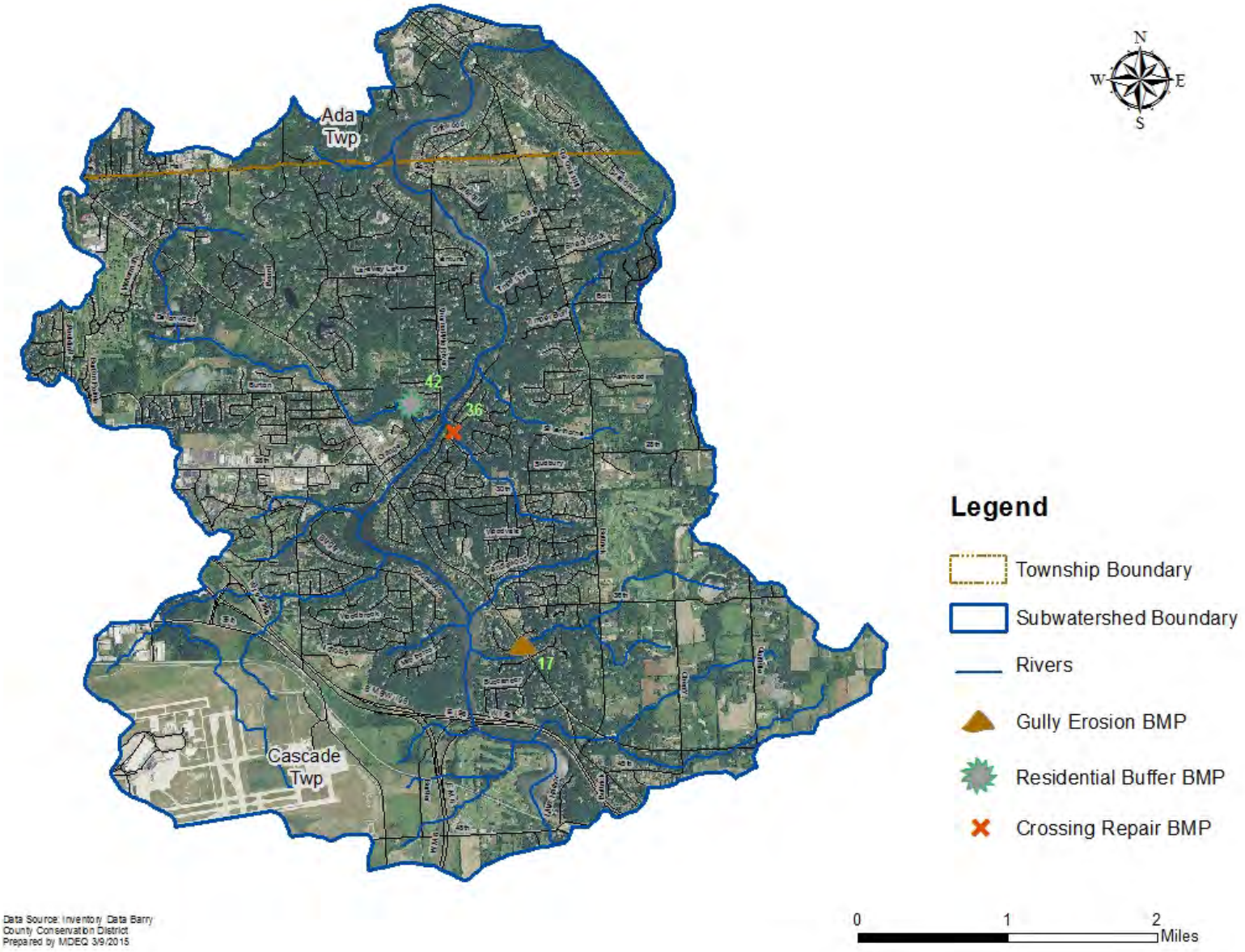
the new outlet for this runoff into the Thornapple River needs to be regularly monitored to determine the effects on river habitat. Pollution prevention planning is critical in the industrial areas. Opportunities for brownfield redevelopment should be sought to reduce potential leaching of contaminated soils into surface and ground water. Improved stormwater management, including enhanced use of retention or detention basins will reduce flashiness and decrease the amount of polluted runoff entering the waterway. Addressing road erosion will reduce sedimentation in the watershed. Residential buffers along the river are also important to assuring water quality in this subwatershed. A septic inspection ordinance should be considered for Kent County to identify and repair failing systems, which can contribute to fecal contamination of water resources. Restoration of wetlands at tributary headwaters, especially in areas prioritized in Figure 5.24.A, is important to maintain and improve water quality in the subwatershed. Opportunities to close abandoned wells and remove unused fuel storage tanks should also be pursued.

Prioritized Improvement Areas: Prioritizing areas for improvement in the Thornapple River subwatershed is based upon the needs addressed above as well as field assessment data. The ranking expressed below indicates projects that would yield the highest benefit to the watershed. The cooperation of private landowners is necessary in nearly all management projects; therefore, future requests for project support will be based both on the project rank and the willingness of landowners to adopt the specified practice(s). Implementation of listed practices outside of the specific areas listed below will also yield valuable water quality improvement. Load reductions for the practices listed below are expressed in Appendix 4 and 5.

Thornapple River Improvement Areas:

Rank	Ref #	Waterbody	Practice	Pollutant(s)
1	Head-waters	Tributaries	Wetland restoration	Nutrients, Sediment
2	42	Thornapple River	Residential buffer	Nutrients, Sediment
3	17	Unnamed tributary	Road repair	Sediment
4	36	Unnamed tributary	Culvert replacement	Sediment
13	TBD	All	Repair failed septic systems	*E. coli;* Nutrients
14	TBD	All	Well closure	Chemical leachate
15	TBD	All	Fuel tank removal	Chemical leachate

Figure 5.24.B – Thornapple River Improvement Areas



6. POLLUTANT LOADS, LOAD REDUCTIONS AND PRIORITIES

6.1 Estimation of Pollutant Loads

Pollutant loads are estimated for the TRW using both models and monitoring data. For the purposes of the Thornapple River Watershed Management Plan, the STEPL Model has been used to determine sediment, nutrient, biological oxygen demand (BOD) and total suspended solid (TSS) loads, where applicable, for the following land management practices: cropping; pasturing; feedlots; urban land use (residential and industrial); wetland restoration; as well as for gully and streambank erosion. The Michigan Department of Environmental Quality has developed a comparative model for determining hydrologic flow trends. This model was utilized to develop the *Thornapple River Watershed Flashiness Report* in Appendix 2. Models for other pollutant loads, including hazardous waste, E. coli and temperature, are not currently available. For *E. coli* and temperature, existing monitoring data has been used to estimate whether particular stream reaches are meeting or exceeding water quality standards for the purpose of this Management Plan. *E. coli* levels were monitored at 14 sites on the Thornapple River and its tributaries over a 16-week period in 2013-2014 by the Barry Conservation District Staff to determine locations where *E. coli* levels were exceeding Michigan's water quality standards. Monitoring data, provided in Appendix 4, was used to determine locations where further study to identify potential sources should take place. Temperature data was logged at five locations on tributaries between 2012 and 2014. This data was used to determine whether cold water streams were meeting water quality standards for temperature. This data will be used to provide a baseline for future BMPs designed to reduce stream temperature. As a part of the implementation process, benchmark data for these pollutants will have to be verified to determine current conditions. When implementation measures are undertaken, pollutants to be addressed by a particular BMP will be determined, and then the appropriate pre-and post-implementation monitoring and/or measurement strategies will be utilized to determine actual load reductions to measure the success of plan strategies for load reductions. For example measurements of loads calculated by applying RUSLE to location-specific conditions will be used to determine actual load contributions and reductions for BMPs installed through implementation activities. If temperature is also to be addressed by the BMP, temperature loggers will be deployed to measure temperature changes as a result of the BMP. This will provide the opportunity to ground-truth pollutant load modeling.

6.1.1 Methodology for Data Inputs in STEPL Modeling

The following is a description of the methods utilized to collect data and populate the Spreasheet Tool for the Estimation of Pollutant Load (STEPL) Model to determine pollutant loads and load reductions for selected best management practices. STEPL Version 4.0, developed for the U. S. Environmental Protection Agency by Tetra Tech, Inc., was used for this plan.

In order to most accurately represent census data within the STEPL model, the Thornapple watershed's 24 subwatersheds were divided into three county categories. Subwatersheds were assigned to a county when the majority of the subwatershed's landmass was within that county. Distribution is as follows:

Eaton County	Barry County	Kent County
Butternut Creek	Quaker Brook	McCords Creek – Thornapple River
Milbourn, Allen & Crane Drain	Mud Creek	Thornapple River
Thornapple Drain	High Bank Creek	
Fish Creek – Little Thornapple River	Cedar Creek	
Hayes Drain – Thornapple River	Thornapple Lake – Thornapple River	
Darken & Boyer Drain – Thornapple River	Fall Creek	
Lacey Creek	Butler Creek – Thornapple River	
Thompson Creek – Thornapple River	Glass Creek	
Shanty Creek	Algonquin Lake – Thornapple River	
Scipio Creek – Thornapple River	Turner Creek – Thornapple River	
Headwaters Mud Creek	Duncan Creek	

6.1.1.1 Input Data

Inputs into the STEPL model for each county are provided in Appendix 4. Land use data by subwatershed from the Annis Water Resources Institute published in the Grand River Watershed Management Plan was utilized to populate the land use table for each subwatershed. The weather station selected to provide rain correction factors was the Michigan Grand Rapids WSFO for Barry and Kent Counties, and the Michigan Lansing WSO Airport for Eaton County.

No paved feedlots were listed for the watershed, so the Feedlot Percent Paved was gaged at 0-24%. For agricultural animals total animal units per type, per county were determined using National Agricultural Statistics Survey data from 2007 for each county. The number of animal units at known farms in each subwatershed (as determined by visual head count and BPJ) were then subtracted from the total animals units in each county. The remaining animal units per county were divided by the number of acres per county to determine the number of animals by type per acre. The number of each animal type per acre was then multiplied by the number of acres in each subwatershed to determine the base number of animal units per subwatershed. Then, for farms where animal numbers were calculated, these numbers were added back in to the base number of animal units per subwatershed to provide a total. The animal unit worksheet is provided in Appendix 4.

The septic failure rates for each county were modified from the default to 26%, the failure rate cataloged through data collected by the Barry-Eaton District Health Department's Time of Sale or Transfer program, which requires well and septic inspections when parcels are sold or

transferred[18]. A direct discharge reduction rate of 25% of failed septic sytems was applied to each subwatershed to determine load reductions associated with repair or replacement of these systems over a ten-year implementation period.

Default settings were used for USLE parameters, reference runoff curve numbers, and nutrient concentrations for runoff and shallow ground water, excepting numbers for the User Defined category of wetlands. Best Professional Judgment (BPJ) was used to determine the following measurements for wetlands: the reference runoff curve was assigned the following values: A-39; B-60; C-73; D-79. Nutrient concentrations in runoff were established as: N-0.1; P-0.1; BOD-0.1. Nutrient concentrations in shallow ground water were established as: N-0.1; P-0.009; BOD-0. Average soil hydrologic groups were determined for the model using USDA soil maps for each subwatershed.

Urban land use distribution was calculated for each subwatershed by measuring polygons representing each land use on aerial photograph layers using the USDA-NRCS Toolkit.

No data was inputted regarding irrigation as it is not commonly used in the watershed.

6.1.1.2 Pollutant Source and Cause Data

Road-stream crossing surveys conducted on over 500 sites throughout the watershed by the Barry Conservation District in 2006-2007 indicate habitat issues including the predominance of sand and muck substrate, lack of woody debris and severely undercut banks in channelized areas (Appendix 3). Agricultural erosion was noted at several locations, as was bank collapse due to channel design and lack of riparian buffers. Also noted were urban runoff and erosion areas, largely due to lack of riparian buffers.

An additional windshield survey of critical areas in the watershed was conducted in 2011 - 2013 in conjunction with a fish passage barrier study by the Barry Conservation District. The windshield survey catalogued visible sources of non-point pollution. Locations where erosion was present were measured in the field to calculate total sediment contributions. Stream lengths at cattle access sites and sites with inadequate buffers were measured using aerial photographs. The general condition and functionality of all culverts and bridges were surveyed as a part of a fish passage barrier study. Undersized, perched, plugged or damaged culverts were considered as critical areas when they impeded fish passage or caused severe erosion, impoundment or scour pools.

Locations of pollutant sources were determined through these surveys of each subwatershed in the watershed. Data from these surveys appears in tabular form by subwatershed in Appendix 5 and utilized to identify improvement areas by subwatershed in Section 5. Locations were identified by crossroad, road-stream crossing and, when possible, address. Locations were also mapped in the field on printouts of aerial photographs. Photographs of sites were taken when possible. Notations for each site also included measured length, width and depth of gully or stream bank erosion when sites were under 500' in length and accessible. Gully erosion on roads was determined to form in one year or less based on the road management practice of filling gullies following erosion-causing storm events. The Modified Bank Erosion Hazard Index

18 Time of Sale or Transfer (TOST) Ordinance – The First Three Years.

formula was utilized to determine the lateral recession rate for stream bank erosion when eroding banks were identified. For unbuffered fields or lawns, approximate lengths were noted. Sites were then measured for actual length using the aerial photograph layer in the USDA-NRCS Toolkit. Soil type notations were included for erosion sites. If pastured animals were present, approximate numbers of animals were determined by head-count. Field sizes associated with each pollutant and relevant best management practice were determined by outlining the perimeters of drainage areas for each practice using USDA-NRCS topographic maps in Toolkit, then calculating the polygon's area in acres. All latitude and longitude locations provided for BMP locations are associated with the nearest road-stream crossing of the water body receiving the drainage from the BMP area. When soil designations from field notes did not match soil types listed in the STEPL model, the following substitutions were made:

Field Note Soil Designation	STEPL Soil Textural Class Used
Gravel/loam	Sands, loamy sands
Sand/gravel	Sands, loamy sands
Sandy loam	Sandy loam
Gravel	Sands, loamy sands
Clay	Clay
Sand	Sands, loamy sands
Clay/loam	Clay loam
Sand/silt	Silt loam
Loam	Sandy loam

Tables outlining improvement areas, categorized by Best Management Practice, were developed for each subwatershed. Field data, including site code, dimensions, field size, longitude and latitude were used to populate the tables. Data from the tables were then inputted into the STEPL model under appropriate land use categories (Cropping, Pasture, Wetland, Urban, Feedlot) or pollutant source categories (gully erosion or streambank erosion).

6.1.1.3. Best Management Practices Utilized

To address key pollutants in the Thornapple River Watershed, the following Best Management Practices (BMPs) were selected from the STEPL BMP List:

Land Use	STEPL BMP	Application
Cropland	Filter Strip	No buffer along stream bank; reduced tillage or cover crop in use
Cropland	Reduced Tillage combined with Filter Strip (combined BMP)	No buffer along stream bank; traditional tillage and no cover crop in use
Pasture	Filter Strip	Pasture along stream bank
Pasture	Stream bank Stabilization and Fencing	Pasture along stream bank with no livestock exclusion
Feedlots	Waste Storage Facility	Earthen feedlots with no liquid storage facility
Urban	Vegetated Filter Strips	Residential or other urban stream bank with no buffer
Gravel Roads	Gully Erosion Repair	Road material erosion into stream at road

Land Use	STEPL BMP	Application
		crossing
Stream Bank Erosion	Stream Bank Stabilization	Eroding stream banks noted at road-stream crossings

All practices listed above were utilized as provided in the STEPL Model excepting those for pasture. No BMPs were provided in the model for pastures. To create pasture BMPs, load reductions for filter strips and stream bank stabilization and fencing were duplicated from the same practices expressed under cropland BMPs.

6.1.1.4 Wetland Restoration Methodology

In order to determine the load/reductions associated with the restoration of presettlement wetland within current agricultural land in seven subwatersheds with critical wetland loss, assistance was sought from MDEQ staff, who applied the following methodology:

- Current wetlands were removed from the presettlement wetland shapefile provided by the Landscape Level Wetland Functional Assessment (LLWFA)for the Thornapple River Watershed
- The modified presettlement file was intersected with NOAA's 2006 CCAP Agricultural lands
- Wetlands that performed high for sediment and other particulate retention and nutrient transformation were selected for restoration

The results of this were then intersected with SSURGO soil data to determine hydrologic group. The hydrologic groups were determined by NRCS's Soil Data Viewer and are based on the viewer's default dominant condition. Selected wetlands total acreage was determined, and acreage per hydrologic group were determined.

Figure 6.1.1.4 Wetland Restoration Areas by Hydrologic Group

Subwatershed	Hydrologic Group A Acres	Hydrologic Group B Acres	Hydrologic Group C Acres	Total Acres
Butternut	0.8	48.9	53.5	103.2
Milbourn	25.6	289.3	5.8	320.7
Thornapple Drain	245.4	256.3	50.3	552
Fish Creek	4.9	87.4	0	92.3
Darken & Boyer	68	105.9	2.7	176.6
Thornapple River	11.4	47.5	11.9	70.8
Mud Creek	0	18.5	0	18.5

This data was entered into the STEPL model by Barry Conservation District Staff as follows: Acres of wetlands per each of the three hydrologic group were entered into the STEPL Model by subwatershed under the Cropland spreadsheet, with total acres entered as line 4. Corresponding hydrological groups were selected, with D class utilized for the User Defined category. The wetland event mean concentrations for nutrients were obtained from the Rouge River Watershed Management Plan and are as follows:

Total phosphorous concentration – 0.08 mg/l

Total Kjeldahl Nitrogen concentration – 0.79 mg/l

The NRCS's curve number of 78 was used for wetlands. Wetland loads were subtracted from current loads to estimate load reductions from wetland restoration in each subwatershed.

The pollutant load estimates expressed below represent the best data and modeling available to determine conditions in the TRW. It is important to note that applied models and monitoring data provide only estimates of current pollutant loads.

6.2 Sediment

6.2.1 Sediment Sources, Causes and Effects

Sources: Sediment within the watershed's streams and lakes comes from both upland and in-stream erosion. Upland sources include construction sites, cropland, roads and storm water. In-stream sources are road crossings, unstable banks and channelization, dredging and straightening of streams and ditches.

