



CASS RIVER WATERSHED MANAGEMENT PLAN
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Submitted by:
University of Michigan-Flint, University Outreach and
Saginaw Bay Resource Conservation and Development Council



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CHAPTER 1: INTRODUCTION

1.1 Layout of Plan

The Cass River Watershed Management Plan (Plan) is organized into ten chapters and six appendices. The organization of the Plan is intended to make a large amount of information about the Cass River into a digestible format for a variety of audiences to read, understand, and utilize. What follows are a summary and rationale for each chapter and appendix in the Plan.

Chapter 1 includes a broad overview of information about the Cass River Watershed planning process and who was involved in the creation and completion of the Plan. Chapter 1 also includes a water quality summary and goals for the overall watershed.

Chapter 2 presents background information about the physical location of the Cass River Watershed, the various underlying factors that influence water quality of the Cass River, and a discussion on the designated uses of the Cass River and the sub-watersheds it contains.

Chapter 3 presents the methods that were used in determining which areas of the watershed were inventoried, the types of inventory methods used, and how restoration sites were identified and prioritized.

Chapter 4 is the urban area analysis, a small percentage of the watershed area wise but still has an impact on the overall water quality of the Cass River. Urban areas were analyzed on the watershed scale as many of the best practices and key stakeholders are similar across the entire watershed.

Chapter 5 is the natural resources section of the watershed that details the vastness of natural lands remaining in the watershed and the opportunities for wetland restoration and priority areas for protection. Similar to Chapter 4, natural resources are presented at the watershed level as many of the project practices and partners are similar across the entire watershed.

Chapter 6 is the overall information and education plan for the watershed and includes strategies by target audience and best practices for each of the pollution problems and threats identified during the planning process.

The requirements set forth by the Environmental Protection Agency (EPA Elements) are organized by sub-basin for Upper Cass River (Chapter 7), Middle Cass River (Chapter 8) and Lower Cass River (Chapter 9). This approach was taken to aid the county conservation districts and the Cass River Greenway committee in developing project proposals for each of the sub-basins as it relates to remediating agricultural based pollution problems.

Chapter 10 outlines next steps that need to occur beyond the scope of the Plan and suggestions for sustaining projects in the Cass River watershed.

Appendices include information that supports recommendations set forth in the Plan but that is not relevant to all of the potential readers of the Plan, these include: (A) Works Cited, (B) Previous Studies and Summaries, (C) Pollutant Loading, (D) Urban Stormwater Inventory and Ordinance, (E) Land Use and Ordinance Recommendations, and (F) Social Monitoring.

1.2 Watershed Management Plan Purpose

The watershed management plan brings together members of our community to manage land activities that affect water quality. It recommends ways to protect and improve water resources as land use changes.

Because water runs over land, land use has the potential to add pollutants to our water resources. We all need water, and all manage our land individually. Our small actions collectively have a large impact on the water quality of the Cass River. The watershed management plan is, in essence, an action plan that details our community's water quality concerns and the most cost-effective strategies to pay for education and installation costs to improve water quality.

This watershed management plan belongs to EVERYONE and can be implemented with funding support from the Nonpoint Source Program of the Michigan Department of Environmental Quality (MDEQ) and additional funding partners through an annual grant application process. Non-profit entities, educational institutions, and government agencies are eligible to apply for funding of this plan per individual funding guidelines.

1.3 Implementation Process

Upon completion of the watershed management plan, it is reviewed by staff from the Michigan Department of Environmental Quality (MDEQ). Upon approval by the MDEQ, the plan is forwarded to the Environmental Protection Agency (EPA) for final review and approval. Watershed Management Plans that are approved on or prior to July 24, 2013 are eligible to apply to MDEQ for funding to fix pollution problems and implement projects identified during the planning phase.

1.4 Steering Committee Roles and Responsibilities

The Steering Committee was comprised of representatives from federal, state, and local government, engineering and education contractors, and residents of the watershed. Collectively, the steering committee members were charged with tracking the progress of the watershed management plan and ensuring its success. The steering committee met monthly during 2011 and bimonthly in 2012. Different presentations were brought in to cover technical topics such as the Landscape Level Functional Wetland Assessment completed by the MDEQ, and the Great Lakes Program of the Nature Conservancy. Additional tasks of the steering committee included the approval of the inventory strategy, prioritization of the implementation plan and education plan.

Table 1.1 Steering Committee Members and Affiliation

Member Name	Affiliation
Robert Zeilinger	Cass River Greenway Committee
Jim Kratz	Tuscola County Conservation District
Joe Kautz	Sanilac County Conservation District
Russ Beaubian	Spicer Group
Brad Barrett	City of Vassar
Michelle Vander Haar	U.S. Fish and Wildlife Service
Charlie Bauer	Michigan DEQ
Sara McDonnell	UM-Flint, Outreach

1.5 Public Participation Process

For the purposes of the watershed management planning process, the ‘public’ is defined as a resident or business owner in the Cass River Watershed. Stakeholders include landowners alongside decision-makers at the federal, state and local levels. Both tiers of the public and stakeholder involvement took place over multiple occasions and multiple forums.

A series of handouts and a presentation were developed and presented to groups including the Saginaw Rotary, Michigan Milk Producers Association, Cass River Greenway Committee, and the Saginaw Bay Coastal Initiative. A large poster and maps were also turned into a display and used at the following events: Bean and Beet Symposium, Saginaw Bay Watershed Conference, annual meetings of the Michigan Association of Conservation Districts and field days hosted by Michigan State University in the Cass River watershed.

During the planning phase, the public was engaged in the steering committee through membership in the Cass River Greenway committee, a local volunteer organization that promotes the wise use and protection of the Cass River for recreation. Residents and stakeholders were also involved in the education committee organized as a subgroup of the steering committee to develop press releases, web content, brochures, and other outreach materials for watershed residents and target groups. Full outcomes of this groups work are outlined in the implementation section.