Causes: Soil exposed by vegetative disturbance, when not protected by proper soil erosion and sedimentation practices, makes its way into water bodies through wind and water erosion. Gully erosion on fields without filter strips or stabilized outlets carries sediment to waterways. Conventional tillage and harvesting practices, which loosen soils and remove most or all of a field's vegetative cover, increase sedimentation through erosion. Overgrazed pasturelands and lands cleared for development also contribute to runoff into waterways. Dirt roads that wash out during storm events or direct runoff into wetlands, streams and creeks add to the sediment load. Similarly, sediment collected on impervious surfaces, such as paved roads and parking lots, is carried into waterways during storm events via storm drains.

Especially in the upper reaches of the watershed, channelization, (straightening, clearing and dredging) of streams for use as drains increases sedimentation through bank scour and by increasing flow and flashiness during storm events, which destabilizes banks within and beyond the channelized streams. Road crossings with undersized, poorly maintained or poorly aligned culverts or bridges cause bank erosion. Unstable banks, whether the result of natural stream meanders, vegetation removal or uncontrolled livestock or human access, contribute to sediment loading.

Effects on Designated and Desired Uses: Sediment has the widest range of effects on designated and desired uses in the TRW. Sediment severely impacts the warm water and cold water fishery, other aquatic life and wildlife, and navigation throughout the watershed. Its effects similarly impact the potential for education and interpretation, wetland resources, and critical natural area resources. Sediment loading also affects the agricultural and industrial water supply. Sediment blankets a water body's natural substrate, covering riffles and filling pools used by fish and other aquatic species. Turbidity caused by sediment damages wildlife habitat and increases water temperature. Excessive sediment also alters stream morphology as deltas develop and create impoundments or redirect flow. Such buildup can impair navigation in streams and the mainstem river channel. Sediment also interferes with water withdraw systems used for irrigation or industry.

6.2.2 Sediment Loads

Sediment contribution calculations have been made for the Thornapple River Watershed using the STEPL Model. Sediment delivery is calculated as a factor of total erosion.

Figure 6.2.2.1 Sediment Delivery from Land Use by Subwatershed (tons/year)

Watershed	Cropland	Pastureland	Forest	Wetland	Sediment
Butternut Creek	13,452	954	40	799	1,074
Milbourn Drain	33,103	1,217	119	911	2,491
Thornapple Drain	26,919	931	57	152	1,977
Fish Creek	41,308	815	107	357	3,001
Hayes Drain	24,784	1,086	73	125	1,837
Darken & Boyer Drain	32,246	609	88	123	2,330
Lacey Creek	29,776	992	112	869	2,237
Thompson Creek	26,563	558	80	184	1,930
Shanty Creek	18,107	984	59	408	1,378
Scipio Creek	26,049	1,309	132	1,481	2,041
Headwaters Mud Creek	40,647	295	99	1,339	2,986
Quaker Brook	24,009	636	131	1,714	1,674
Mud Creek	46,431	520	217	1,260	3,060
High Bank Creek	39,261	1,074	241	5,195	2,892
Cedar Creek	41,559	1,963	459	7,108	3,228
Thornapple Lake	24,944	821	208	2,407	1,793
Fall Creek	19,353	1,128	235	4,804	1,613
Butler Creek	27,894	1,427	229	1,501	1,962
Glass Creek	23,636	1,558	541	5,081	1,947
Algonquin Lake	37,900	1,314	428	3,413	2,721
Duncan Creek	38,201	508	92	651	2,493
Turner Creek	23,910	1,684	459	1,855	1,763
McCords Creek	44,580	6,215	394	1,864	5,885
Thornapple River	5,841	2,599	175	1,355	1,106
TOTALS	**710,473**	**31,199**	**4,774**	**44,959**	**55,420**

Based on the STEPL calculations of sediment delivery by subwatershed, as well as results of water quality assessments from the 2014 IR, subwatersheds have been prioritized for sediment load reduction. Prioritization is based on total sediment load, with additional prominence given to the two subwatersheds that are not currently meeting the designated use for other indigenous aquatic life and wildlife: Church Creek in Milbourn Drain subwatershed and the Little Thornapple River in the Fish Creek subwatershed, as well as the Mud Creek subwatershed, which is not meeting its designated use as a warm water fishery. In the Unnamed Tributary of the Thornapple River subwatershed (Trout Creek,) the identified pollutant, de-icing fluid, and

the current measures underway to reduce this load from the creek have lowered its priority ranking for sediment reduction.

Figure 6.2.2.2 Priority Subwatersheds for Sediment Reduction

Sediment Delivery		Tons/Year
Priority	**Watershed**	**Sediment**
High Priority	Mud Creek	3,060
	Fish Creek	3,001
	Milbourn Drain	2,491
	McCords Creek	5,885
	Cedar Creek	3,228
	Headwaters Mud Creek	2,986
	High Bank Creek	2,892
	Algonquin Lake	2,721
Medium Priority	Duncan Creek	2,493
	Darken & Boyer Drain	2,330
	Lacey Creek	2,237
	Scipio Creek	2,041
	Thornapple Drain	1,977
	Butler Creek	1,962
	Glass Creek	1,947
	Thompson Creek	1,930
	Hayes Drain	1,837
	Thornapple Lake	1,793
	Turner Creek	1,763
	Quaker Brook	1,674
	Fall Creek	1,613
Low Priority	Shanty Creek	1,378
	Thornapple River	1,106
	Butternut Creek	1,074

Best management practices targeted to reduce sediment loads include filter strips, reduced tillage practices and grass swales on croplands; filter strips, fencing and streambank restoration on pastureland; vegetated buffers on residential and other urban lands; road repair on gravel roads; and streambank stabilization on eroding streams. Descriptions of these best management practices can be found in the *MDEQ Nonpoint Source Best Management Practices Manual*[19]. In Barry County, a stormwater ordinance is recommended to reduce urban runoff and associated pollutants. The Eaton County Drain Commmission provides clear guidelines for stormwater development in its Eaton County Stormwater Manual and Act 40 Drains Design and Construction Regulations, at http://www.eatoncounty.org/departments/drain-

19 http://www.michigan.gov/deq/0,4561,7-135-3313_3682_3714-118554--,00.html

commissioner/113-departments/drain-commissioner/447-rules-of-the-eaton-county-drain-commissioner . The Proposed Model Storm Water Ordinance for Kent County Townships and Municipalities has provided a template for Kent County communities within the TRW (https://www.accesskent.com/Departments/DrainCommissioner/pdfs/kc_modelordinance.pdf) and may provide a solid model for Barry County communities to follow. For Milbourn Drain, Fish Creek and Mud Creek, all county drains, a stream buffer ordinance, such as is provided by the Huron River Watershed Council at http://www.hrwc.org/wp-content/uploads/2009/11/HRWC_riparianbuffer_model_ordinance.pdf , is recommended to reduce sediment inputs. For the urban communities in Kent County, as well as the cities of Charlotte and Hastings, use of Low Impact Design (LID) practices, including bioswales, rain gardens, green roofs and rain barrels, is encouraged to reduce the impact of stormwater and associated pollutant runoff. *The Low Impact Development Manual for Michigan*, developed by the Southeast Michigan Council of Governments (SEMCOG), provides extensive information on design and implementation of LID practices. SEMCOG's web-based LID database found at, http://www.semcog.org/Data/lid.cfm can also help communities and businesses select LID practices and determine their general benefits and costs based on their current use in Michigan SEMCOG communities.

6.2.3 Sediment Load Reduction

Sediment load reductions by practice are calculated using the STEPL Model. BMPs selected to address sediment loading in the TRW are: reduced tillage and/or filter strips on crop fields; streambank stabilization and/or fencing for pastures; residential buffers in urban areas; grassed waterways for gully erosion; and streambank stabilization for eroding banks. Individual listings of subwatershed reductions by BMP are found in Section 5. BMPs, locations and acres are listed in Appendix 5, along with cost estimates for implementation. Through the course of plan implementation, other, site-specific, practices including non-agricultural BMP's may be substituted for those used in the STEPL Model to estimate load reductions. RUSLE calculations will be used to determine actual sediment and nutrient load reductions for BMPs installed in the TRW.

Figure 6.2.3.1 Sediment Load Reductions for STEPL BMPS in Tons/Year

Watershed	Sediment	Sediment Reduction	%Reduction
Butternut Creek	1,074	37	3.4
Milbourn Drain	2,491	115	4.6
Thornapple Drain	1,977	74	3.8
Fish Creek	3,001	63	2.1
Hayes Drain	1,837	89	4.9
Darken & Boyer Drain	2,330	467	20.0
Lacey Creek	2,237	49	2.2
Thompson Creek	1,930	90	4.7
Shanty Creek	1,378	20	1.4
Scipio Creek	2,041	202	9.9
Headwaters Mud Creek	2,986	0	0.0

Watershed	Sediment	Sediment Reduction	%Reduction
Quaker Brook	1,674	25	1.5
Mud Creek	3,060	9	0.3
High Bank Creek	2,892	7	0.2
Cedar Creek	3,228	50	1.6
Thornapple Lake	1,793	36	2.0
Fall Creek	1,613	17	1.0
Butler Creek	1,962	166	8.4
Glass Creek	1,947	29	1.5
Algonquin Lake	2,721	15	0.5
Duncan Creek	2,493	300	12.0
Turner Creek	1,764	0	0.0
McCords Creek	5,885	1	0.0
Thornapple River	1,106	0	0.0
TOTALS	**55,420**	**1,859**	**3.35**

Figure 6.2.3.2 Sediment Load Reductions for Gully Repair

Watershed	Annual Load (ton)	Load Reduction (ton)
Hayes Drain	23.1	22.0
Lacey Creek	104.8	99.6
Thompson Creek	26.4	25.0
Shanty Creek	14.0	13.3
Scipio Creek	57.1	54.2
Headwaters Mud Creek	7.0	6.7
Quaker Brook	2,135.4	2,028.7
Mud Creek	5.9	5.6
High Bank Creek	109.9	104.4
Cedar Creek	272.4	258.8
Thornapple Lake	123.2	117.0
Fall Creek	493.0	468.4
Butler Creek	342.4	325.3
Glass Creek	198.8	188.9
Algonquin Lake	10.4	9.9
Duncan Creek	3.0	2.9
Turner Creek	8.8	8.3
McCords Creek	4.3	4.1
Thornapple River	9.5	9.0
TOTAL	**3,949.3**	**3,751.9**

Figure 6.2.3.3 Sediment Load Reductions for Streambank Restoration

Watershed	Annual Load (ton)	Load Reduction (ton)
Milbourn Drain	14.8	14.1
Thornapple Drain	11.3	10.7
Fish Creek	4.8	4.6
Lacey Creek	4.8	4.5
Thompson Creek	25.4	24.2
Shanty Creek	27.0	25.7
Scipio Creek	0.4	0.4
Quaker Brook	881.6	837.5
Mud Creek	1.8	1.8
High Bank Creek	77.0	73.2
Cedar Creek	48.0	45.6
Duncan Creek	154.0	146.3
TOTAL	**1,250.9**	**1,188.5**

Figure 6.2.3.4 Sediment Load Reductions for Wetland Restoration

Watershed	Wetland Acres	Sediment Load Reduction
Butternut Creek	103.2	293.9
Milbourn Drain	320.7	579.0
Thornapple Drain	552	964.2
Fish Creek	92.3	255.5
Darken & Boyer Drain	176.6	470.8
Thornapple River	70.8	214.0
Mud Creek	18.5	61.4
Total Acres	**13,34.1**	
Cost per Acre	**$2,000**	
Total Cost	**$2,668,200**	

6.3 Nutrients

6.3.1 Nutrient Sources, Causes and Effects

Sources: Fertilizer, human and animal wastes, and other organic matter are key sources of nutrients in the watershed.

Causes: Fertilizers applied to crops, lawns and gardens enter the waterway through stormwater runoff and soil erosion. Fertilizer or manure overapplication and application shortly before storm events increase nutrient loading. Manure application on field with tile systems and unknown tiles connecting pastures to waterways have been identified as sources of nutrient

loading in the TRW. Fertilizer application on riparian lawns, gardens and fields, and lack of buffers between fertilized areas and waterways are also causes of nutrient runoff.

Nutrients from human and animal wastes also leach, leak or drain into surface waters through failing septic systems, dysfunctional manure storage systems, illicit connections, direct discharges and even abandoned farm tiles. A connection to a storm sewer or other drain is "illicit" when the wastewater requires treatment before it is discharged and should be routed to a sanitary sewer. Animal wastes are also the result of livestock and wildlife access to streams. Other organic matter, including leaves, yard clippings, garden wastes and decomposing aquatic plants produce nutrients which feed algae and other plants.

Effects on Designated and Desired Uses: Nitrates impact groundwater in several areas of the TRW. Nutrients, commonly phosphorus and nitrogen, degrade warm water and cold water fisheries and other aquatic life and wildlife in several lakes and impoundments in the watershed. Also degraded by excessive nutrients are partial and total body contact recreation and navigation, other recreation, critical natural area resources and the potential for quality education and interpretation of the watershed ecosystem.

Excessive nutrients cause eutrophication, or depletion of oxygen in water, a process by which a body of water rich in nutrients encourages the growth and decomposition of oxygen-depleting plant life, resulting in harm to aquatic organisms. Algae grow at a rapid rate when fed by nutrients. When algae die, they settle on the substrate in lakes and streams in a thickening layer of organic materials. As this layer decomposes, it utilizes the water's oxygen, making life impossible for small and large members of the aquatic food chain.

In the Thornapple River watershed, Carter, Duncan and Clear Lakes are listed in the2004 *MDEQ Integrated Report* as eutrophic. Thornapple Lake, a heavily used sports lake, has reached the stage of hypereutrophication, with minimum transparency, maximum chlorophyll-a, and maximum phosphorus. Leach Lake and Fine Lake are listed as mesoeutrophic, which means they are leaning toward eutrophic classification. Other highly residential recreational lakes, including Algonquin, Cloverdale, Long and Wall Lakes, utilize heavy treatment regimens to reduce or eliminate weed and algae growth.

Algae blooms and weedy plant growth, characteristic of nutrient-loaded waters, foul boat motors and make fishing difficult. Even canoeing and kayaking are a challenge in algae-thick areas. These recreational obstacles extend to hunting and historic navigation trail use. Along with the algae and weeds, decomposing organic matter, which creates a mucky, malodorous substrate, makes swimming unappealing and wading dangerous. Nutrient-laden waters provide poor illustrations for watershed ecosystem education and impact the quality of critical natural area resources within the TRW.

6.3.2 Nutrient Loads

Nutrient load calculations have been made for the Thornapple River Watershed using the STEPL Model. Nutrient loads are calculated to express nitrate – represented as N, phosphorous – represented as P, biological oxygen demand – represented as BOD, and total suspended solids – represented as TSS. The STEPL model calculates nutrient loads from sediment delivery and also

from feedlots and urban sources. Only those subwatersheds with identified feedlots have been included in feedlot load calculations.

Figure 6.3.2.1 Nutrient Load from Sediment by Subwatershed (tons/year)

Watershed	N conc.%	P conc.%	BOD conc.%	N Load	P Load	BOD Load
Butternut Creek	0.080	0.031	0.160	1.719	0.662	3.438
Milbourn Drain	0.080	0.031	0.160	3.985	1.534	7.971
Thornapple Drain	0.080	0.031	0.160	3.163	1.218	6.327
Fish Creek	0.080	0.031	0.160	4.801	1.848	9.602
Hayes Drain	0.080	0.031	0.160	2.939	1.131	5.878
Darken & Boyer Drain	0.080	0.031	0.160	3.728	1.435	7.456
Lacey Creek	0.080	0.031	0.160	3.579	1.378	7.158
Thompson Creek	0.080	0.031	0.160	3.087	1.189	6.175
Shanty Creek	0.080	0.031	0.160	2.205	0.849	4.410
Scipio Creek	0.080	0.031	0.160	3.266	1.257	6.532
Headwaters Mud Creek	0.080	0.031	0.160	4.778	1.839	9.556
Quaker Brook	0.080	0.031	0.160	1.719	0.662	3.438
Mud Creek	0.080	0.031	0.160	3.985	1.534	7.971
High Bank Creek	0.080	0.031	0.160	3.163	1.218	6.327
Cedar Creek	0.080	0.031	0.160	4.801	1.848	9.602
Thornapple Lake	0.080	0.031	0.160	2.939	1.131	5.878
Fall Creek	0.080	0.031	0.160	3.728	1.435	7.456
Butler Creek	0.080	0.031	0.160	3.579	1.378	7.158
Glass Creek	0.080	0.031	0.160	3.087	1.189	6.175
Algonquin Lake	0.080	0.031	0.160	2.205	0.849	4.410
Duncan Creek	0.080	0.031	0.160	3.266	1.257	6.532
Turner Creek	0.080	0.031	0.160	4.778	1.839	9.556
McCords Creek	0.080	0.031	0.160	9.417	3.625	18.834
Thornapple River	0.080	0.031	0.160	1.770	0.681	3.539
TOTALS				**85.688**	**32.989**	**171.376**

Figure 6.3.2.2 Nutrient Load from Urban Sources by Subwatershed (lbs./year)

Watershed	Nutrient Load			
	N	P	BOD	TSS
Butternut Creek	12,278	1,926	46,363	574,279
Milbourn Drain	3,848	629	14,341	179,200
Thornapple Drain	6,260	1,040	21,343	306,078

Watershed	Nutrient Load			
	N	P	BOD	TSS
Fish Creek	1,480	254	5,332	71,648
Hayes Drain	3,925	634	14,597	182,284
Darken & Boyer Drain	3,295	560	11,219	161,609
Lacey Creek	754	129	2,658	36,704
Thompson Creek	624	105	2,030	30,891
Shanty Creek	152	261	5,198	75,755
Scipio Creek	3,346	546	12,540	156,443
Headwaters Mud Creek	3,655	609	12,985	176,179
Quaker Brook	3,135	511	10,980	152,907
Mud Creek	1,927	324	6,234	95,527
High Bank Creek	4,369	746	15,222	213,188
Cedar Creek	6,835	1,140	24,109	328,174
Thornapple Lake	4,742	789	16,658	227,912
Fall Creek	6,678	1,110	23,456	320,927
Butler Creek	15,907	2,584	56,085	758,417
Glass Creek	3,037	504	10,176	147,968
Algonquin Lake	7,315	1,179	26,309	347,711
Duncan Lake	5,744	958	20,002	278,407
Turner Creek	7,189	1,168	26,084	336,378
McCords Creek	18,225	3,022	65,215	892,093
Thornapple River	27,440	4,543	90,089	1,375,286
TOTALS	**153,554**	**25,272**	**539,224**	**7,425,966**

Figure 6.3.2.3 Nutrient Load from Feedlot Sources by Subwatershed (lbs./year)

Watershed	N load	P Load	BOD load
Fish Creek	9,545	1,909	12,727
Shanty Creek	5,303	1,061	7,070
Mud Creek	55,526	9,716	68,883
High Bank Creek	54,498	10,900	72,664
Cedar Creek	11,311	2,262	15,081
Butler Creek	31,510	3,404	31,956
Algonquin Lake	81,233	16,247	108,310
Duncan Creek	13,984	2,797	18,646
TOTALS	**262,910**	**48,295**	**335,337**

Based on STEPL calculations for nutrient loads delivered through sediment per subwatershed, each subwatershed has been given a priority ranking for reducing nutrient loading. Nitrate

loads per year (in tons) were selected to rank subwatersheds, with loads between four and ten tons given high priority; loads between three and four tons given medium priority, and loads below three tons per year given low priority.