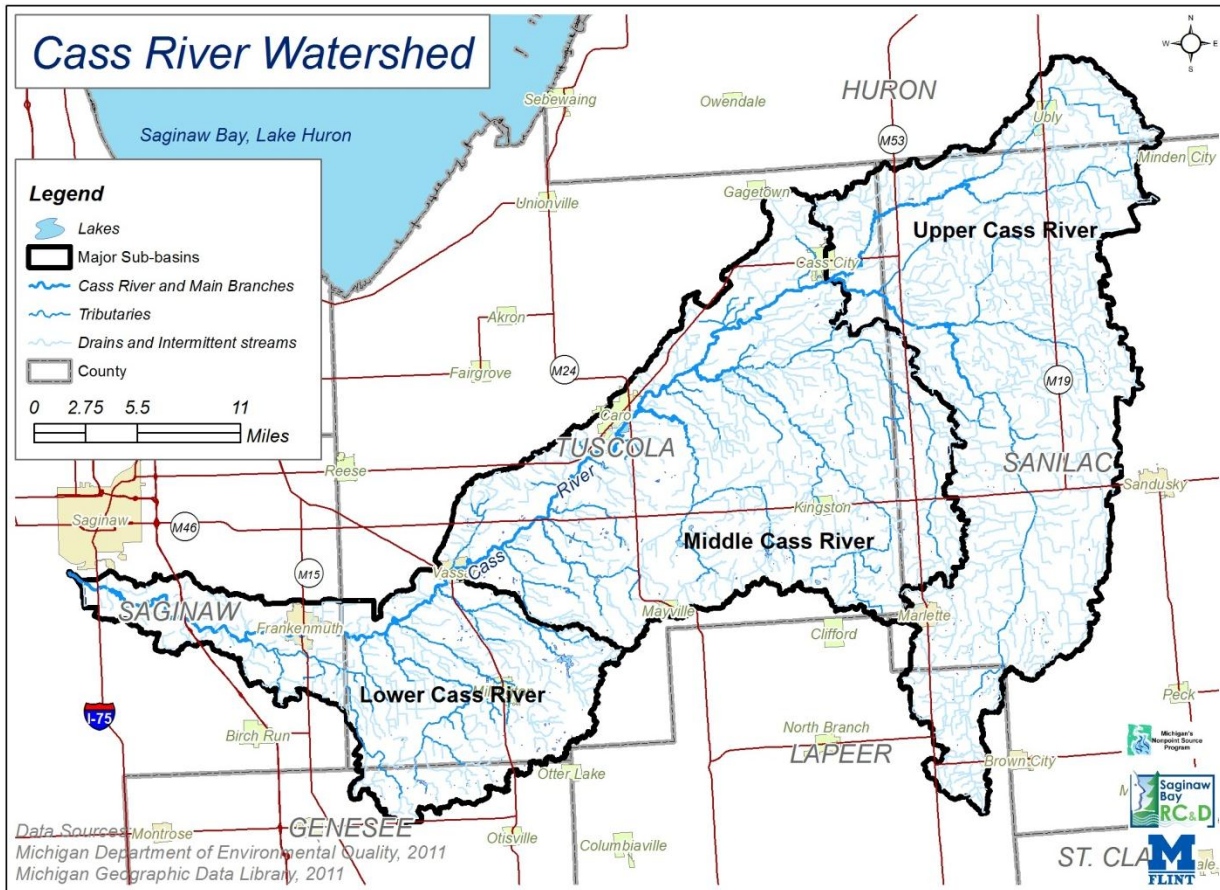
1.6 Public Commenting

The watershed management plan was made available for public comment via print and online viewing from February 26, 2013 – March 26, 2013. The Plan was also reviewed by the Sanilac, Tuscola, and Saginaw Conservation District staff and partners over the course of April-May 2013 where staff from the Saginaw Bay RC&D, UM-Flint, and DEQ gained feedback on restoration priorities and incorporated their recommendations into the final Plan.

1.7 Location of Cass River Watershed, Michigan, U.S.A.

The Cass River Watershed is located in mid-Michigan primarily in the counties of Sanilac, Tuscola, and Saginaw and portions in Genesee, Huron, and Lapeer counties shown in Figure 1.1.

Figure 1.1: Cass River Watershed



1.8 Water Quality Summary

The Cass River Watershed water quality statement includes an assessment of existing water quality data, along with objectives to maintain and further designated uses. This assessment of water quality incorporates previous studies by the Michigan Department of Environmental Quality (MDEQ) and Michigan Department of Natural Resources (MDNR). These entities performed an analysis of the river for many years. Throughout the years, improvements in water quality were measured based on various parameters including DO, biological and habitat surveys, sediment, phosphorus, nutrients, pathogens, and more.

Historically the Cass River has faced many environmental challenges. In 1967 the Federal Water Pollution Control Administration (FWPCA) assembled documentation to assist in

controlling pollution in the Cass River Watershed. During this time period, fishing in the Cass River was deemed its largest recreational use (DOI, 1967). Downstream from Frankenmuth was considered too polluted for fish species to flourish. Due to the Cass River's shallow depth, swimming was a minimal activity.

Although many cities in the basin had constructed treatment plants by 1965, the DO levels below Frankenmuth were reported as very low. This was widely associated with overloading of sewage by industrial waste sources. Phosphates were high in portions of the Cass River, but moderate throughout the rest of its regions. Bacterial pollution was concluded to be moderate, with the exception downstream of the City of Frankenmuth having higher levels.

In 1992, the MDNR Great Lakes and Environmental Assessment Section (GLEAS) assessed the Cass River to determine if aquatic toxicity requirements were being met. This test utilized *Ceriodaphnia dubia* (*C. dubia*) and fathead minnow. The toxicity data indicated the water tested was not chronically toxic to fathead minnows or *C. dubia*. These criteria satisfied the aquatic toxicity requirements of the Michigan Water Quality Standards (MWQS).

In 1993, the MDNR conducted a biological survey determining the current conditions of the Cass River watershed. The macroinvertebrate communities and taxa had continuously improved throughout 1974 to 1988. Sediment metal concentration was lower than previous samples collected by Grant (1976) with the exception of slightly higher total arsenic concentrations. In addition, sediment samples collected in Duff Creek did exceed EPA requirements for arsenic and total zinc. Previously, sedimentation was reported as the greatest contributor to stream habitat reduction (Morse, 1992).

In 2000, GLEAS conducted a biological survey to assess point and nonpoint source impacts on the Cass River Watershed. Based on their findings, "macroinvertebrate and fish populations were rated as acceptable or excellent". Total phosphorous concentrations were regarded as extremely high (0.38 mg/l) at the Mayville Road location (Marlette Township). Sediment samples indicated acceptable levels of organic compounds and metals, with the exception of a depositional area located downstream of the South Branch Cass River Drainage Ditch. In addition, a visual assessment was conducted by MDEQ district staff (Charlie Bauer and Tom Young), along with other biologists. Findings indicated severe flow fluctuations in the wooded floodplain of the Cass River. However, stream bank erosion along the main stem was not an issue. Cattle access was identified as a source causing damage to the surrounding headwater tributaries.

The water quality of the Cass River has improved substantially from the 1960s. However, a continuation of improvement is necessary to assess existing conditions and trends of previous studies. A biological survey conducted by MDEQ Surface Water Assessment Section describes the existing macroinvertebrate communities as acceptable to excellent throughout the main branch. In-stream habitats were generally regarded as good in the main branch, whereas river bank conditions were regarded as poor in areas of the middle and lower branch (Cooper, 2007).

Sediment samples containing heavy metal contaminants between Cass City and Bridgeport did not exceed previous concentration trends (Gerard and Jones, 1999).