Figure 6.3.2.4 Prioritization for Reduction of Nutrient Load from Sediment

Nutrient Load from Sediment		Tons/Year		
Nutrient Priority	**Watershed**	**N Load**	**P Load**	**BOD Load**
High Priority	McCords Creek	9.417	3.625	18.834
	Fish Creek	4.801	1.848	9.602
	Cedar Creek	4.801	1.848	9.602
	Headwaters Mud Creek	4.778	1.839	9.556
	Turner Creek	4.778	1.839	9.556
Medium Priority	Mud Creek	3.985	1.534	7.971
	Milbourn Drain	3.985	1.534	7.971
	Darken & Boyer Drain	3.728	1.435	7.456
	Fall Creek	3.728	1.435	7.456
	Lacey Creek	3.579	1.378	7.158
	Butler Creek	3.579	1.378	7.157
	Scipio Creek	3.266	1.257	6.532
	Duncan Creek	3.266	1.257	6.523
	Thornapple Drain	3.163	1.218	6.327
	High Bank Creek	3.163	1.218	6.327
	Thompson Creek	3.087	1.189	6.175
	Glass Creek	3.087	1.189	6.175
Low Priority	Hayes Drain	2.939	1.131	5.878
	Thornapple Lake	2.939	1.131	5.878
	Algonquin Lake	2.205	0.849	4.410
	Quaker Brook	1.719	0.662	3.438
	Shanty Creek	2.205	0.849	4.410
	Thornapple River	1.770	0.681	3.539
	Butternut Creek	1.719	0.662	3.438

Best management practices targeting reduction of nutrient loading from sediment are: filter strips, reduced tillage practices and grass swales on croplands; filter strips, fencing and streambank restoration on pastureland; vegetated buffers on residential and other urban lands; and streambank stabilization on eroding streams. Descriptions of these best management practices can be found in the *MDEQ Nonpoint Source Best Management Practices Manual*[20]. In Barry County, a stormwater ordinance is recommended to reduce urban runoff and

20 http://www.michigan.gov/deq/0,4561,7-135-3313_3682_3714-118554--,00.html

associated pollutants. For Milbourn Drain, Fish Creek and Mud Creek, all county drains, a stream buffer ordinance, such as is provided by the Huron River Watershed Council at http://www.hrwc.org/wp-content/uploads/2009/11/HRWC_riparianbuffer_model_ordinance.pdf , is recommended to reduce nutrient inputs. For the urban communities in Kent County, as well as the cities of Charlotte and Hastings, use of Low Impact Design (LID) practices, including bioswales, rain gardens, green roofs and rain barrels, is encouraged to reduce the impact of stormwater and associated pollutant runoff.

Based on STEPL calculations for urban nutrient loads, as well as identified areas of urban source contributions, priorities for nutrient reductions from urban sources were ranked. Prioritization is based on the total nitrate load expressed from urban sources in each subwatershed.

Figure 6.3.2.5 Prioritization for Reduction of Nutrients from Urban Sources

Urban Priority	Subwatershed	N Load	P	BOD	TSS
High Priority	Thornapple River	27,440	4,543	90,089	1,375,286
	McCords Creek	18,225	3,022	65,215	892,093
	Thornapple Lake	4,742	789	16,658	227,912
	Duncan Lake	5,744	958	20,002	278,407
	Thompson Creek	624	105	2,029	30,891
	Scipio Creek	3,346	546	12,540	156,443
	Butler Creek	15,907	2,584	56,085	758,417
	Darken & Boyer Drain	3,295	560	11,219	161,609
Medium Priority	Hayes Drain	3,926	634	14,597	182,284
	Algonquin Lake	7,315	1,179	26,309	347,711
	Fish Creek	1,480	254	5,332	71,648
	Shanty Creek	1,541	261	5,198	75,755
	Thornapple Drain	6,260	1,040	21,343	306,078
	Butternut Creek	12,278	1,926	46,363	574,279
	Fall Creek	6,678	1,110	23,456	320,927
Low Priority	Turner Creek	7,189	1,168	26,084	336,378
	Cedar Creek	6,835	1,140	24,109	328,174
	High Bank Creek	4,369	746	15,222	213,188
	Milbourn Drain	3,848	629	14,341	179,200
	Headwaters Mud Creek	3,655	609	12,985	176,179
	Quaker Brook	3,135	511	10,980	152,907
	Glass Creek	3,037	504	10,176	147,968
	Mud Creek	1,927	324	6,234	95,527
	Lacey Creek	754	129	2,658	36,704

Best management practices targeted to reduce nutrient loading from urban sources include vegetated buffers in residential and urban areas as well as detention basins to filter runoff from impervious surfaces in residential, commercial and industrial developments. Descriptions of

these best management practices can be found in the *MDEQ Nonpoint Source Best Management Practices Manual*[21].

Prioritization of nutrient load reductions from feedlot areas was made based on STEPL calculations for total nutrient delivery from feedlots. Subwatersheds with the highest nitrate loads were given highest priority for feedlot best management practices. Since feedlots were identified by windshield surveys of the watershed, it is likely that not all feedlots were identified and entered into the STEPL Model. Medium priority was given to subwatersheds with known medium to high animal concentrations, but without currently identified feedlots. The remaining subwatersheds were assigned low priority. No loads are calculated for medium and low priority subwatersheds due to the fact that no feedlots were assessed in those areas.

Figure 6.3.2.6 Prioritization for Reduction of Nutrients from Feedlot Sources

Nutrient Load from Feedlots		Lbs./Year		
Feedlot Priority	**Watershed**	**N load**	**P Load**	**BOD load**
High Priority	Algonquin Lake	81,233	16,247	108,310
	Mud Creek	55,526	9,716	68,883
	High Bank Creek	54,498	10,900	72,664
	Butler Creek	31,510	3,404	31,956
	Duncan Creek	13,984	2,797	18,646
	Cedar Creek	11,311	2,262	15,081
	Fish Creek	9,545	1,909	12,727
	Shanty Creek	5,303	1,060	7,070
Medium Priority	Quaker Brook	0.00	0.00	0.00
	Thompson Creek	0.00	0.00	0.00
	Scipio Creek	0.00	0.00	0.00
	Hayes Drain	0.00	0.00	0.00
	Darken & Boyer Drain	0.00	0.00	0.00
	Headwaters Mud Creek	0.00	0.00	0.00
	Thornapple Drain	0.00	0.00	0.00
	Thornapple Lake	0.00	0.00	0.00
Low Priority	Fall Creek	0.00	0.00	0.00
	Milbourn Drain	0.00	0.00	0.00
	Butternut Creek	0.00	0.00	0.00
	Lacey Creek	0.00	0.00	0.00
	Glass Creek	0.00	0.00	0.00
	Turner Creek	0.00	0.00	0.00
	McCords Creek	0.00	0.00	0.00
	Thornapple River	0.00	0.00	0.00

21 http://www.michigan.gov/deq/0,4561,7-135-3313_3682_3714-118554--,00.html

The targeted best management practice for reduction of nutrients from feedlot sources is the waste storage facility, which provides the ability to store wastes when spreading is not advantageous or environmentally sound. Other potential BMPs include Comprehensive Nutrient Management Planning, and the use of anaerobic digesters on larger feedlot systems. Descriptions of these best management practices can be found in the *MDEQ Nonpoint Source Best Management Practices Manual*[22].

Prioritization of nutrient load reductions from septic system sources was made based on STEPL calculations for total nutrient delivery from estimated failed septic systems. Loads are based on the approximate number of septic systems per subwatershed, calculated at a failure rate of 26%, based on actual failure rate statistics from the Barry-Eaton District Health Department. Subwatersheds with the highest nitrate loads were given the highest priority for septic system repair.

Figure 6.3.2.7 Prioritization for Reduction of Nutrients from Septic Systems

Septic Priority	Watershed	N Load, lb/yr	P Load, lb/yr	BOD, lb/yr
High Priority	Thornapple River	61,062	19,040	285,379
	McCords Creek	49,608	15,468	231,848
	Fish Creek	30,637	9,553	143,188
	Headwaters Mud Creek	29,482	9,193	137,785
	Milbourn Drain	28,328	8,832	132,399
	Scipio Creek	25,441	7,933	118,900
	Lacey Creek	24,864	7,752	116,207
	Darken & Boyer Drain	24,277	7,570	113,463
Medium Priority	Cedar Creek	24,057	7,501	112,433
	Thornapple Drain	21,390	6,670	99,964
	Hayes Drain	21,390	6,670	99,964
	Thompson Creek	20,236	6,309	94,578
	Algonquin Lake	20,151	6,283	94,179
	Glass Creek	19,251	6,002	89,973
	High Bank Creek	17,739	5,531	82,907
	Turner Creek	17,145	5,345	80,131
	Mud Creek	16,235	5,063	75,875
Low Priority	Shanty Creek	16,185	5,046	75,642
	Butternut Creek	15,616	4,869	72,982
	Butler Creek	14,733	4,593	68,860
	Fall Creek	12,933	4,032	60,447

22 http://www.michigan.gov/deq/0,4561,7-135-3313_3682_3714-118554--,00.html

Septic Priority	Watershed	N Load, lb/yr	P Load, lb/yr	BOD, lb/yr
	Duncan Creek	12,329	3,845	57,621
	Thornapple Lake	12,024	3,749	56,191
	Quaker Brook	9,918	3,093	46,349
	TOTAL	**545,029**	**169,942**	**2,547,265**

Targeted best management practices for the reduction of nutrients from septic sources are the development of septic inspection ordinances for the municipalities that do not have them: Kent, Ionia and Allegan Counties; as well as the repair or replacement of systems that are contributing raw sewage to the waterways.

6.3.3 Nutrient Load Reductions

Nutrient load reductions are calculated by subwatershed for various BMPs in the STEPL Model. The figures below express these reductions by sediment delivery, urban and feedlot nutrient reduction practices. BMPs selected to address nutrient loading in the TRW are: reduced tillage and/or filter strips on crop fields; fencing for pastures; residential buffers in urban areas; waste storage facilities for feedlots; wetland restoration and failing septic system repair. Individual listings of subwatershed reductions by BMP are found in Section 5. BMPs, locations and acres are listed in Appendix 5, along with estimated costs. Through the course of plan implementation, other, site-specific, practices including non-agricultural BMP's may be substituted for those used in the STEPL Model to estimate load reductions. RUSLE calculations will be used to determine actual sediment and nutrient load reductions for BMPs installed in the TRW.

Figure 6.3.3.1 Nutrient Load Reductions from Sediment by Subwatershed (tons/year)

Watershed	N Load	P Load	BOD Load	N Reduction	P Reduction	BOD Reduction
Butternut Creek	1.719	0.662	3.438	0.059	0.023	0.118
Milbourn Drain	3.985	1.534	7.971	0.184	0.071	0.367
Thornapple Drain	3.163	1.218	6.327	0.119	0.046	0.238
Fish Creek	4.801	1.848	9.602	0.101	0.039	0.202
Hayes Drain	2.939	1.131	5.878	0.143	0.055	0.286
Darken & Boyer Drain	3.728	1.435	7.456	0.747	0.288	1.494
Lacey Creek	3.579	1.378	7.158	0.078	0.030	0.157
Thompson Creek	3.087	1.189	6.175	0.145	0.056	0.290
Shanty Creek	2.205	0.849	4.410	0.031	0.012	0.063
Scipio Creek	3.266	1.257	6.532	0.323	0.124	0.646
Headwaters Mud Creek	4.778	1.839	9.556	0.002	0.001	0.004

Watershed	N Load	P Load	BOD Load	N Reduction	P Reduction	BOD Reduction
Quaker Brook	1.719	0.662	3.438	0.059	0.023	0.118
Mud Creek	3.985	1.534	7.971	0.184	0.071	0.367
High Bank Creek	3.163	1.218	6.327	0.119	0.046	0.238
Cedar Creek	4.801	1.848	9.602	0.101	0.039	0.202
Thornapple Lake	2.939	1.131	5.878	0.143	0.055	0.286
Fall Creek	3.728	1.435	7.456	0.747	0.288	1.494
Butler Creek	3.579	1.378	7.158	0.078	0.030	0.157
Glass Creek	3.087	1.189	6.175	0.145	0.056	0.290
Algonquin Lake	2.205	0.849	4.410	0.031	0.012	0.063
Duncan Creek	3.266	1.257	6.532	0.323	0.124	0.646
Turner Creek	4.778	1.839	9.556	0.002	0.001	0.004
McCords Creek	9.417	3.625	18.834	0.001	0.002	0.002
Thornapple River	1.770	0.681	3.539	0.000	0.000	0.001
TOTALS	**88.672**	**34.138**	**154.971**	**2.975**	**1.145**	**5.948**

Figure 6.3.3.2 Nutrient Load Reductions from Urban BMPs by Subwatershed (lbs./year)

Watershed	Load Reduction			
	N	P	BOD	TSS
Lacey Creek	7.2	1.5	41.3	596.8
Thornapple Drain	9.7	14.0	333.0	8,862.7
Fish Creek	18.9	3.9	108.4	1,566.7
Hayes Drain	20.2	4.2	116.1	1,678.6
Darken & Boyer Drain	22.5	4.6	129.0	1,865.1
Thompson Creek	26.5	5.4	151.9	2,195.2
Shanty Creek	7.8	1.1	26.7	713.7
Scipio Creek	29.6	6.1	169.7	2,452.6
Thornapple Lake	74.5	15.3	427.3	6,177.0
Fall Creek	1.7	0.4	10.1	145.5
Butler Creek	22.8	4.7	130.9	1,891.9
Algonquin Lake	18.9	3.9	108.5	1,568.5
Duncan Lake	47.4	9.8	272.2	3,935.6
McCords Creek	67.9	14.0	389.4	5,629.4
Thornapple River	34.0	7.0	195.2	2,822.2
TOTALS	**409.6**	**95.9**	**2,609.7**	**42,101.5**

Figure 6.3.3.3 Nutrient Load Reductions from Feedlot BMPs by Subwatershed (lbs./year)

Watershed	N Reduction	P Reduction	BOD Reduction
Fish Creek	6,204.3	1,145.4	0.0
Shanty Creek	3,446.8	636.3	0.0
Mud Creek	36,092.0	5,829.9	0.0
High Bank Creek	35,423.7	6,539.7	0.0
Cedar Creek	7,352.1	1,357.3	0.0
Butler Creek	20,481.8	2,042.2	0.0
Algonquin Lake	52,801.3	9,747.9	0.0
Duncan Creek	9,089.8	1,678.1	0.0
TOTALS	**1,708,91.79**	**28,976.9**	**0.0**

Figure 6.3.3.4 Nutrient Load Reductions for Wetland Restoration

Watershed	Wetland Acres	N Load Reduction	P Load Reduction	BOD Reduction
Butternut Creek	103.2	1,282.1	416.0	2,601.2
Milbourn Drain	320.7	2,709.5	848.5	5,512.2
Thornapple Drain	552	4,402.9	1,395.8	8,949.9
Fish Creek	92.3	1,064.8	353.8	2,156.5
Darken & Boyer Drain	176.6	1,923.6	645.9	3,892.7
Thornapple River	70.8	880.3	294.5	1,781.8
Mud Creek	18.5	247.0	83.6	499.5
Total Acres	**1,334.1**			
Cost per Acre	**$2,000**			
Total Cost	**$2,668,200**			

Figure 6.3.3.5 Nutrient Reductions from Septic System Repair

Watershed	Reduction: Direct Wastewater Flow, l/hr	Reduction: N Load, lb/hr	Reduction: P Load, lb/hr	Reduction: BOD Load, lb/hr
Butternut Creek	2,106	0.19	0.037	1.021
Milbourn Drain	38,201	0.36	0.067	1.853

Watershed	Reduction: Direct Wastewater Flow, l/hr	Reduction: N Load, lb/hr	Reduction: P Load, lb/hr	Reduction: BOD Load, lb/hr
Thornapple Drain	2,883	0.25	0.051	1.399
Fish Creek	4,131	0.36	0.073	2.004
Hayes Drain	2,883	0.25	0.051	1.399
Darken & Boyer Drain	3,274	0.29	0.058	1.588
Lacey Creek	3,354	0.30	0.059	1.627
Thompson Creek	2,730	0.24	0.048	1.324
Shanty Creek	2,182	0.19	0.038	1.059
Scipio Creek	3,430	0.30	0.061	1.664
Headwaters Mud Creek	3,975	0.35	0.070	1.928
Quaker Brook	1,337	0.12	0.024	0.648
Mud Creek	2,188	0.19	0.039	1.061
High Bank Creek	2,392	0.21	0.042	1.160
Cedar Creek	3,244	0.29	0.057	1.573
Thornapple Lake	1,621	0.14	0.029	0.786
Fall Creek	1,745	0.15	0.031	0.846
Butler Creek	1,987	0.18	0.035	0.964
Glass Creek	2,597	0.22	0.046	1.259
Algonquin Lake	2,718	0.24	0.048	1.318
Duncan Creek	1,662	0.15	0.029	0.806
Turner Creek	2,313	0.20	0.041	1.122
McCords Creek	6,689	0.59	0.118	3.245
Thornapple River	8,233	0.73	0.145	3.993

6.4 Hazardous Waste

6.4.1 Hazardous Waste Sources, Causes and Effects

Sources: Hazardous waste sources are both historic and current. Chemical wastes from factories, landfills, farms and fuel facilities that thrived in previous generations still remain in the atmosphere, water or soil. Current businesses lawfully discharge chemical byproducts and wastes into waterways. Illicit dumping of hazardous wastes continues, with two documented incidents occurring in the TRW in the last two years. Though laws now exist to ban or limit most known hazardous wastes entering the environment, new research continues to uncover previously unknown or unconsidered sources of chemical pollution, such as the recent detection of pharmaceuticals in U.S. surface waters and the increased ability to track atmospheric deposition of chemical wastes in the U. S. to sources around the globe.

Causes: Hazardous wastes are most often associated with point-source discharges from industry and wastewater treatment facilities. Lawful, current sources are regulated through statewide permit processes to assure that pollutant levels do not exceed water quality standards. Fertilizer and pesticide overspray, and fertilizer which leaches into groundwater aquifers contribute to hazardous waste levels in the TRW. Abandoned wells can be unknown conduits for groundwater contamination. Purposeful dumping of hazardous wastes on land or in water still occurs when citizens are unaware of or unconcerned about environmental impacts. Oil and gas can enter surface waters when leaking automotive fluids are carried from pavement through runoff. Leaking underground storage tanks also contribute fuel to ground and surface waters. Known and unknown locations of buried hazardous waste, including brownfields, closed landfills and other historic industrial or waste storage sites may leach chemicals into soils, and ultimately into groundwater and surface water. Chemical spills occurring outside approved mix and load facilities also contribute to hazardous waste pollution. As previously noted, atmospheric deposition causes airborne chemicals to continuously re-circulate through soil, water and air.

Effects on Designated and Desired Uses: Hazardous wastes are known to impact groundwater, the drinking water resource for the TRW, causing excessive nitrate levels in several locations. Groundwater research indicates that connections between drift and bedrock aquifers threaten contamination of bedrock aquifers. Historic mercury and PCB contamination impair all of the TRW's waters and fisheries and likely affect other indigenous aquatic species in surface waters and wetlands. Fish advisories based on these contamination levels deter sport fishing and may affect tourism associated with the TRW's recreational resources.

6.4.2 Hazardous Waste Loads

According to the MDEQ's 2014 Integrated Report, all subwatersheds in the TRW are exceeding water quality standards for PCBs in the water column and in fish tissue. Assessed subwatersheds are also exceeding water quality standards for mercury in fish tissue.

Figure 6.4.2.1 – PCB and Mercury Loads for the TRW

	PCBs in the Water Column	Mercury in the Water Column	PCBs in Fish Tissue	Mercury in Fish Tissue
Thornapple River Watershed	>0.026 ng/L	>1.8 ng/L	>0.026 ng/L in water column	>0.35 mg/kg

As noted in Section 4.2.1.1 above, these contaminants derive from continental and even global sources, and thus may be beyond the reach of this management plan to control or limit.

In the Thornapple River subwatershed, an unnamed tributary known as Trout Creek is not supporting the use of other indigenous aquatic life and wildlife due to bacterial slimes. This condition is attributed to airport de-icer which is channeled to the stream from runway drains at the Gerald R. Ford Airport. A TMDL is scheduled for 2016. A 2013 NPDES permit requires the airport to reduce de-icer levels to this stream and others currently taking the chemical. The airport is constructing a new runoff system that will direct the runoff through a filtration system and into the Thornapple River.

Permitted discharges of chemicals into the waters of the Thornapple River watershed are regulated by the MDEQ. Known hazardous waste sites, leaking underground storage tank sites, and brownfield sites, listed by subwatershed in Chapter 5, are also monitored by the MDEQ. When opportunities arise, restoration of these sites through the state's Brownfield Redevelopment program should be undertaken.

Figure 6.4.2.2 Contaminated Site Redevelopment Priorities

Priority	Subwatershed	Brownfield Sites	Active LUST Sites	Hazardous Waste Sites
High Priority	Butler Creek	50	12	0
	Butternut Creek	33	14	0
	Fall Creek	20	10	0
	McCords Creek	18	4	1
	Turner Creek	14	4	1
Medium Priority	Headwaters Mud Creek	11	6	0
	Thornapple River	11	2	2
	Scipio Creek	9	4	0
	Cedar Creek	6	3	0
	Hayes Drain	4	7	0
	Quaker Brook	5	1	0
Low Priority	Thornapple Drain	1	1	0
	Milbourn Drain	1	0	1
	Fish Creek	1	0	0
	Darken & Boyer Drain	1	0	0
	Thornapple Lake	0	1	0

Other measures can be taken throughout the watershed in order to reduce the likelihood of hazardous waste reaching surface or ground water. Closing abandoned wells reduces the opportunity for chemicals and other pollutants infiltrating ground water. Utilizing chemical mix-load pads for agricultural applications, properly disposing of hazardous wastes stored around the home or farm, and removing and properly disposing of abandoned fuel tanks can limit the possibility of accidental spills or leaks of hazardous substances reaching ground or surface water. Reduction of chemical weed treatments on recreational lakes will also reduce direct application of chemicals to surface waters.

6.4.3 Hazardous Waste Load Reductions

While PCB and mercury loads may remain unchanged by practices implemented through the TRW Management Plan, other hazardous waste threats will be targeted for reduction through brownfield redevelopment, abandoned well closures, farm and residential fuel tank removal and construction of chemical storage and mix-and-load facilities. Support or development of community hazardous waste collections and education regarding alternatives to chemical weed treatement for lakes should be ongoing. The STEPL Model does not provide calculations for

hazardous waste load reductions. Alternately, Figure 6.4.3.1 below illustrates load reduction targets for removal of hazardous waste sources.

Figure 6.4.3.1 Hazardous Waste Source Reduction Targets

Watershed	Brownfield Redevelopment	Well Closure	Fuel Tank Removal	Chemical Mix/Load Pad	Hazardous Waste Collection Support	Chemical Lake Treatment Reduction
Butternut Creek	**1**		**1**		**1**	
Milbourn Drain		**2**	**1**	**1**		
Thornapple Drain		**2**	**1**			
Fish Creek		**2**	**1**	**1**		
Hayes Drain		**2**	**1**	**1**		
Darken & Boyer Drain		**2**	**1**	**1**	**1**	
Lacey Creek		**2**	**1**			
Thompson Creek		**2**	**1**			
Shanty Creek		**2**	**1**	**1**	**1**	
Scipio Creek		**2**	**1**			
Headwaters Mud Creek		**2**	**1**	**1**		
Quaker Brook		**1**	**1**	**1**		
Mud Creek		**2**	**1**	**1**		
High Bank Creek		**2**	**1**			**1**
Cedar Creek		**2**	**1**			**1**
Thornapple Lake		**2**	**1**			**1**
Fall Creek	**1**	**1**	**1**			**1**
Butler Creek	**1**	**1**	**1**		**1**	
Glass Creek		**1**	**1**			
Algonquin Lake		**2**	**1**	**1**		**1**
Duncan Creek		**2**	**1**	**1**		**1**
Turner Creek	**1**	**2**	**1**			
McCords Creek	**1**	**1**	**1**		**1**	**1**
Thornapple River		**1**	**1**		**1**	**1**
TOTALS	**5**	**36**	**24**	**10**	**6**	**8**
Cost per unit	**$500,000**	**$500**	**$300**	**$5,000**	**$3,000**	**$250**
Total Cost	**2,500,000**	**$18,000**	**$7,200**	**$50,000**	**$18,000**	**$2,000**

6.5 Increased Hydrologic Flow

6.5.1 Increased Hydrologic Flow Sources, Causes and Effects

Sources: Manmade alterations to drainage patterns and land use changes resulting in a net loss of natural areas affect a stream's natural hydrology. Hydrologic changes that increase a stream's flow cause channel instability, leading to increased erosion.

Causes: The volume of urban storm water runoff continues to increase as impervious surfaces increase. New construction, new paved surfaces, clearing and leveling of land for lawns and other habitat alterations associated with urban development tend to move water quickly toward storm drains; whereas undisturbed areas delay runoff by detaining it in vegetated depressions or allowing for recharge into ground water aquifers. Urban runoff is increased by practices of piling snow and ice from road clearings in or near flood plains.

Undersized culverts, which increase water velocity during high-flow periods, also contribute to the damages associated with increased hydrologic flow. Similarly, debris, trash, fallen trees and brush also impact stream flow by creating detention areas which destabilize stream banks and by concentrating flow velocity into narrow channels. Subsurface drainage and stream channelization, largely from historic agricultural operations, have also increased hydrologic flow in the watershed.

Filling and draining of wetlands, which serve as natural storm water detention basins, also force storm water more quickly into the main stream flow. Development within floodplains, which combines the problems of increased impervious surface and wetland loss, also disturbs natural floodplain surface conditions which support water detention, infiltration and storage.

Effects on Designated and Desired Uses: Increased hydrologic flow, or flashiness, impacts warm- and cold water fisheries by disrupting the spawning cycle and disturbing or altering riffles and pools within the stream channel. Such habitat alteration also jeopardizes the life cycles of other indigenous aquatic life and wildlife. Increases in peak flow conditions also affect navigation by creating dangerous waters and by increasing debris obstructions within the waterways.

6.5.2 Hydrologic Flow Loads

Hydrologic flow loads for the TRW were calculated in the *Thornapple River Watershed Flashiness Report* by David Fongers, MDEQ, 2008. The study used USGS data from gages at Quaker Brook, the Thornapple River at McKeown Bridge and the Thornapple River near Caledonia. By applying the Richards-Baker Flashiness Index to gage readings, then comparing these values to values for similarly-sized watersheds across the state, the study determined that the quartile rankings for the TRW gages were typical of other gages in southwest Lower Michigan. According to the study, "for the Thornapple River watershed gages, only one of the three gages has an increasing trend. The increasing flashiness trend of that gage, USGS #04118000 – Thornapple River near Caledonia, appears to be the result of the operation of a power plant.[23]" A complete description of the methodology used in the hydrology study is provided in Appendix 2.

As the study notes, trends apply only to the stream or streams in the vicinity of the gage, so it is possible that individual subwatersheds or tributaries may be exhibiting increasing or decreasing flashiness trends. The study cautions that, "Although the flow regime appears to be currently stable, it is possible that the Thornapple River's morphology continues to adapt to past hydrologic changes. There may also be some local channel instabilities in more sensitive headwater streams due to nearby land use transitions or other local causes. Flow increases due

23 Fongers, p. 10.

to projected urbanization may be of concern if not properly managed, however[24]." To this end, subwatersheds in the TRW have been prioritized by their contribution to increased hydrologic flow in an effort to maintain or decrease flashiness levels.

Data contributing to the ranking of subwatersheds for increased hydrologic flow risk include:

- Impervious surface area percentages by subwatershed
- Phase II storm water areas
- Subwatersheds cited in the MDEQ 2014 Integrated Report as not attaining water quality standards due to anthropogenic and other flow regime alterations – Little Thornapple River in the Fish Creek Subwatershed and Mud Creek subwatershed.
- High wetland loss areas

Figure 6.5.2 Prioritization for Hydrologic Flow Reduction

Hydrologic Flow Reduction	
Priority	**Subwatershed**
High Priority	Butternut Creek
	Fish Creek
	Mud Creek
	Milbourn Drain
	Thornapple River
	Thornapple Drain
	McCords Creek
	Butler Creek
	Headwaters Mud Creek
Medium Priority	Duncan Creek
	Algonquin Lake
	Quaker Brook
	Scipio Creek
	Thompson Creek
	Darken & Boyer Drain
	Hayes Drain
Low Priority	Turner Creek
	Glass Creek
	Fall Creek
	Cedar Creek
	High Bank Creek
	Thornapple Lake
	Shanty Brook
	Lacey Creek

Best management practices to reduce hydrologic flow include streambank restoration using natural channel design techniques developed by Dave Rosgen, reduction of dredging in designated drains, replacement of undersized or misaligned culverts, use of retention/detention basins in stormwater systems and wetland restoration. Descriptions of these best management

24 Fongers, p. 17.

practices can be found in the *MDEQ Nonpoint Source Best Management Practices Manual*[25]. In Barry County, a stormwater ordinance is recommended to reduce urban runoff. For Milbourn Drain, Fish Creek and Mud Creek, all county drains, a stream buffer ordinance, such as is provided by the Huron River Watershed Council at http://www.hrwc.org/wp-content/uploads/2009/11/HRWC_riparianbuffer_model_ordinance.pdf , is recommended to reduce runoff in these areas. For the urban communities in Kent County, as well as the cities of Charlotte and Hastings, use of Low Impact Design (LID) practices, including bioswales, rain gardens, green roofs and rain barrels, is encouraged to reduce the impact of stormwater and associated pollutant runoff.

6.5.3 Hydrologic Flow Load Reductions

The long-range target for hydrologic flow in the TRW is to maintain the current trend of stability in the upper reaches of the watershed, as indicated by gage data, and to stabilize the trend toward flashiness in the watershed's lower reach. This target will be reached through implementation of storm water detention and retention basins, wetland restoration and natural channel design for stream bank restoration, as well as replacing undersized or misaligned culverts and reducing channelization and channel maintenance. The STEPL Model does not provide calculations for hydrologic flow load reductions. Alternately, Figure 6.5.3.1 below illustrates quantitative practice reduction targets for reducing hydrologic flow. Individual listings of subwatershed reductions by BMP are found in Section 5. BMPs, locations and acres are listed in Appendix 5, along with associated costs. Through the course of plan implementation, other, site-specific, practices may be substituted for those used in this plan to estimate load reductions. Flow measurements will be used to determine actual load reductions for BMPs installed in the TRW.

Figure 6.5.3 Hydrologic Flow Load Reduction Targets

Watershed	Detention Basins	Culvert Replacement	Streambank Restoration	Reduced Channel Maintenance	Wetland Restoration (Acres)
Butternut Creek					**103.2**
Milbourn Drain		**3**	**2**	**1**	**320.7**
Thornapple Drain	**2**	**1**	**1**	**1**	**552**
Fish Creek			**2**	**1**	**92.3**
Hayes Drain		**1**		**1**	
Darken & Boyer Drain		**1**		**1**	**176.6**
Lacey Creek		**3**	**2**		
Thompson Creek		**4**	**2**		

25 http://www.michigan.gov/deq/0,4561,7-135-3313_3682_3714-118554--,00.html

Watershed	Detention Basins	Culvert Replacement	Streambank Restoration	Reduced Channel Maintenance	Wetland Restoration (Acres)
Shanty Creek		**3**	**1**		
Scipio Creek		**1**	**1**		
Headwaters Mud Creek		**1**		**1**	
Quaker Brook		**18**	**1**	**1**	
Mud Creek		**2**	**1**	**1**	**18.5**
High Bank Creek		**11**	**1**		
Cedar Creek		**14**	**2**		
Thornapple Lake		**3**			
Fall Creek		**7**			
Butler Creek		**7**			
Glass Creek		**15**			
Algonquin Lake				**1**	
Duncan Creek		**1**	**3**	**1**	
Turner Creek		**1**			
McCords Creek					
Thornapple River		**1**			**70.8**
TOTAL UNITS	**2**	**99**	**12848 ft**	**10**	**1334.1 Ac.**
Cost per unit	**$20,000**	**$20,000**	**$65**	**$0**	**$2000**
Total Cost	**$40,000**	**$1,980,000**	**$835,120**	**$0**	**$2,668,200**

6.6 *E. Coli*

6.6.1 *E. Coli* Sources, Causes and Effects

Sources: *E. coli* bacteria is found in the digestive system of warm-blooded animals and is transferred to surface waters through animal manure, human sewage and other wastewater. While most strains of coliform bacteria are not dangerous, they can indicate the presence of other disease-causing bacteria. Sources of *E. coli* and other bacteria in surface waters include malfunctioning onsite sewage disposal systems or manure storage systems, illicit wastewater connections to storm sewers, ditches or subsurface drains, wild and domestic animal waste, and improper land application of manure. A connection to a storm sewer or other drain is "illicit" when the wastewater requires treatment before it is discharged and should be routed to a sanitary sewer.

Causes: Runoff from storm events often carries leakage and overflow from sewage and manure storage systems into surface waters. Likewise, contaminated runoff from pastures and other animal detention areas can also be triggered by storm events. Improper or poorly timed land application of manure adds bacteria to waterbodies. Undersized, poorly placed, unmaintained, or failing septic systems or manure storage facilities also contribute to *E. coli* contamination of surface waters. Illicit wastewater connections can cause ongoing *E. coli* problems, as can

unrestricted livestock access to waterbodies. Wildlife, especially in concentrated populations, can also be a source of *E. coli* contamination.

Effects on Designated and Desired Uses: *E. coli* can cause serious illness in humans and animals and is therefore a high risk to partial and total body contact recreation.