In 2008, MDEQ conducted a Total Maximum Daily Loads (TMDLs) for the Cass River to determine sources of low dissolved oxygen (DO). The TMDL reach was defined as a 4 mile stretch starting at East Dayton Road, and ending at Deckerville Road. The target DO TMDL for this reach was determined to be 5mg/l minimum. The primary cause of the impairment was determined to be an abundant plant growth stimulated by organic enrichment from agricultural NPS within the watershed. The drainage basin is primarily designated to agriculture purposes (63.1%), while forest (25.8%) encompasses a vast section (MDEQ, 2008). This is consistent with agriculture being an ample land use contributor within the drainage basin.

According to the EPA, Escherichia coli (E. coli), has been identified as an indicator causing waterborne illness. MDEQ water quality standards recognize concentrations of 300 E. coli per 100 milliliters as unsafe conditions for total body contact recreation. The Cass River was sampled for E. coli during a TMDL study at six stations within Sanilac County over a 12 week period. Concentrations were observed in 100% of the samples with a maximum of 9,600 cfu/100ml in the South Branch of the Cass River at Walker Road (LimnoTech, 2011). The DEQ authored a TMDL for the Lower Cass River Watershed in 2013, "TMDL for E. Coli in Portions of the Cass River and Tributaries, including Millington, Cole, Perry, and Dead Creeks" that summarizes data collected in 2010 and 2012 that documented exceedances of acceptable E. Coli levels for total body contact and partial body contact. The TMDL recommends several strategies mirrored in this watershed plan and that testing for E. coli be taken prior to swimming and wading in the mainstem Cass River primarily during high flow events.

Today the Cass River has a broad range of intended uses, which includes boating, fishing, kayaking, canoeing, swimming, recreation and more. The most recent event held was Frankenmuth's inaugural Relay Swim (June 16, 2012). Local citizens swam approximate 4 miles, beginning at Ormes Road and ended at Heritage Park. This event, along with other recreation, and studies demonstrates the continued improvement of water quality in the Cass River.



Frankenmuth Relay Swim - Courtesy of Frankenmuth News (Web, 2012)

Based on historic water quality testing from 2001 - 2012 the following waterways in the Cass River are safe for:

Eating fish out of: certain species should not be eaten more than once per month by children and women of child-bearing age. More online at www.michigan.gov/eatsafefish

Swimming in: The county health departments conduct testing for bacteria at public bathing beaches. Public notices are placed at the public beaches if bacteria levels are unsafe for swimming. However, many of us like to canoe or kayak and take a dip in the river. Fortunately for us, the Cass River is not known to have any problems with bacteria pollution as a general rule. Areas that should not be swam or waded in include: Cole Creek, Dead Creek (including Carpenter Branch and Zehnder Drain), Duff Creek, Spring Drain, Stony Creek, Perry Creek, and the main branch Cass River downstream of I-75.

Support a healthy ecosystem: The Cass River is it's healthiest in the middle reaches of the watershed thanks to the large areas of forest and wetland that serve as filters for any type of pollutants that may enter the system.

1.9 Cass River Watershed Goals

The steering committee determined that a set of broad goals were needed for the watershed that supported and detailed those required by the MDEQ and that were outside of the scope of designated uses.

1. Preserve the Cass River as a natural and recreational corridor along the mainstem.
2. Support the creation of a natural network for the Cass River watershed and work with partners to protect and connect priority conservation areas.
3. Support the restoration of wetlands in the watershed that restore water quality and hydrologic function.

CHAPTER 2: WATERSHED CHARACTERISTICS

2.1 Geographic Scope and Boundaries

The Cass River Watershed lies within the eastern portion of the Lower Peninsula of Michigan and is 908 square miles in area. The streams and rivers in this watershed total 1,352 river miles, but only 352 linear miles are considered perennial (flow year round) (RC&D pg. 1). The South Branch Cass River forms out of swampland and farm fields in northern Lapeer County while the North Branch Cass River begins in southern Huron County. These two branches flow towards each other forming the Main Branch of the Cass River near Cass City. The Main Branch Cass River flows west through the cities of Caro, Vassar, and Frankenmuth into the Shiawassee National Wildlife Refuge. Cass River water eventually ends up in the Saginaw River and Bay, then Lake Huron.

Within the Cass River Watershed lie 3 major sub-basins – Upper Cass River, Middle Cass River, and Lower Cass River. Each of these sub-basins contains even smaller basins called sub-watersheds; in total the Cass River Watershed contains 25 sub-watersheds and each have unique characteristics. Of the three major sub-basins the Upper Cass and Middle Cass are about equal in area – occupying 39.7% and 39.9% of the watershed respectively. Map 2.1 shows the location of the Cass River Watershed within the 6 county region and 3 major sub-basins.

Map 2.1: Cass River Watershed Location



2.2 Topography

The topography of the Cass River Watershed, the shape of its surface, can be attributed to the most recent glacial period about 14,000-8,000 years ago. During this time, erosion and deposition occurred creating the landforms that are present in the Cass River Watershed today and aided in dictating the elevations of the watershed. The Cass River Watershed is its highest in the Huron County area, at 850 feet above sea level, and its lowest in the Saginaw region (where the Cass River meets the Saginaw River), at 580 feet above sea level. In this watershed the surface generally appears flat, with streams that tend to show a stream flow of less than one foot per second. In general, the watershed varies in width from 15 miles to 35 miles and reaches about 55 miles long (RC&D pg. 1).

The Cass River Watershed has a unique topography that influences the agriculture and other economic activity that takes place. The glacial erosion and deposition aided in creating current landforms and soil compositions. In the Cass River Watershed there are two Level III ecoregions as described by the Environmental Protection Agency (EPA). The first, the Southern Michigan/Northern Indiana Drift Plains, spans 834 miles of the watershed. The last 74 miles belong to the Huron/Erie Lake Plains ecoregion. Each of these ecoregions has unique characteristics that influence the land use and major industries that take place (RC&D pg. 2).

The first ecoregion, the Southern Michigan/Northern Indiana Drift Plains comprises about 92 percent of the watershed and is located in the eastern portion. This ecoregion is characterized by its soils, varying landforms, and broad till plains. The soils of this region have more drainage than the soils of the Huron and Erie Lake Plains region and are more nutrient-rich than the soils to the north of this ecoregion. This region's soils and landforms make for an agricultural industry that typically produces feed grain, soybeans, and livestock (Ecoregion Details: Southern).

The Huron/Erie Lake Plains ecoregion is located on the western side of the Cass River Watershed and makes up about 8 percent of the total watershed area. This region is dominated by broad, flat lands that are characteristically fertile. Originally this ecoregion's soil had very poor drainage, but there are now several man-made drains. The characteristically fertile soils of this ecoregion have led to high farming activity that mainly produces corn, soybeans, and livestock (Ecoregion Details: Huron).

2.3 Soils

The geology and soils of the Cass River Watershed affect hydrology, temperature regime, and the feasibility of certain Best Management Practice (BMP) installations. The types and location of soils often determine what managerial, structural or vegetative activities are feasible. For example, specific geologic landforms and soils contain highly permeable soils that are more suitable for the installation of BMPs that function to increase infiltration. Likewise some soils types are susceptible to extensive erosion if managed incorrectly and need to be planned for

with particular strategies in mind. The soils in the Cass River Watershed can be described and understood through

1. drainage classifications,
2. the presence of hydric soils, and
3. the K-factor

Each of these categories describes a different aspect of soils and can aid us in discovering the BMPs for different areas of the Cass River Watershed and the watershed as a whole.

1. *Drainage Classification*

Drainage classification is determined by the frequency and interval in which wet periods, with the same conditions that the soil originally formed, occur. Drainage classifications aid us in determining the drainage capability, and therefore the saturation, of the soil at hand. In the case of the Cass River Watershed, the soils are heavy and often very saturated due to the poor or very poor classification of the drainage in the Cass River Watershed (RC&D pg. 7). Soils with poor or very poor drainage classifications often require artificial drainage to be suitable for crop production. Due to this, there are many artificial drains in the Cass River Watershed. After the crop fields in the Cass River Watershed are drained and tilled the resulting soil is perfect for agriculture (RC&D pg. 7).