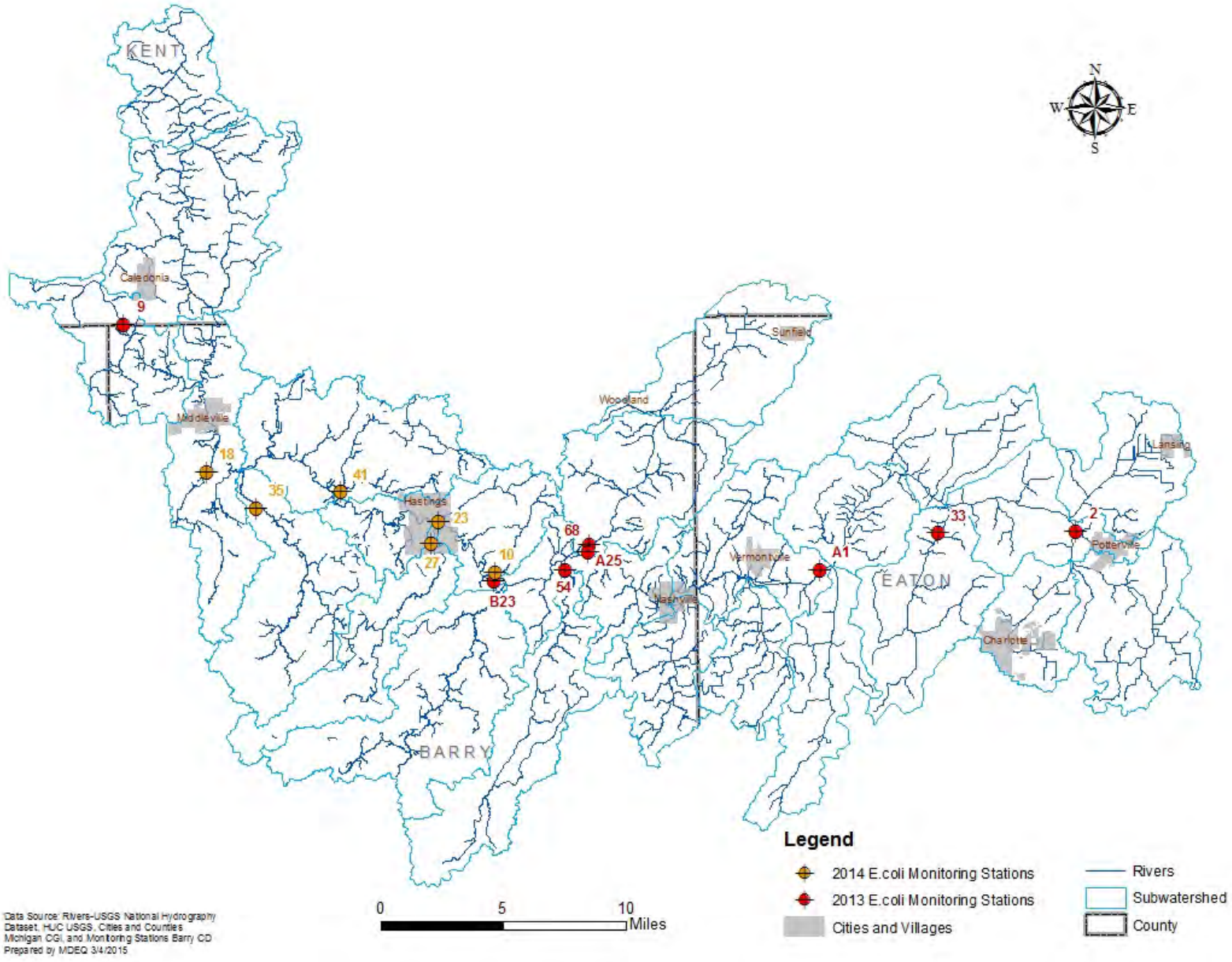
6.6.2 *E. Coli* Loads

As *E. coli* is mainly a transitory contaminant, regular and frequent monitoring schedules are necessary to determine its presence and load levels. Current *E. coli* monitoring in the TRW project area includes a two-year study conducted by the Barry Conservation District, spanning 2013 and 2014, as well as monitoring conducted by the Barry-Eaton District Health Department on two public beaches, Charlton Park and Fox Memorial Park. Results from the Barry Conservation District study, 2013-14, indicate that only one of the fourteen sites monitored, the Thornapple River at McKeown Road, regularly met water quality standards for *E. coli.* Complete study results are listed in Appendix 4. Several beach closures occurred at Charlton Park beach in 2012, with only one incident in 2013. Seasonal beach monitoring results can be accessed at www.deq.state.mi.us/beach/.

Figure 6.6.2.1 Results of the 2013 - 2014 Thornapple Watershed *E. coli* Monitoring Program

Water Body Name	# Results exceeding 1000 E. coli per 100 mL of water	# of Times 30-day geometric mean exceeds 130 E. coli per 100 mL of water	# Results exceeding 300 E.coli per 100 mL of water
Hayes Drain - Thornapple River at Gresham	6	12	51
Fish Creek - Little Thornapple River at Gresham	6	12	54
Thornapple Lake - Thornapple River at McKeown	0	0	4
Scipio Creek -Thornapple River at Shaytown	3	12	51
Mud Creek at Barger Road	1	12	10
Thornapple Lake - Thornapple River at Barger	1	11	12
High Bank Creek at Thornapple Lake Road	3	12	47
Duncan Creek at 108th St.	2	12	37
Butler Creek at McKeown Road	9	12	55
Butler Creek at Mill Street	7	12	51
Fall Creek at Shriner Road	3	12	44
Glass Creek at Peets Road	0	8	6
Algonquin Lake at Solomon Road	4	12	49
Turner Creek at Kiser Road	0	5	7

Figure 6.6.2.2 *E. coli* Monitoring Locations



Prioritization of *E. coli* risk areas in the TRW are determined based on the following data:

- Subwatersheds not meeting WQS for partial and/or total body contact recreation
- Livestock access to streams
- Areas without sewer inspection ordinances
- Major residential lakes without sewer systems

Figure 6.6.2.3 Prioritization for *E. coli* Reduction

***E. Coli* Reduction**	
***E. coli* Priority**	**Subwatershed**
High Priority	Hayes Drain
	Fish Creek
	Thompson Creek
	High Bank Creek
	Algonquin Lake
	Fall Creek
	Duncan Creek
	Mud Creek
	Thornapple Lake
Medium Priority	Darken & Boyer
	Scipio Creek
	Cedar Creek
	Turner Creek
	Glass Creek
	Headwaters Mud Creek
	Butler Creek
	Butternut Creek
	Quaker Brook
Low Priority	Milbourn Drain
	Lacey Creek
	Thornapple Drain
	Shanty Brook
	McCords Creek
	Thornapple River

Best management practices to reduce *E. coli* loads include the installation of animal waste storage facilities at high-density animal facilities, location and repair of failing septic systems, exclusion fencing and filter strips along waterways in pastures, and cover crops or reduced tillage in conjunction with filter strips in crop areas. Descriptions of these best management practices can be found in the *MDEQ Nonpoint Source Best Management Practices Manual*[26].

26 http://www.michigan.gov/deq/0,4561,7-135-3313_3682_3714-118554--,00.html

6.6.3 *E. Coli* Load Reductions

New information continues to indicate widespread *E. coli* problems in the TRW. Implementing selected BMPs, including repair of failing septic systems, filter strips in crop fields and pastures, cattle exclusion from streams through fencing, and use of waste storage facilities will reduce *E. coli* levels below state water quality standards for partial and full body contact recreation. Individual listings of subwatershed reductions for sediment and nutrients by BMP are found in Section 5. BMPs, locations and acres are listed in Appendix 5, along with estimated costs. Through the course of plan implementation, other, site-specific, practices including non-agricultural BMP's may be substituted for those expressed in this plan. The STEPL Model does not provide calculations for *E. coli* reduction through BMP implementation. BMPs expressed in Section 6.2.3 for sediment reduction and listed in Appendix 5 for Cropping, Pasture, Urban and Feedlot; as well as BMPs expressed in 6.3.3 for nutrient reduction and listed in Appendix 5 for Urban, Feedlot, Wetlands and Septic Systems will be used to address E. coli loads. Locations, dimensions and costs for these BMPs are listed in Appendix 5.

6.7 Temperature

6.7.1 Temperature Sources, Causes and Effects

Sources: Lack of riparian vegetation, which leaves waters exposed to direct sun, is a major cause of high water temperatures in areas of the Thornapple River watershed. Likewise, the absence of in-stream aquatic plant cover and woody debris also increases water temperatures. Another contributor to high temperatures is turbidity, or suspended solids within the water which attract and hold heat.

Causes: Increasing development in riparian areas often leads to the removal of riparian vegetation to improve views or recreational access. A lack of educational resources for riparian landowners has resulted in stream management techniques that include mowing up to the banks of streams and waterbodies, placing yard wastes on banks or in waterways to smother aquatic vegetation, dredging streams, burning or digging vegetation out of waterways and ditches and removing all woody debris.

Turbidity is often the result of a combination of sediment and organic matter in the substrate and natural or manmade disturbance of the streambed. The most common sites for turbidity are areas with high rates of water velocity, such as bridges, culverts or other obstructed areas, and recreational sites including lakes, navigable streams and fishing holes.

Effects on Designated and Desired Uses: High temperatures are a major impairment to cold water fisheries, as fish species particular to cold water habitats require certain temperature maintenance to thrive and reproduce. Extreme or prolonged high temperatures can also affect warm water fisheries in a similar manner.

6.7.2 Temperature Loads

Based on temperature data reported in the 1998[27] and 2003 Biological Surveys of the Thornapple River and Selected Tributaries[28], as well as data recorded in the 2006-2007 Thornapple River Watershed Road Stream Crossing Surveys, no monitored streams are currently exceeding Michigan's water quality standards for temperature. However, according to the MDNR's Status of the Fishery report for Quaker Brook, the tributary is not supporting a trout population. Stocking trout on this stream was discontinued in 1998. Figure 6.2.6 below represents water quality standards for inland lakes, warm- and cold-water streams within the TRW.

Figure 6.7.2.1 Michigan Water Quality Standards for Temperature

Month	Inland Lakes (degrees F)	Warmwater Fishery Standards (degrees F)	Coldwater Fishery Standards (degrees F)
January	45	41	38
February	45	40	38
March	50	50	43
April	60	63	54
May	70	76	65
June	75	84	68
July	80	85	68
August	85	85	68
September	80	79	63
October	70	68	56
November	60	55	48
December	50	43	40

The data in all the above referenced studies represents single-sample information which may or may not accurately reflect annual conditions in these water bodies. Longer term temperature monitoring of waterbodies at risk for excessive temperatures in the TRW need to be undertaken to pinpoint problem areas.

The Barry Conservation District utilized HOBO temperature loggers to monitor temperature on three cold water tributaries in the Thornapple River watershed from January 2012 through October 2014. Of the five loggers deployed, one was placed in Glass Creek at Goodwill Road. This logger was not located for retrieval. Two loggers were placed on Quaker Brook – one at Lawrence Road and one at Francis Road. These locations were chosen to be upstream and downstream of streambank restoration projects on Quaker Brook. Two loggers were placed in High Bank Creek – one at Maple Grove Road and one at Thornapple Lake Road. These locations were upstream and downstream of a bridge construction project carried out by the Barry County Road Commission and Barry Conservation District to improve fish passage. These locations were also within (Maple Grove Road) and beyond (Thornapple Lake Road) the

27 Hanshue, S. 2002. A Biological Survey of the Thornapple River and Selected Tributaries: Barry, Eaton, Ionia and Kent Counties. MDEQ Surface Water Quality Division.
28 Rockafellow, D. 2004. A Biological Survey of the Thornapple River Watershed and Selected Tributaries: Barry, Eaton, Kent and Ionia Counties, Michigan. MDEQ Water Division.

designated cold water portion of High Bank Creek. While both loggers were retrieved, the logger at Maple Grove Road contained a corrupted file and the data was not able to be salvaged. Maximum monthly temperature data from Quaker Brook and High Banks Creek are charted below, with tables expressed in Appendix 4. Monthly temperatures for Quaker Brook at both locations and for High Banks Creek at Thornapple Lake Road regularly exceed Michigan's water quality standards for cold water streams. Quaker Brook exceedences reach a maximum of 12 degrees Fahrenheit (July 2012). High Banks Creek exceedences reach a maximum of nine degrees Fahrenheit (July 2012 and July 2013).

Figure 6.7.2.2 Maximum Monthly Temperatures for Quaker Brook

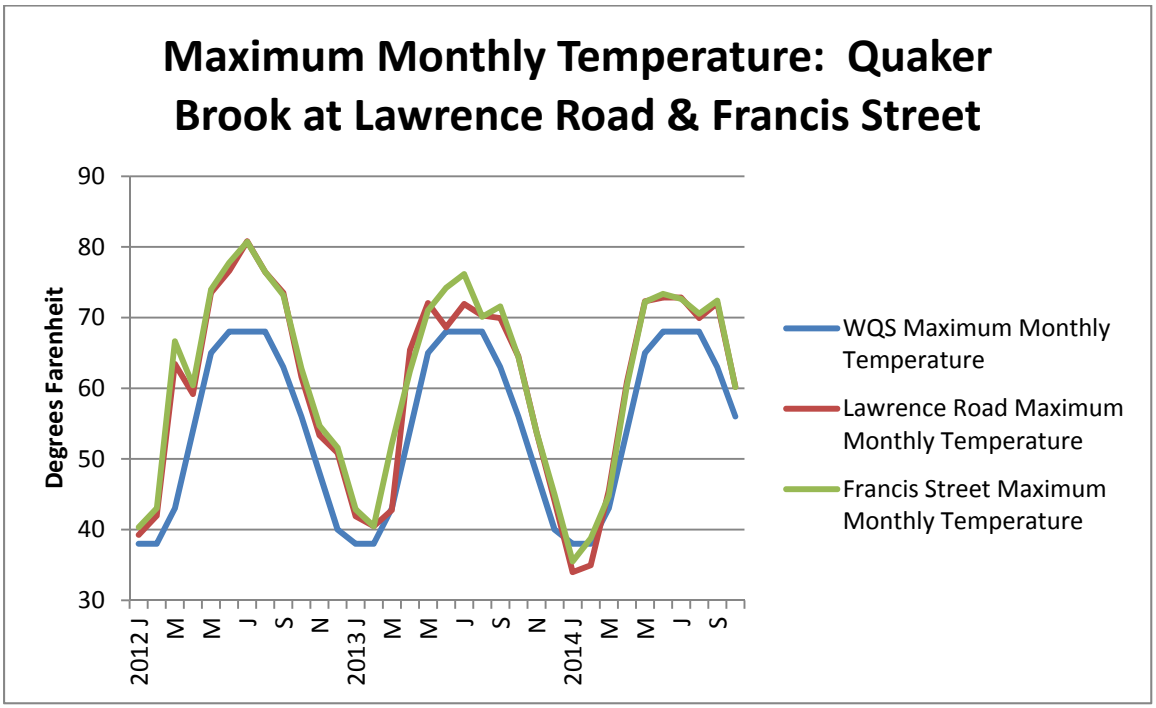
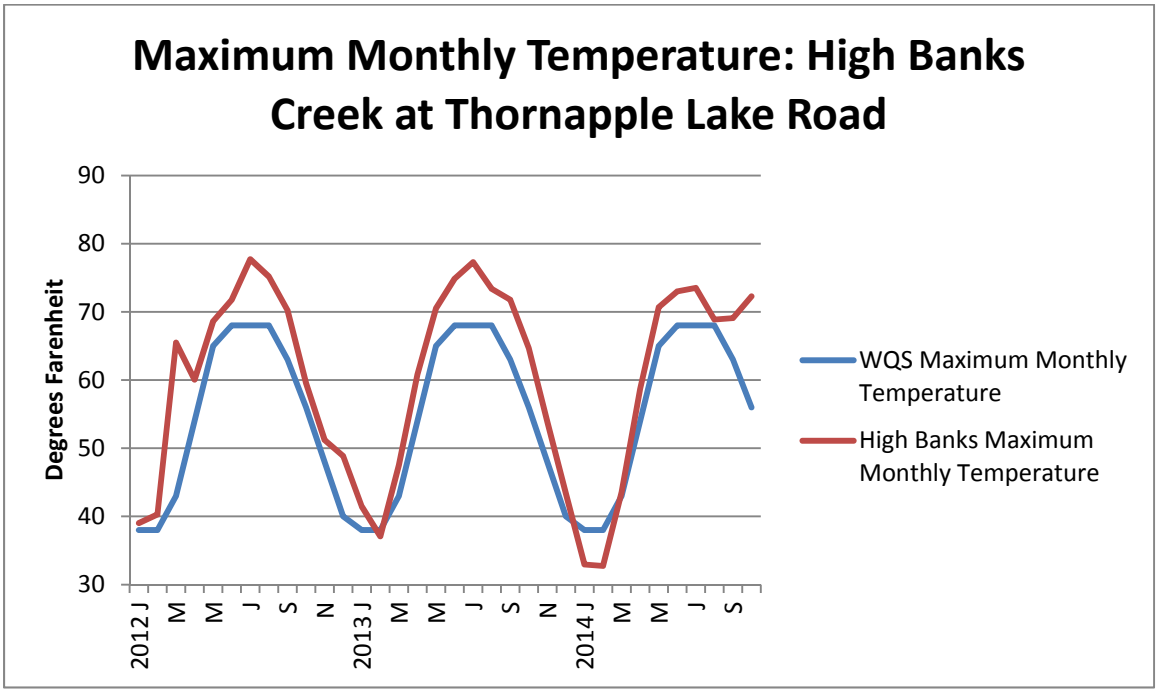


Figure 6.7.2.3 Maximum Monthly Temperatures for High Banks Creek



Prioritization of risk factors for increased temperature in the TRW was determined using the following data sources:

- Trout streams not supporting cold water fisheries
- Cold- and cold-transitional stream designation
- Number of wastewater discharges per subwatershed

Figure 6.7.2.4 Prioritization for Temperature Reduction

Temperature Reduction	
Temperature Priority	**Subwatershed**
High Priority	Quaker Brook
	Cedar Creek
	Thornapple River
	Butler Creek
	Turner Creek
	Thornapple Lake
	McCords Creek
	High Bank Creek
	Glass Creek
Medium Priority	Fish Creek
	Butternut Creek
	Milbourn Drain
	Duncan Creek

Temperature Reduction	
Temperature Priority	**Subwatershed**
	Thompson Creek
	Scipio Creek
	Hayes Drain
	Algonquin Lake
	Fall Creek
	Lacey Creek
	Shanty Brook
Low Priority	Headwaters Mud Creek
	Mud Creek
	Darken & Boyer Drain
	Thornapple Drain

Best management practices targeted for reducing temperatures include vegetated buffers, stream bank restoration using natural channel design on channelized streams, and protection and restoration of wetlands. In Barry County, a stormwater ordinance is recommended to reduce urban runoff and associated pollutants. For Milbourn Drain, Fish Creek and Mud Creek, all county drains, a stream buffer ordinance, such as is provided by the Huron River Watershed Council at http://www.hrwc.org/wp-content/uploads/2009/11/HRWC_riparianbuffer_model_ordinance.pdf , is recommended to reduce temperature. For the urban communities in Kent County, as well as the cities of Charlotte and Hastings, use of Low Impact Design (LID) practices, including bioswales, rain gardens, green roofs and rain barrels, is encouraged to reduce the impact of stormwater and associated pollutant runoff.