2. *Hydric Soils*

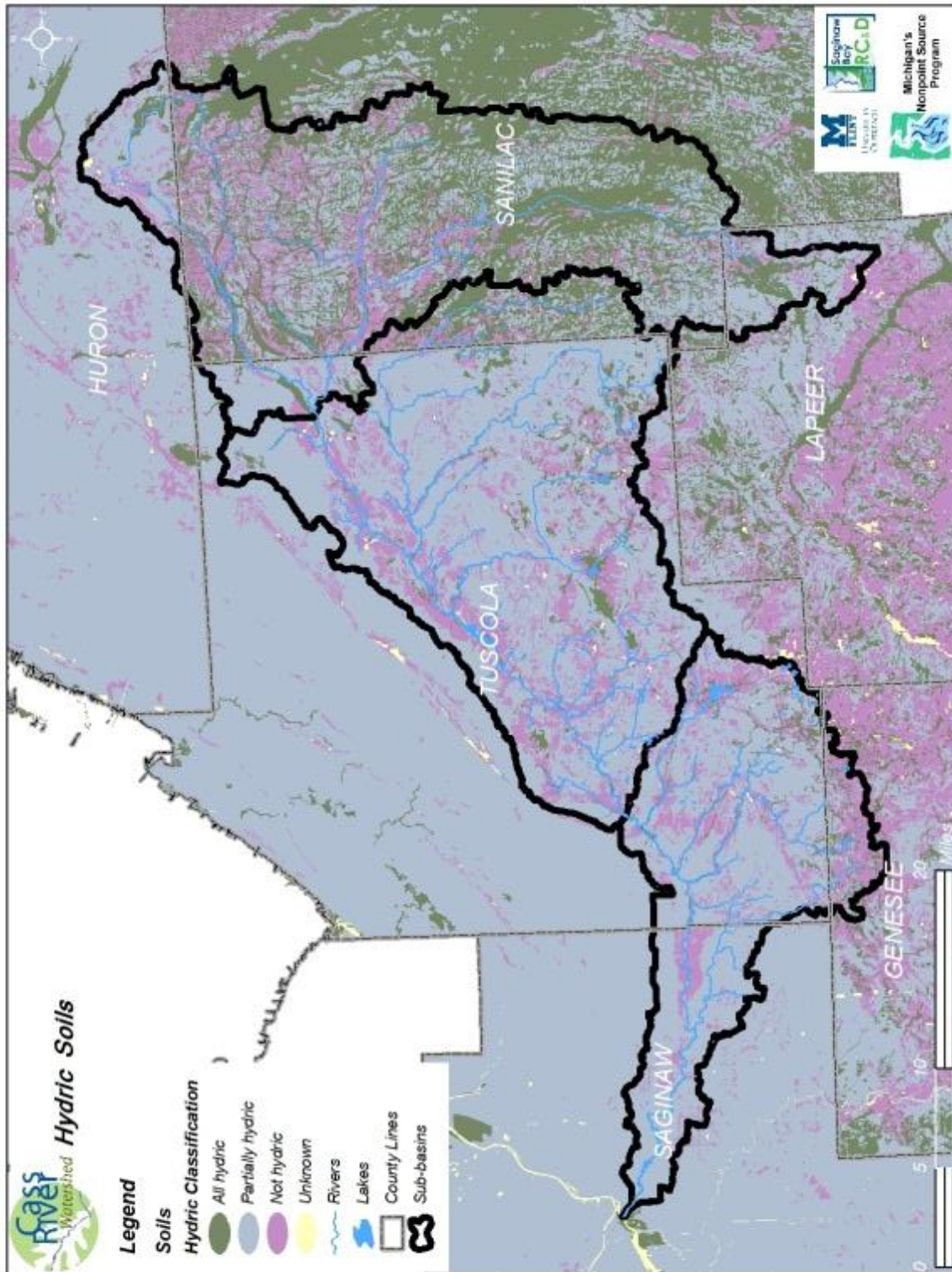
Hydric soils are formed when flooding, ponding, or saturation occurs for a prolonged period of time and creates an anaerobic (without oxygen) environment for the top portion of the soil. Soils that are hydric are often home to hydrophytic vegetation. This is because hydrophytic plants are adapted to living in aquatic environments or soils that are saturated for prolonged periods of time. This soil characteristic is important to determine because hydric soils are one of the criteria that must be present for a piece of land to be considered a wetland. Hydric soils are shown in Map 2.2.

3. *K-Factor*

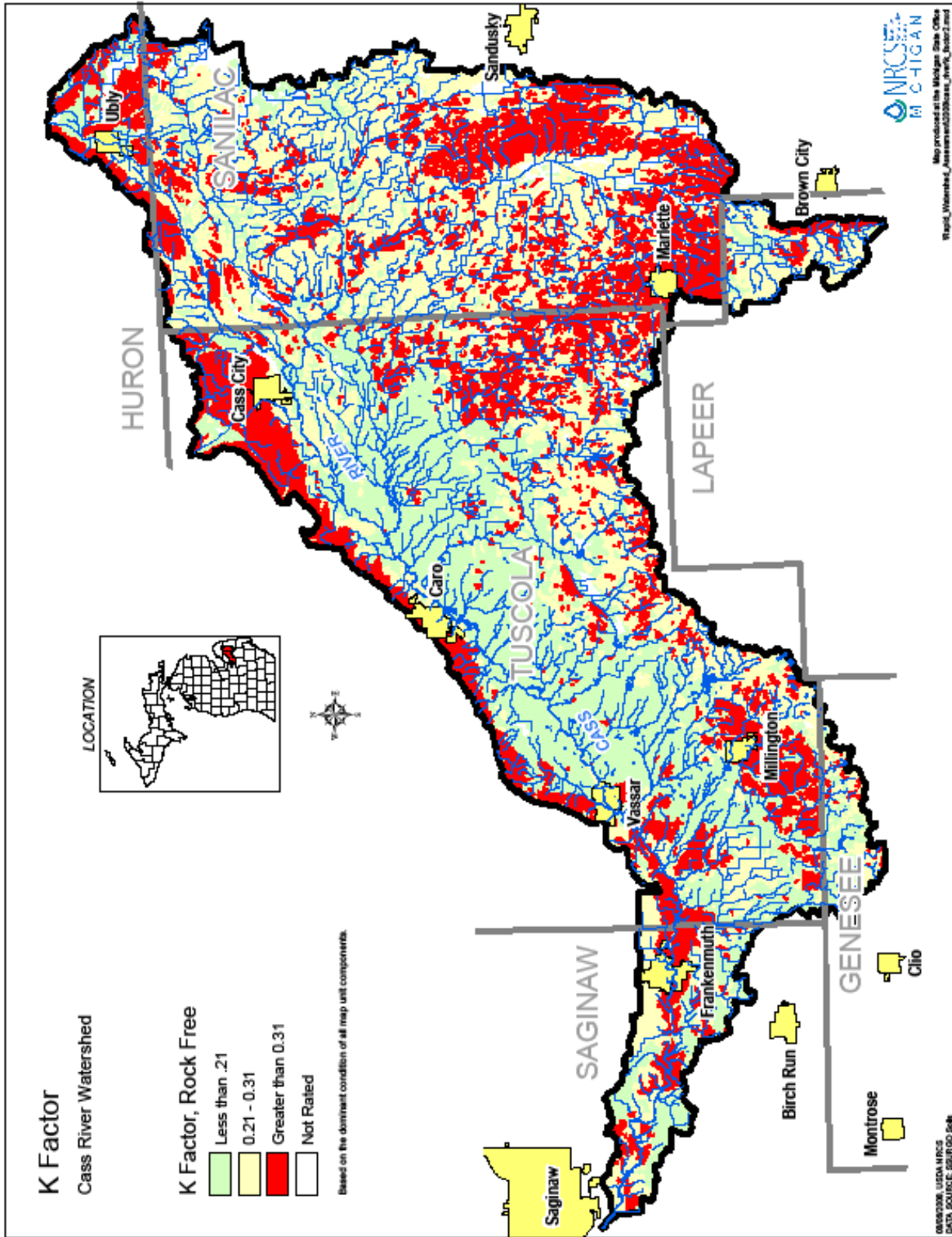
A significant indicator of the soils that are in the Cass River Watershed is the K-factor. The K-factor determines a soil's susceptibility to sheet and rill erosion. Not only does this indicator provide us valuable insight into one aspect of erosion, but it is one of six factors that are used in the Revised Universal Soil Loss Equation. In the equation, the K-factor predicts the annual rate of soil loss due to sheet and rill erosion per year; it is measured in tons per acre per year (RC&D pg. 9). K-factor values are shown in Map 2.3.

To determine the K-factor the percentage of silt, sand, and organic matter are measured. These percentages are combined with the soil structure and saturated hydraulic conductivity, also known as K_{sat} , to produce an estimate prediction. The K-factor is typically between .02 and .64. A higher value of the K-factor indicates that there is increased susceptibility to erosion. In Map 2.3 the K-factors were grouped into three categories to aid in the visualization of the erosion potential for the Cass River Watershed and to better determine the acreages and percentage that each group covers (RC&D pg. 9). Areas with high K-factor values are targeted in the implementation plans (Chapters 7-9) for erosion control practices.