6.7.3 Temperature Load Reductions

Limited information on annual waterbody temperatures is available for the TRW. This management plan's target for temperature loads is to maintain or decrease current temperatures to levels consistent with Michigan Water Quality Standards for temperatures in inland lakes, warm- and cold water fisheries. The STEPL Model does not provide calculations for temperature load reductions. Implementing selected BMPs, including filter strips in crop fields and pastures, and installing residential buffers on streams will reduce temperature levels below state water quality standards. BMPs, locations and acres for these practices are listed in Appendix 5, along with estimated costs. Through the course of plan implementation, other, site-specific, practices may be substituted for those expressed in this plan. BMPs expressed in Section 6.2.3 for sediment reduction and listed in Appendix 5 for Cropping, Pasture, and Urban, will be used to address temperature loads. Locations, dimensions and costs for these BMPs are listed in Appendix 5.

6.8 Priority Areas for Preservation

Aerial photos, land use data, occurrences of threatened and endangered species and habitat areas for the Thornapple River Watershed all indicate that there are locations of critical fish and wildlife habitat within the TRW. While it is of utmost importance to improve water quality in

declining areas, it is also important to protect and preserve high-quality portions of the watershed. For this reason, critical areas for preservation have been ranked for the TRW, using the following data sources:

- Potential Conservation Area ranking within Michigan Natural Features Inventory reports
- Size of potential conservation areas within the subwatershed
- Number of listed threatened, endangered or special concern species
- Groundwater dependence
- Designated trout streams

Figure 6.8.1 Prioritization for Water Resource Preservation

Preservation	
Preservation Priority	**Subwatershed**
High Priority	Glass Creek
	Turner Creek
	Scipio Creek
	Thompson Creek
	Thornapple River
	Cedar Creek
	McCords Creek
	Fall Creek
	Mud Creek
Medium Priority	Algonquin Lake
	Thornapple Lake
	High Bank Creek
	Lacey Creek
	Headwaters Mud Creek
	Quaker Brook
Low Priority	Milbourn Drain
	Fish Creek
	Hayes Drain
	Darken and Boyer Drain
	Shanty Brook
	Butler Creek
	Butternut Creek
	Thornapple Drain
	Duncan Creek

Best management practices targeted to support preservation of critical water resource areas include conservation easements and land purchase for conservation or public use, as well as wetland restoration and enrollment of farmland into Conservation Reserve or Continuous Conservation Reserve programs.

6.8.2 Priority Area Protection Targets and Costs

Certain management objectives and practices in the Thornapple River Watershed Management Strategy emphasize protection rather than improvement. Because of the quality of natural resources in key areas of the TRW, protection functions as a means of future potential load

reduction. No load reductions are calculated for these BMPs and management measures. Subwatersheds prioritized for protection also have BMPs for improvement listed in Section 5.

Figure 6.8.2 Priority Area Protection Targets

Practice	Priority Area	Protection	Total Cost
Protect priority areas through conservation easements	Glass Creek, Turner Creek, Scipio Creek, Thompson Creek, Cedar Creek	500 acres	$500,000
Restore wetlands	Glass Creek, Turner Creek, Scipio Creek, Thompson Creek, Cedar Creek	90 acres	$180,000
TOTAL COST TO 2025			***$680,000***

7 WATERSHED GOALS, OBJECTIVES, TARGETS AND STRATEGIES

7.1 Watershed Goals and Objectives

The goals and objectives of the Thornapple River Watershed Management Plan, presented in table form below, are derived from the rankings of designated and desired uses, the pollutants that degrade these uses, their sources, causes and levels of pollution contribution. Recognizing that education and awareness are necessary steps to initiate action, an Education and Information Strategy, found in Section 7.3, accompanies these management goals. Objectives for these goals have management strategies expressed in Appendix 6 as well as education and information strategies found in Appendix 7.

Figure 7.1 Thornapple River Watershed Goals and Objectives

Goals	Objectives
Goal 1 – Address impairments within the watershed	❖ Milbourn Drain: ➢ Determine causes of impairment of other indigenous aquatic life and wildlife ➢ Improve habitat through agricultural and residential filter strips, stream restoration and wetland restoration ❖ Fish Creek: ➢ Identify locations of flow regime and other anthropogenic alterations impairing other indigenous aquatic life and wildlife ➢ Improve habitat through agricultural and residential filter strips, stream restoration and wetland restoration ❖ Mud Creek: ➢ Identify locations of flow regime and other anthropogenic alterations impairing the warm water fishery ➢ Improve habitat through agricultural and residential filter strips, stream restoration and wetland restoration ❖ Thornapple River: ➢ Assist MDEQ in monitoring stream improvement on Trout Creek due to redirection of pollution sources ➢ Monitor impact of new outlet on Thornapple River
Goal 2 – Improve degraded areas within the watershed	❖ All Degraded Sites: ➢ Reduce agricultural sedimentation ➢ Reduce agricultural nutrient loading ➢ Reduce urban sediment & nutrient loading ➢ Reduce failing septic systems ➢ Restore channelized streams ➢ Reduce sedimentation from road erosion

Goals	Objectives
	➢ Improve riparian land management practices ➢ Remove fish-passage barriers ➢ Close abandoned wells ➢ Reduce the number of lake and river chemical weed control programs ➢ Reduce industrial runoff ➢ Remove non-operational dams
Goal 3 – Protect and enhance natural areas in high quality subwatersheds	❖ Thompson Creek, Scipio Creek, Cedar Creek, Glass Creek, and Turner Creek: ➢ Increase the acreage protected by conservation easements ➢ Undertake wetland restoration in high priority areas ➢ Increase acreage enrolled in Conservation Reserve and Continuous Conservation Reserve Programs ➢ Protect high groundwater recharge areas
Goal 4 – Study areas where insufficient information exists regarding water quality standards, preventing identification of pollutants, sources and/or causes	❖ Cold water fishery status: ➢ Quaker Brook ➢ Headwaters Mud Creek ➢ Cedar Creek ❖ Warm water fishery status: ➢ Headwaters Mud Creek ➢ Thornapple Lake ❖ Other indigenous aquatic life and wildlife: ➢ Hayes Drain ➢ Darken & Boyer Drain ➢ Lacey Creek ➢ Thompson Creek ➢ Scipio Creek ➢ High Banks Creek ➢ Thornapple Lake ➢ Butler Creek ➢ Algonquin Lake ➢ Duncan Creek ➢ Turner Creek ➢ McCords Creek ➢ Thornapple River ❖ Total and partial body contact recreation: ➢ Thornapple Drain ➢ Fish Creek ➢ Butternut Creek ➢ Mud Creek ➢ High Banks Creek ➢ Thornapple Lake ➢ Fall Creek ➢ Butler Creek

Goals	Objectives
	➢ Algonquin Lake
Goal 5 – Raise citizen and government awareness of and participation in water quality improvement	❖ Publicize watershed issues ❖ Educate targeted audiences in impaired areas regarding impairments and restoration options ❖ With government entities, review and amend relevant land use planning ordinances and other policies

7.2 Management Strategy

The Thornapple River Watershed Management Strategy, outlined Appendix 6, provides a template for developing and strengthening partnerships and utilizing existing and future resources to collaboratively address the goals and objectives of the management plan. The TRW Management Strategy expands the above objectives to targeted improvement areas based on water quality conditions expressed in Section 5 and tables for pollutant load reductions found in Section 6. Five and ten year milestones for each objective are quantified. Criteria for measuring the effectiveness of installed best management practices in meeting load reduction goals is expressed in the Evaluation Criteria for Load Reduction table in Appendix 6. The process for implementing BMPs is expressed in the Private Land BMP Process Chart in Appendix 6. Monitoring measures outlined in the objectives for Goals 1 and 4 above are expressed in the Monitoring and Assessment Strategy in Appendix 6. The companion to the Thornapple River Watershed Management Strategy, the Information and Education Strategy, is found in Section 7.3 below. These two action plans represent a comprehensive method to address pollutant sources and causes which threaten water quality in the TRW and to protect areas of high conservation value throughout the watershed.

7.3 Information and Education Strategy

The Thornapple River Information & Education (I&E) Strategy is a practical tool that will be used to increase the general public's understanding of what a watershed is and why it is important to protect the numerous resources it provides. The I&E Strategy highlights specific water quality problems discussed in the other sections of this watershed management plan and outlines positive actions that stakeholders need to take in order to resolve these problems and maintain good water quality throughout the watershed. Where possible, the I&E Strategy focuses on utilizing existing education tools to help raise awareness, educate, and motivate these stakeholders into taking action.

7.3.1 I&E Strategy Goals and Objectives

The goal of this I&E Strategy (Appendix 7) is to raise citizen and government awareness of and participation in water quality improvement. This goal is designed to support the Thornapple River Watershed Management goals.

The implementers of this I&E Strategy will achieve these goals by utilizing existing education-based resources, partnerships and other ongoing efforts and outlets, to encourage the key target audiences to change their behaviors and/or implement practices that result in improved

water quality throughout the watershed. Specific action items, as identified in the I&E Strategy Appendix 7, will be used to achieve one or more of the following objectives:

- Objective 1 – Publicize watershed issues: Raise the general awareness of the overall target audience and the general public about watershed issues, specifically informing them of identified problems and what action is needed to achieve the objectives expressed in the Management Strategy.

- Objective 2 – Educate targeted audiences in impaired areas regarding impairments and restoration options: This involves a more intense outreach/education effort that will include specialized workshops, presentations, recreational events and individual risk assessments to help achieve the objectives expressed in the Management Strategy.

- Objective 3 - With government entities, review and amend relevant land use planning ordinances and other policies: With government entities, assess and amend land use planning, ordinances and other policies and procedures relevant to the actions that are needed to achieve the objectives expressed in the Management Strategy.

7.3.2 Strategy Components

The I&E Strategy lays the foundation for collaborative partnerships and planning efforts that promote restoration and protection of areas within the watershed that have been, or are at risk of, being negatively impacted by anthropogenic (human) activities. Special emphasis is given to critical areas of pollutant contribution as listed in Section 6.2 of this document and to critical areas for protection, as defined in Section 6.3.

The I&E Strategy identifies key target audiences, outlines specific action-oriented messages to these audiences, describes how these messages will be conveyed, and the process that will be used to receive input and feedback from the public on the actions taken. All of these components are linked in the Education and Information Strategy Plan (Appendix 7), which will serve as an important tracking tool during the implementation phase of the watershed management plan.

7.4 Target Audiences

The purpose of the Thornapple River Watershed Management Plan is to involve local stakeholders, inform citizens about watershed management, and a focus of resources and actions on the part of the watershed that most affects water quality. Most of the pollutant sources identified in Section 6.1 above are linked to how people use, or in some cases, unintentionally misuse the watershed's resources. The focus of much of the I&E and management strategies will target the following watershed users who have been identified as being key stakeholders and target audiences:

- Agricultural community
- Riparian landowners
- Critical area landowners and the general public
- Municipalities and their employees
- Business community

- Recreational users
- State and federal and non-profit organizations
- Youth

7.4.1 Agricultural Community

The agricultural community represents a significant number of landowners, the majority of land area in the TRW and is a major economic segment within the watershed. Both the historic and current agricultural practices impact water quality within the watershed. State and federal agriculture and natural resource agencies working in the watershed have been effective in partnering with large working farms and have helped to address significant non-point sources of pollution, especially through Farm Bill and pollution prevention programs. In addition to the large farms, it is critical to include "hobby" (medium to small) farms located throughout the watershed. These farms are often less regulated and may have less awareness of their impact on water quality. Both large and small farms in the highest priority subwatersheds for sediment and nutrient loading will be specifically targeted.

7.4.2 Riparian Landowners

Waterfront property owners within the Thornapple River watershed can have a major impact, both positive and negative, on the quality of water and, therefore, are considered an important target audience of this I&E Strategy. Nonpoint source pollution such as contamination from failing septic systems, sedimentation, and nutrient loadings from poorly timed fertilizer applications are some of the major causes of poor water quality. Riparian landowners are both stewards and users of the vital land/water interface. They are the group most likely to enjoy the watershed's designated uses of fisheries, partial and total body contact recreation and navigation. These stakeholders will reap the most benefit once localized water quality problems such as eutrophication and E. coli contamination have been addressed. Landowners in areas for non-agricultural sediment and nutrient loading, and *E. coli* contamination will be specifically targeted.

7.4.3 Improvement Area Landowners and the General Public

The urban communities within the watershed continue to expand, which is leading to the conversion of agricultural land and open space into residential and commercial land uses. Non-riparian, improvement area landowners and the general public may not be aware they are having an impact on water quality. Urban landowners impact water quality as a result of unmanaged storm water and pollutant runoff from their property to storm sewers, inappropriate fertilizer use, improper pet waste disposal, and removal of soil-stabilizing vegetation from the land. The majority of the residents in the Thornapple River watershed, however, are considered rural landowners. Rural residential landowners affect water quality in the same way as urban landowners, as their properties are often connected to the TRW's surface waters through ditches, wetlands and tributaries. Landowners in the TRW's improvement areas for sediment, nutrients and hydrologic flow will be specifically targeted for protection.

7.4.4 Municipalities and Their Employees

The TRW transverses many political and municipal boundaries as it makes its way to the Lower Grand River. Local government officials, including: township, village, city, and county commissioners; planning commissions; zoning board of appeals; road commissioners; and, drain commissioners are a key targeted audience because they make the day-to-day decisions that can have the greatest impact (both positive and negative) on water quality within the watershed. In addition, local government employees are often charged with implementing the decisions made by local officials. Thus, raising their awareness of the benefits of restoring and protecting water quality is also crucial to achieving the watershed goals. Local and regional government support will ensure that the watershed resources are protected for use by future generations.

7.4.5 Business Community

There is a diverse mix of business and industry segments within the watershed, many of which are located on or in close proximity to the Thornapple River. With the advent of "green marketing," business communities in the watershed should have a strong economic interest in restoring water quality and protecting the watershed in the areas where they conduct business. In addition, the TRW's many inland lakes and publicly owned lands provide a recreational resource for local employees and their families. The adoption of storm water runoff reduction strategies and green landscaping techniques are can be positive first steps to business community involvement in water quality improvement. From a tourism perspective, local canoe liveries, marinas, sporting good shops, and other chamber of commerce members may serve as key partners in the effort to raise awareness about the benefits of recreating and living within a sustainable watershed.

7.4.6 Recreational Users

Recreational users include residents, seasonal residents and visitors to the TRW who enjoy the swimming, boating, fishing, hunting, hiking and other recreational opportunities its lands and waters provide. Like riparian landowners, recreational users reap many benefits from a healthy watershed and therefore may be more likely to take positive actions. Unlike riparian landowners, recreational users are not likely to be reached through conventional education and information strategies like press releases, workshops and presentations. Signage at popular public access points, information provided on tourism websites and partnerships with recreation facility managers are needed to reach this target audience.

7.4.7 State and Federal Agencies and Non-Profit Organizations

Natural resource/environmental agencies (e.g., Conservation Districts, U.S. Dept. of Agriculture, and the Michigan Departments of Natural Resources and Environmental Quality) and specialized organizations (e.g., Ducks Unlimited, Pheasants Forever and land conservancies) have the technical expertise to assist landowners with on-the-ground restoration and/or protection activities. This group of stakeholders will often form partnerships to achieve a common goal and/or objective, and will benefit in knowing where those opportunities may exist in the Thornapple River watershed.

7.4.8 Youth

The youth living in the watershed are important stakeholders because they are the future stewards of the land and water. Positive and detrimental actions of the other aforementioned stakeholders can have significant influence the behaviors of youth within the watershed. Negative perception of the TRW's water quality can stifle interest in taking advantage of outdoor recreational opportunities the watershed offers. Involving youth in developing and disseminating key messages related to achieving watershed management goals will not only increase their awareness, but as they share their knowledge with friends and family, more people are made aware of the benefits of being good watershed stewards.

7.5 Messages for Targeted Audiences

General messages have been identified and are specific to each target audience in the TRW. Where possible, the messages are action-oriented and encourage the target audience to do their part to restore and protect the water quality of the Thornapple River Watershed. Because the Thornapple River Watershed Management and I&E Strategies are considered to be working documents, these messages may change as implementation moves forward. They may also be modified or customized depending on the outreach method used. The groups that will be involved in disseminating the messages will work closely with appropriate partners to implement local outreach campaigns that incorporate shared goals and objectives. Each I&E Strategy message will include, at a minimum, information on watershed awareness (What is a watershed?), key pollutant sources (What is the problem?), and how individual behaviors and communities can have a positive impact on the watershed (How does the problem affect me, why I should care, and what can I do?). Each message will also be tied to at least one of the goals and one of the objectives outlined above. Below are examples of key themes or messages that may be used for each target audience.

Agricultural Community

- The importance of establishing sound agricultural BMPs
- Advantages of and opportunities for buffer and filter strips
- Alternatives to fertilizer/pesticide use
- Alternative uses of livestock waste (e.g., biofuel production)
- Farmland preservation opportunities
- Importance of wetland preservation

Riparian Landowners

- Riparian land management including the importance of riparian buffers
- Water quality-friendly lawn and garden practices
- Septic system maintenance
- Forest management

Improvement Area Landowners and the General Public

- Water quality-friendly lawn and garden practices
- Septic system
- Managing stormwater on your property
- Land preservation

- Habitat management

Recreational Users
- Stewardship
- Eco-friendly recreation
- Importance of critical area protection

Local Government Officials and Employees
- The leadership role that local governments can play in protecting the watershed
- The importance of establishing sound, enforceable natural resource protection ordinances
- Social, economic and environmental benefits of environmental restoration and protection

Business Community
- Advantages of and opportunities for innovative stormwater management
- The leadership role area businesses can play in protecting the watershed
- Advantages of and opportunities for Low Impact Development (LID)
- Identification and protection of degraded areas
- Advantages of and opportunities for open space protection and financial incentives for conservation
- Impact of earthmoving activities, importance of soil erosion and sedimentation control practices, construction BMPs

State, Federal and Tribal Agencies, and Non-Profit Organizations
- The importance of forming partnerships with landowners and other stakeholders
- The leadership role agencies and non-profits can play in restoring and/or protecting the watershed
- The importance of agency and non-profit staff's technical expertise, on-the-ground restoration experience, and funding opportunities
- The importance of outreach/education and advocacy activities to raise the awareness of landowners about watershed protection
- The benefits of watershed I&E strategies in increasing landowner participation in conservation programs

Youth
- Adoption and promotion of a state-approved watershed curriculum in K-12 schools
- The connection between watershed organization's programs and school activities
- Active participation in watershed protection activities and stewardship

7.5.1 Select Message Delivery Mechanisms

Messages can be delivered to key audiences by mail, phone, door-to-door, e-mail, presentations, workshops, meetings, the local access channel, the local radio station, and at local events. Who will deliver the message depends on the target audience to be reached. Where possible, the Thornapple River Watershed Council and Conservation Districts will partner

and share outreach material with other regional watershed educators, decision makers, and land use planners. The specific delivery mechanism(s) for each message is identified in the I&E Strategy under the column titled Education Strategy. The following bullets are examples of ways that the outreach material can be delivered to stakeholders:

- Place signs by waterways to point out watershed boundary information.
- Invite resource managers and other technical experts to present positive best management practices to membership groups.
- Promote certification opportunities, such as the Residential Environmental. Assistance Program (REAP) and MAEAP to recognize citizens who employ good watershed practices. Place certification signage on landowners' properties in recognition of adopting BMPs.
- Conduct Farm*A*Syst and Home*A*Syst onsite risk reduction programs.
- Hold "Train the Trainer" workshops to share best management practice information.
- Disseminate existing assessment guides at local events and other public places. The MGSP's Farm, Home, Lake and Lawn*A*Syst assessment guidebooks, for example, emphasize pollution prevention and enable citizens to make informed decisions on which best management practices to implement for their particular situation.
- Promote summer float tours on different lakes each summer and use the opportunity to educate homeowners on the lake about water quality and best management practices. The Four Township Water Resource Council's float tours provide a functional model for this program.
- Engage K-12 students and youth programs, such as 4-H, FFA and scout troops to assist in watershed monitoring, restoration and protection projects.
- Invite watershed management experts to attend and present at local government meetings to discuss effective best management practices and land use planning techniques that may be used to address water quality issues or protect desired uses.
- Invite local elected officials to attend watershed meetings and activities to keep them engaged in the implementation process.
- Encourage intergovernmental cooperation by hosting watershed forums tailored to address common water quality issues and highlight individual and community-wide restoration and protection successes.
- Engage local media to help promote and cover watershed-wide activities and special events. Submit information pieces to local media as a way to reach a broad audience.

7.6 Selected Actions for Targeted Audiences

A general list of actions has been identified for each target audience in the TRW. These actions can be perceived as indicators of successful I&E Strategy message delivery and are directly related to the TRW Management Strategy's objectives.

Agricultural Community

- Complete appropriate Farm*A*Syst evaluations
- Attain MAEAP Verification
- Complete Conservation Plan and/or Comprehensive Nutrient Management Plan
- Install conservation practices on critical areas for soil loss or nutrient loading

Riparian Landowners

- Manage riparian areas using BMP's including buffers and limited lawn and access areas
- Limit fertilizer use and choose non-phosphorus fertilizers
- Undertake routine septic system inspections
- Repair or replace failing septic systems
- Forego chemical weed treatments
- Limit use and storage, and use proper disposal methods for hazardous wastes
- Attain REAP Certification
- Educate others regarding riparian BMPs

Restoration and Improvement Area Landowners and the General Public

- Limit fertilizer use and choose non-phosphorus fertilizers
- Undertake routine septic system inspections
- Limit use and storage, and use proper disposal methods for hazardous wastes
- Manage onsite stormwater using BMP's including rain gardens and rain barrels
- Restore unused land areas to native habitat
- Manage forested areas using BMP's including selective harvesting and invasive species management
- Develop long-term conservation plans for large tracts, including management plans and conservation easements

Recreational Users

- Practice environmental stewardship activities including public area clean-ups, catch-and-release fishing, and reducing human impacts on recreational areas
- Educate others regarding stewardship practices
- Take appropriate steps to deter the spread of invasive species

Local Government Officials and Employees

- Participate in watershed management implementation activities
- Develop or enhance natural resource protection ordinances and policies in relation to TRW Management Plan recommendations
- Engage in cross-jurisdictional planning projects to limit urban sprawl and maintain open space
- Support the maintenance or development of state laws that enhance watershed and natural resource protection
- Collaborate on projects to restore, maintain and improve water quality

Business Community

- Develop or replicate innovative strategies to reduce point-source pollutant loads
- Utilize Low Impact Development strategies
- Implement onsite stormwater management practices
- Utilize soil erosion and sedimentation BMPs
- Take leadership roles in modeling and sharing information on water quality protection
- Collaborate on projects to restore, maintain and improve water quality

State, Federal and Tribal Agencies, and Non-Profit Organizations

- Incorporate TRW Management Plan goals, objectives and critical area focuses in annual plans of work
- Assist in TRW I&E Strategy message delivery
- Participate in TRW Management Plan implementation activities
- Collaborate on projects to restore, maintain and improve water quality

Youth

- Participate in I&E programs
- Participate in watershed-based monitoring and clean-up activities
- Practice environmental stewardship
- Take leadership roles in modeling and sharing information on water quality protection

7.7 Evaluation

A feedback loop is very important to determine the success of an action or task undertaken during the implementation phase of the watershed management plan. Specific evaluation criteria in the form of indicators and measurable milestones have been identified for each objective outlined in the Management and I&E Strategies (Appendices 6 and 7). Evaluation ranges from measuring the number or size of BMPs installed, recording the number of stakeholders reached at various events to using surveys such as those developed through the Social Indicator Planning and Evaluation System (SIPES) for Nonpoint Source Management[29] to gage general public and workshop participant levels of watershed awareness. Progress on objectives will be monitored throughout the implementation period, with annual assessments conducted to determine the level of effectiveness of management and I&E strategies. Strategy modifications will be made to increase overall program effectiveness.

29 Genskow, Ken and Linda Prokopy (eds.). 2008. *The Social Indicator Planning and Evaluation System (SIPES) for Nonpoint Source Management: A Handbook for Projects in USEPA Region 5*. Great Lakes Regional Water Program. Publication Number GLRWP-08-SI01 (169 pages).

8 IDENTIFICATION OF MANAGEMENT AND EDUCATIONAL RESOURCES

8.1 Existing Resources

There are numerous Federal, State and local resources that can be utilized or directed toward forwarding the TRW's management and I&E goals and objectives. Coordination and application of existing technical assistance, funding resources and educational support is necessary to bring these resources together to support the TRW Management Plan.

8.1.1 Federal Resources

8.1.1.1 Conservation Reserve Program (CRP) and Continuous Conservation Reserve Program (CCRP):

The USDA's CRP and CCRP encourage agricultural producers to voluntarily protect sensitive areas through establishment of long-term vegetative cover to address the environmental issues of soil erosion, water quality and wildlife habitat. Qualified landowners can enroll for conservation practices including grass waterways, contour grass buffer strips, shelterbelts, field windbreaks, shallow water areas for wildlife riparian buffers and filter strips. Producers signing 10-15 year agreements receive annual per-acre rental payments and cost-sharing for up to 90% of establishment costs and 50% of management costs. Landowners may enroll eligible acres into the Continuous Conservation Reserve Program without waiting for an announced sign-up period.

8.1.1.2 Environmental Quality Incentive Program (EQIP)

The USDA's Environmental Quality Incentive Program (EQIP) is voluntary conservation program providing financial and technical assistance to agricultural producers in reducing threats to soil, water, air and related natural resources. EQIP promotes agricultural production and environmental quality as compatible goals and offers financial and technical assistance to eligible participants for installing or implementing structural and management practices, including waste storage facilities, agrichemical containment facilities, conservation tillage, buffer strips and pest management. These practices are identified through conservation planning and implemented using NRCS technical standards adapted to local conditions. Under the current farm bill, practices may be cost-shared up to 75 per cent, or 90 percent for limited resource producers and beginning farmers and ranchers. Other important EQIP programs include:

- Conservation Planning**:** Conservation planning is a natural resource problem- solving and management process. The process integrates ecological (natural resource), economic, and social considerations to meet private and public needs. This approach, which emphasizes identifying desired future conditions, improves natural resource management, minimizes conflict, and addresses problems and opportunities.

- Comprehensive Nutrient Management Plan (CNMP): A CNMP is a conservation plan that is unique to animal feeding operations. It is a grouping of conservation practices and management activities which, when implemented as part of a conservation system, will help to ensure that both production and natural resource protection goals are achieved. A CNMP incorporates practices to utilize animal manure and organic by-products as a

beneficial resource. A CNMP addresses natural resource concerns dealing with soil erosion, manure, and organic by-products and their potential impacts on water quality, which may derive from an AFO. A CNMP is developed to assist an AFO owner/operator in meeting all applicable local, tribal, State, and Federal water quality goals or regulations. For nutrient impaired stream segments or water bodies, additional management activities or conservation practices may be required to meet those water quality goals or regulations.

Local USDA-NRCS Service Centers in the TRW assist approximately seven producers in developing Conservation Plans and three to five AFO owners in completing CNMP's annually. With additional technical assistance, more Conservation Plans and CNMP's could be completed, creating more cost-share-eligibility for additional EQIP practices among AFO's in the watershed.

8.1.1.3 Wetland Reserve Program (WRP)

The USDA-NRCS Wetland Reserve Program provides protection, in the form of a 10-year, 30-year or permanent conservation easement, for prior-converted farmland that is returned to functioning wetland capacity. In return for program enrollment, landowners receive cost share funds for wetland restoration and are reimbursed for a percentage of the value of the easement. This program has been used successfully in the TRW to restore floodplain wetland parcels.

8.1.1.4 Wildlife Habitat Incentive Program (WHIP)

WHIP is a voluntary NRCS program for private landowners, including non-agricultural landowners to create or enhance high-quality habitat for significant wildlife species. Cost share rates of up to 75% of installation are available for conservation cover, tree and shrub establishment and habitat restoration.

8.1.1.5 Conservation Stewardship Program (CSP)

The USDA's CSP provides annual payments and cost share for producers who are currently meeting stewardship thresholds for at least one resource concern and are willing to address an additional priority resource concern during the stewardship contract.

8.1.1.6 Thornapple River Floodplain Management Plan

The USDA-NRCS developed the *Thornapple River Floodplain Management Plan* and database for the Thornapple River from its headwaters to McKeown Gage in 2004. The plan re-determines the river's floodplain in relation to structural improvements including roads, culverts, bridges and dams. The database was designed to be utilized by road and drain commission offices in order to predict floodplain alterations due to proposed structural changes. In addition, once new structures were in place, they could be permanently entered into the database to create new maps of floodplain areas. Unfortunately, the database was not adopted by local road and drain commissions, so this tool has not been kept current. However, the plan's recommendations were considered in the development of the Barry County Master Plan and Land Use Ordinances in 2007. The *Thornapple River Floodplain Management Plan's*

recommendations should be used to inform the new master plan currently being developed in Eaton County, and any other long-range land use planning occurring within the TRW.

8.1.1.7 Dam Removal Programs

Funding for dam removal to restore fish passage is available through both federal and state sources. The U.S. Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration (NOAA) provide grants for dam removal and river restoration. The Michigan DNR's Inland Fisheries Grant program has prioritized dam removal for fish passage restoration as well. The USFWS and MDNR, along with the National Fish and Wildlife Foundation provided funds for the removal of the Nashville Dam on the mainstem of the Thornapple River and the Maple Hill Dam on Butternut Creek in 2009. These programs should continue to be utilized to remove non-functioning dams on the TRW's tributaries.

8.1.1.8 Partners for Fish and Wildlife Program

The U.S. Fish and Wildlife Service's Partners Program emphasizes stewardship, partnership, fish and wildlife and future generations through working in collaboration with conservation organizations and agencies and private landowners to restore and enhance fish and wildlife habitat. In Michigan, the primary focus is wetland restoration, with additional assistance for grassland, stream and riparian corridor restoration. Restoration of habitat critical to federally-listed threatened or endangered species is also within the scope of the Partners Program. Program commitment is a minimum of 10 years. There are seven restored wetland areas in the TRW that have been supported through this program.

8.1.1.9 Environmental Protection Agency (EPA) 319 Funds

The EPA provides grants to states which, in Michigan, are directed through MDEQ, to implement nonpoint source programs and projects related to the Clean Water Act. Funding can address issues in agriculture, forestry, construction and urban environments and also protect high-quality habitat.

8.1.1.10 Five-Star Restoration Program

EPA funds to this committee are subgranted to support community-based wetland and riparian restoration projects which include long-term ecological, educational and/or socioeconomic benefits to the community.

8.1.1.11 Sustain Our Great Lakes (SOGL)

The SOGL program provides funding for habitat restoration and enhancement projects in the Great Lakes region. Partners include ArcelorMIttal, EPA, U.S. Fish and Wildlife Service, U.S. Forest Service, National Fish and Wildlife Foundation (NFWF) and National Oceanic and Atmospheric Administration (NOAA).

8.1.1.12 Bring Back the Natives (BBN)

The BBN Initiative is administered by NFWF and focuses on the restoration of native aquatic species through rehabilitation of aquatic habitat.

8.1.1.13 USDA Rural Utilites Service

The Rural Utilities Service program an assist rural communities in funding new and improved water and waste disposal facilities. Funding assistance extends to repair and expansion of existing facilities.

8.1.2 State Resources

State resources are provided primarily through the Departments of Agriculture, Environmental Quality and Natural Resources. Programs are funded by earmarked sources, federal grants and departmental budgets. Programs vary from year to year depending upon available funding.

8.1.2.1 Michigan Wildlife Habitat Grant Program (WHGP)

The Michigan Department of Natural Resources' WHGP provides financial assistance to enhance, restore and protect wetland and grassland habitats to enhance game species in Michigan. Assistance can be sought for prairie planting, restoration and management, wetland restoration and exotic or invasive species removal.

8.1.2.2 Michigan Agricultural Environmental Assurance Program (MAEAP)

The Michigan Agricultural Environmental Assurance Program (MAEAP) provides technical assistance to the entire TRW from offices in the Kent, Ionia and Eaton Conservation Districts. On-farm groundwater risk assessments are available for all producers, with customized tools for various practices including crops, livestock, orchards and greenhouses. MAEAP is an innovative, proactive program that helps farms of all sizes and all commodities voluntarily prevent or minimize agricultural pollution risks. MAEAP teaches farmers how to identify and prevent environmental risks and comply with state and federal environmental regulations. Farmers who successfully complete the three phases of a MAEAP system are rewarded by becoming verified in that system**.** Verification, provided to producers who follow the state's Generally Accepted Agricultural and Management Practices (GAAMPS) affords nuisance protection for producers under the Michigan Right to Farm Act. There are multiple "systems" or areas of concentration for MAEAP verification, including, livestock, crops, small farms, orchards and others. Verification in each MAEAP system requires meeting all three phases for that system, which include attendance at an educational session, completing an on-farm risk assessment and undergoing a third-party verification. Since its inception, approximately four farms per year have achieved MAEAP certification in the TRW.

8.1.2.3 Clean Michigan Initiative (CMI)

The Clean Michigan Initiative provides grant funds for several water protection programs. The Abandoned Well Management Grants Program funds the location and closure of abandoned wells in wellhead protection areas (WHPAs) around community water sources. Five cities and villages in the TRW have benefited from the Abandoned Well Management Grants Program. The CMI's Brownfield Redevelopment Grants program provides funds to local units of government to investigate and remediate environmental contamination sites that will be used for economic redevelopment. Loans made through this program can be utilized for the same purpose. The Contaminated Sediment Program investigates and provides remediation, when

necessary, to handle contaminated sediments resulting from current or historic pollutant leaks or spills affecting ground or surface waters. CMI provides grant funds for watershed management planning and implementation, distributed through MDEQ's Nonpoint Source Control Program. CMI funds support local water quality monitoring through beach monitoring, volunteer stream montirong and volunteer river stream and creek clean up grants. CMI funds also support parks and recreation grant programs (see below).

8.1.2.4 Nonpoint Source Control (NPS) Program

The MDEQ's NPS program provides technical and financial assistance in developing and implementing watershed management plans. Financial assistance comes through CMI and the Federal Clean Water Act Section 319 grant programs. Additionally, the NPS program develops NPS information and education tools and activities, provides compliance and enforcement for NPS complaints, and monitoring to identify pollutant sources and remediation effectiveness.

8.1.2.5 Stormwater, Asset Mangement and Wastewater Program (SAW)

The SAW program provides funds to assist municipalities in developing plans to manage water, wastewater and stormwater systems and to reduce nonpoint source pollution to improve water quality.

8.1.2.6 Clean Michigan Initiative/Michigan Natural Resources Trust Fund /Land and Water Conservation Fund (CMI/MNRTF/LWCF)

The State of Michigan provides grant funds through its CMI, MNRTF and LWCF programs to municipalities with approved Parks and Recreation plans in order to acquire or improve parks and recreation facilities. Local units of government have used these funds for parks along the Thornapple River in Nashville, Hastings, Middleville and Ada. Continued use of these funds to purchase additional properties in critical area of the watershed and to provide attractive and environmentally sustainable water-based recreation destinations will support the goals of the TRW Management Plan.

8.1.2.7 Aquatic Habitat Grant Program (AGHP)

The MDNR's Aquatic Habitat Grant Program provides funds and technicial assistance to support habitat improvement for fish and other aquatic organisms.

8.1.2.8 Dam Management Grant Program (DMGP)

The MDNR's DMGP provides support through funding and technical assistance to repair or remove dams in order to improve aquatic habitat and fisheries.

8.1.2.9 Michigan Invasive Species Grants Program (MISGP)

The MISGP program supports strategic efforts to identify, prevent, control or eradicate terrestrial or aquatic invasive species.

8.1.3 Local/Regional Resources

8.1.3.1 Agricultural Preservation Programs

Agricultural preservation programs exist in Allegan, Kent and Barry Counties. These programs seek to preserve farmland in perpetuity through development of permanent easements limiting land use to agricultural pursuits. Private, state and federal funding sources are often utilized to purchase the development rights on qualified properties. Criteria for farmland qualification and ranking include soil quality data and requirements for USDA conservation plans, CNMP's and MAEAP verification, making these programs supportive of water quality improvement.

8.1.3.2 Land Conservancy Programs

The TRW region is served by the Southwest Michigan Land Conservancy and the West Michigan Land Conservancy. These non-profit organizations accept the donation of, and at times purchase conservation easements on properties considered critical habitat areas. With the assistance of land conservancy staff, landowners develop and carry out habitat management and protection plans to increase the habitat value of their properties. Over the past two decades, these programs have met with unprecedented success in the TRW, conserving over 1000 acres within the watershed while providing invaluable landowner outreach and education regarding the value of the TRW's natural resources.

8.1.3.3 Barry State Game Area Conservation Planning Project (BSGA)

The BGSA Planning Project has developed a private-public partnership to increase protected land that has the greatest benefit for conservation of the Barry State Game Area and its wildlife habitats and water resources. The BGSA area, including the Yankee Springs Recreation Area, comprises 22,000 acres of pubic open space and wildlife habitat which supports a number of state threatened (14), endangered (2) and special concern (26) species. Geographic information system mapping helped to identify in-holdings as well as development pressure areas and wildlife corridors outside the BSGA that, if protected, would increase the potential for survival of critical species and would protect and improve water quality in two coldwater subwatersheds of the TRW. The goals of the BSGA Planning Project include enhancing and protecting 2000 acres within the project's identified priority conservation areas. The BSGA Planning Project directly supports the goals and objectives of the TRW Management Plan.

8.1.3.4 Municipal Sewer Systems

Urban areas of the TRW are all served by municipal sewer systems. The Southwest Barry County Sewer Authority (SWBCSA) also provides municipal sewer to some lake communities in the southwest portion of the watershed. When feasible, these municipal sewer systems should be extended to residential lake communities to decrease the potential for runoff from failed septic systems entering the lakes.

8.1.3.5 Thornapple River Watershed Council

The Thornapple River Watershed Council (TRWC), a non-profit watershed organization, has provided education, outreach and volunteer activities within the TRW since its inception in

1995. The TRWC's white paper, *The Thornapple River Watershed: Prospectus for Protection*, provided the impetus for developing the Thornapple River Watershed Management Plan. This volunteer organization has a strong leadership component which seeks grants, organizes annual river clean-ups, provides educational workshops, engages in outreach activities at local events and works with local government units on water quality monitoring and improvement projects. Its volunteer base, numbering in the hundreds, represents community members, businesses and sports enthusiasts from all corners of the TRW and beyond. The TRWC's history and capacity for outreach and education provides a firm foundation and resource for community participation in water quality improvement.

8.1.3.6 Conservation Districts

The five Conservation Districts in the TRW each provide local points of landowner contact and information regarding land and water management in their respective counties of Allegan, Barry, Eaton, Ionia and Kent. Districts provide educational workshops, tours and field days to raise awareness of natural resource protection and promote best management practices. Conservation Districts also work closely with local units of government to address natural resource concerns through educational programs, ordinance development and program development. The TRW's Conservation Districts, as the local centers for information, education and BMP programs for watershed improvement, are vital to watershed plan implementation.

8.1.3.7 Resource Conservation and Development Councils (RC&Ds)

Counties in the TRW are served by the Potawatomi RC&D or the Timberland RC&D. These councils, supported by local units of government and foundations, provide technical, financial and educational support for natural resource conservation and economic development projects. Both councils are active in their respective regions, assisting in watershed-based projects.

8.1.3.8 Hazardous Waste Disposal Programs

The TRW project area is served by numerous hazardous waste disposal programs sponsored by multiple agencies including health departments, municipalities and MGSP programs. Hazardous waste disposal programs provide homeowners and agricultural operators with resources to properly dispose of unneeded hazardous waste materials including pharmaceuticals, fuel, pesticides and fertilizers. These programs are successful, but with additional volunteers and publicity could serve a greater sector of the TRW population.

8.1.3.9 Michigan Natural Shoreline Partnership (MNSP) and Michigan Inland Lakes Partnership

These collaborative programs provide tools and training to help landowners and contractors manage lakes as ecosystesm by adopting beneficial riparian land management techniques.

8.1.4 Foundations and Environmental Organizations

8.1.4.1 Foundations

Several local and regional foundations include environmental protection and enhancement in their missions. The W.K. Kellogg Foundation, based in Battle Creek, Michigan, provides global support for education and environmental stewardship, among other things. The Barry Community Foundation includes several funds dedicated to environmental education, stewardship activities, leadership and youth-focused programs. The Willard and Jesse Pierce Foundation supports the Pierce Cedar Creek Institute in the TRW, which provides environmental education, outreach and internship opportunities. The Pierce Foundation has supported projects including the Barry County Potential Conservation Area Analysis.

8.1.4.2 Environmental Organizations

Non-profit environmental organizations, including Pheasants Forever, Ducks Unlimited, Trout Unlimited and the Michigan United Conservation Club (MUCC) have been active in habitat restoration and protection efforts as well as education program and material development within the TRW for many years. Local chapter leaders and members can assist in directing organization support to TRW Management Plan implementation.

8.1.5 Local Models

8.1.5.1 Barry County Master Plan

The Barry County Master Plan and its supporting ordinances developed in 2006 and 2008, respectively, offer models of environmentally sensitive priorities and planning. Riparian corridor protection through setbacks, low-density zoning and natural area classifications contribute to the maintenance of floodplains and habitat corridors. Open space and LID incentives help to preserve rural quality while providing for planned growth. Joint planning ventures with urbanizing areas help to consolidate infrastructure while preserving resources around city centers.

8.1.5.2 City of Hastings Riparian Protection Ordinance

The City of Hastings' Riparian Protection Ordinance, approved in 2008, limits removal of existing riparian vegetation along the banks of the Thornapple River and provides incentives for businesses and residents to restore or develop riparian buffers using native plants and trees. This model ordinance and support program directly addresses objectives of the TRW Management Plan and provides a target audience for I&E strategies as well as opportunities for demonstration projects.

8.1.5.3 Time of Sale or Transfer Ordinance (TOST)

The Barry-Eaton District Health Department's Time of Sale or Transfer Ordinance, in force since late 2007, has contributed greatly to reducing the number of failing septic systems and illicit connections in the Barry and Eaton County portions of the TRW. These potential sources of nutrient and E. coli loading in the TRW would likely be overlooked without the requirement of

well and septic inspection when properties are sold or transferred. The overwhelming success of the program in its first year illustrates both the extent of septic non-point source pollution in the TRW and the need for similar programs throughout the watershed area.

8.2 Additional Resources Needed to Achieve Goals

8.2.1 Federal Resources

Many of the Federal Resources outlined above in Section 8.1.1 currently provide essential means to reduce sediment and nutrient loading from agricultural areas, restore and protect converted wetlands and assist in dam removal on the TRW. Personnel resources are needed at the watershed level to attract more support from these programs through grant writing, partnership development and watershed publicity.

8.2.1.1 USDA-NRCS

Agreements with USDA-NRCS field offices in the TRW will help to focus federal resources in the watershed's critical areas and may prioritize TRW project applications for funding. Programs such as AWEP may help target funds for the TRW or the larger Lower Grand River Watershed. Producers who may currently rank below NRCS funding benchmarks for BMP cost-share assistance would benefit from either strategy.

8.2.2 State Resources

Similar to federal resources, state resources offer important support for the watershed goals, objectives and strategies outlined above. Budget cuts and program elimination will likely continue to reduce the availability and effectiveness of existing resources, making them less reliable for future implementation plans.

8.2.2.1 Conservation Reserve Enhancement Program (CREP)

The Michigan Department of Agriculture's CREP program has proven successful in installing best management practices on agricultural lands in southeast Michigan. Such a resource in the Lower Grand River Watershed would benefit the many watershed planning units, including the TRW, working to improve water quality in the Lower Grand River Watershed.

8.2.3 Watershed Resources

8.2.3.1 Watershed Coordinator

Many local, state and federal resources already exist to address the causes of non-point source pollution in the TRW. What is lacking is a concerted effort to direct these resources to landowners in the watershed's critical areas. A watershed coordinator/technician knowledgeable of these existing programs is needed to focus outreach efforts in targeted areas and direct landowners to the appropriate resources. The watershed coordinator would also develop the tools needed to implement the proposed Thornapple River Watershed Information and Education plan, work with project partners to develop I&E programs and train partners to

present programs to citizens and government units throughout the watershed. Costs to employ a watershed coordinator, including benefits and indirect costs are estimated as follows:

Hourly Rate	5-year Cost	10-year Cost
$30.00	$312,000	$614,000

8.2.3.2 Targeted Watershed Information and Education Program

The Thornapple River Watershed Management Plan includes a Thornapple River Watershed Information and Education Strategy. Local and regional partners, including the Thornapple River Watershed Council and local Conservation Districts will need training and resources to carry out the proposed plan and evaluate its results. Based on the I&E Strategy estimates (Appendix 7), this component will cost:

Program	5-year Cost	10-year Cost
I&E Strategy	$124,500	$246,000

8.2.3.3 Watershed Monitoring Program

The development of an enhanced watershed monitoring program during the implementation phase of the TRW Management Plan is necessary to gather more specific baseline data on impaired reaches as well as those with insufficient information or results showing high *E. coli* or temperature levels. These monitoring needs are charted in Appendix 6. In addition, pre- and post-implementation assessments during the implementation phase, as expressed in Appendix 6, are needed to determine the actual reductions achieved through the implementation of best management practices. The cost estimate to implement this monitoring program, including equipment and sample analysis, is for each five-year period.

Program	5-year Cost	10-year Cost
Watershed Monitoring	$755,884	$1,095,948

8.2.3.4 Management Strategy Implementation

The Thornapple River Watershed Management Strategy presents action items that need to be undertaken in critical areas of the TRW to reduce the highest sources of pollutant loads. Many of these actions are structural or procedural best management practices, or BMP's, while others involve local planning and legislation, and still others encourage landowners to preserve and protect their property as natural habitat. Funding for these undertakings will be required from several sources, including federal Farm Bill programs, federal, state, local and non-profit grant programs, local units of government, private citizens and project partners. The overall cost estimate for implementing the TRW Management Strategy, less monitoring costs, based on estimates in Appendix 6, is as follows:

Program	5-year Cost	10-year Cost
Management Strategy	$7,659,283	$15,426,730

9 Management Plan Implementation

9.1 Resource Needs

Resources needed to implement the Thornapple River Watershed Management Plan include the existing resources outlined in Section 8.1 as well as the additional resources outlined in Section 8.2. The two most important factors in sustaining implementation will be centralizing responsibility and communication in a single role – the watershed coordinator – and continuing to develop and expand the partnerships that have been generated through the planning process. A coordinator whose sole focus is watershed management and education will be able to provide up-to-date assessments of plan progress and knowledgeable recommendations for technical and educational assistance and develop funding proposals for programs and projects. In addition, a central point of contact for project partners and the general public will facilitate clear and reliable watershed information delivery while promoting new partnerships throughout the watershed.

9.2 Estimation of Project Costs

Total estimated costs for implementation of the Thornapple River Watershed Management Plan are based on cost estimates for each element of the plan, found in Appendix 6, 7 and 8. Project costs will be met from a variety of sources, including Farm Bill program funds, landowner matching contributions, federal, state, local and non-profit grant programs, individual and corporate donations and in-kind services provided by project partners and volunteers. Funding will be directed on a project-basis to the landowners, units of government, agencies and organizations undertaking projects including agricultural BMPs, brownfield redevelopment, road structure improvements, municipal sewer projects and educational programs. Directing funding on this scale to local communities for water quality improvement will help to create jobs, sustain businesses and improve overall economic conditions while protecting watershed resources for future generations. The chart below combines all implementation project costs to provide five- and ten-year total estimates

Figure 9.2 Estimated Implementation Costs

Implementing all of the proposed elements to the Thornapple River Watershed Management Plan will include the services of a watershed coordinator for education, outreach, grant management and implementation oversight; education and outreach programs and publications; watershed monitoring and management measures. Funding to undertake the elements of the management plan may come from a combination of sources listed in Section 8.1. Similarly, support and in-kind assistance will be requested from project partners such as those listed in Section 8.1 and others that are interested in supporting this plan's goals.

Program	5-year Cost	10-year Cost
Watershed Coordinator	$312,000	$614,000
I&E Strategy	$124,500	$246,000
Watershed Monitoring	$755,884	$1,095,948
Management Strategy	$7,659,238	$15,426,730
TOTAL	$8,851,622	$17,382,678

9.3 Implementation Tasks, Responsibilities and Timeline

9.3.1 Current and Ongoing Projects

Several water quality improvement projects are already underway in the TRW, and nearly all stem from the partnerships and communication developed through the TRW management planning process. The table below provides information on each project:

Figure 9.3.1. Current and Ongoing Projects in the TRW

Project	Lead Agency	Goal(s)	Completion Date	Costs
Annual Thornapple River Clean Up	Thornapple River Watershed Council	To raise awareness of watershed issues while providing models for watershed stewardship	Ongoing since 1994	$7,500/year
Watershed BMP Education Series	Barry Conservation District	To raise awareness about watershed issues and encourage the adoption of BMPs by residential and agricultural landowners	Ongoing since 2005	$3,000/year
Time of Sale or Transfer Ordinance	Barry-Eaton District Health Department	To improve environmental health by insuring the functionality of well and septic systems	Ongoing since 2007	$100,000/year
Potential Conservation Area Analysis	Conservation Districts	To determine high quality natural areas and establish measures for their preservation and protection	Barry - 2007, Eaton - 2009	$15,000 per county
Riparian Buffer Protection project	City of Hastings	To encourage the establishment of natural riparian buffers along the Thornapple River within the City limits	Ongoing since 2008	$5,000 per year
Barry State Game Area Conservation Planning Project	Southwest Michigan Land Conservancy	increase protected land that has the greatest benefit for conservation of the Barry State Game Area and its wildlife habitats and water resources	Ongoing since 2009	In-kind donations to $10,000,000

9.3.2 Task Organization and Timeline

The Thornapple River Watershed Management Plan implementation phase is subdivided into task-oriented categories based on partnerships and resources needed to achieve its goals. As expressed in the timeline provided in Appendix 8, each category includes a set of related tasks, assigns leadership and support for the tasks, and includes an evaluation process to measure implementation success.

9.3.2.1 Support

Support refers to financial and in-kind support needed to carry out the implementation plan. Tasks include securing partnership agreements and grant funds to sustain the implementation process.

9.3.2.2 Technical Assistance

Technical assistance includes on-the-ground site visits, engineering, and cost-share programs needed to implement necessary BMPs. Technical assistance can be provided by state, federal and local agencies as well as non-profit organizations. Providing access to available technical assistance requires educating technical assistance providers about management plan's goals and objectives, forming and strengthening partnerships and directing available resources to critical areas.

9.3.2.3 Water Quality Monitoring

An expanded water quality monitoring program and the technical expertise to carry it out are necessary to further hone implementation critical areas and to measure the results of plan implementation. Developing partnerships, such as the volunteer Thornapple River Watershed Monitoring Team, which is comprised of resource professionals with expertise in a variety of monitoring protocols, will be necessary especially in the early stages of implementation.

9.3.2.4 Government Partnerships

Developing and sustaining relationships with government entities within the TRW while providing leadership in water quality and natural resource programs and projects is essential in assuring long-term improvements in the TRW. Local government agencies can provide models for citizen and business community action based on their policies, programs and priorities. Raising awareness within government agencies about watershed issues and the means to best address them and encouraging cross-jurisdictional collaboration are important components of the implementation phase.

9.3.2.5 Stewardship Program Support

The task of stewardship program support included assisting in existing projects and programs that support water quality improvement, including the Annual Thornapple River Clean Up, hazardous waste collections and the TRW Macroinvertebrate Monitoring Program. When watershed partners share their resources, including volunteer bases, public relations capacities

and collaborative education and information campaigns, each of these projects has the capacity to reach larger numbers of TRW citizens.

9.3.3 Partner and Stakeholder Roles and Responsibilities

In its early phase, the TRW Management Plan will need to rely on volunteer support from partner organizations to achieve objectives and goals. The Thornapple River Watershed Steering Committee, organized by the Barry Conservation District, and the Thornapple River Watershed Council, a volunteer organization, will take the lead role during this period. For each task category, leaders will be identified and asked to assume responsibility for specific tasks including education, research and reporting carried out by task group members. At the point when a watershed coordinator is hired, she or he will assume leadership responsibilities within each task group, while maintaining and expanding group membership.

9.4 Evaluation Framework

To evaluate both the success of plan implementation and the effects of BMPs and future conditions on the determination of critical areas, the following process will be undertaken to assess and revise this management plan:

- Develop a framework for documenting and publishing results for each task area as expressed in Section 9.3.2
- Report results annually, in written form, to the TRWSC
- Compare results to management and I&E goals, objectives and strategies
- Assess strengths and weaknesses of current task approaches
- Develop and disseminate annual recommendations for program improvements
- Assess new monitoring and task data in relation to critical area assessments, pollutant load calculations and pollutant reduction targets
- Revise critical area assessments, pollutant load calculations and pollutant load reduction targets as well as target audiences and messages on a five-year basis in relation to new data
- Publish five-year plan revisions and disseminate to stakeholders and partners

Each year, an evaluative project summary will be compiled, published and made available for stakeholder review. The summary will include annual and cumulative task results, progress toward milestones, project revenues and expenditures, program assessments and recommendations.

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