Map 2.2: Cass River Watershed Soils - Hydric



Map 2.3: Cass River Watershed Soils - K Factor



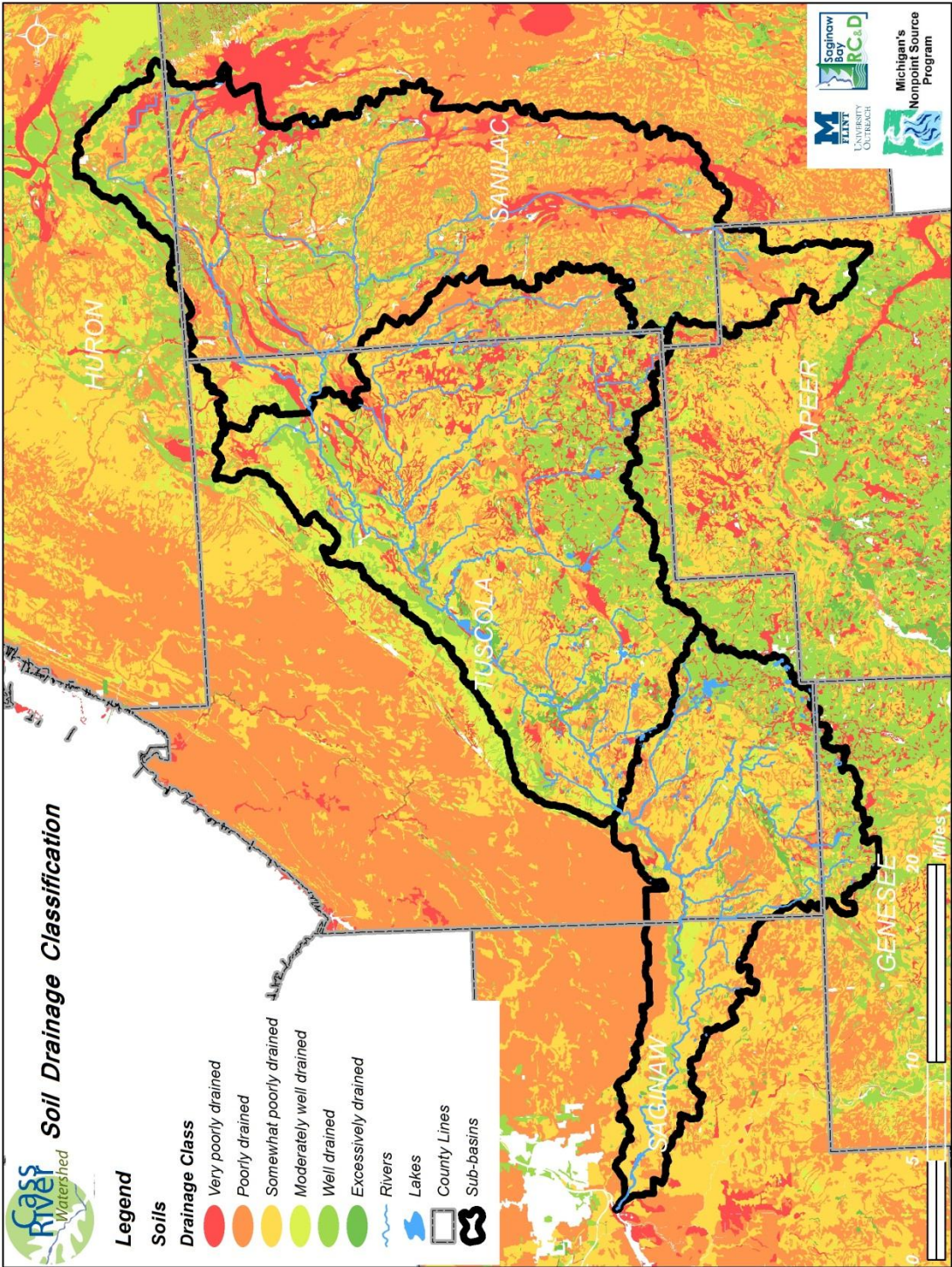
Septic Limitations

Given the amount of concern and documented issues with bacteria in the watershed, it was pertinent to include an analysis of where soils are limited for septic tank absorption fields. Soils are evaluated from 24-60 inches below the surface and are rated based on absorption of the effluent, construction and maintenance of the system. The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect the specified use. "Not limited" indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for the specified use. The ratings were derived from the following properties that affect absorption of septic effluent: saturated hydraulic conductivity (Ksat), depth to water table, ponding, depth to bedrock or a cemented pan, and flooding (U.S.G.S.). The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for the specified use.

The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on the use (1.00) and the point at which the soil feature is not a limitation (0.00). Some soils are underlain by loose sand and gravel or fractured bedrock at a depth of less than 4 feet below the distribution lines. In these soils the absorption field may not adequately filter the effluent, particularly when the system is new. As a result, the ground water may become contaminated.

USDA-NRCS, 2006

Figure 2.4 Soil Limitations for Septic Effluent



2.4 Hydrology

Hydrology is the study of the movement, distribution, and quality of water on Earth. To understand the hydrology of the Cass River Watershed one needs to know where and how water moves through the watershed. A watershed is the total area in which water drains into one main body of water, in this case the main body is the Cass River. One of the main aspects of how water moves through the watershed is through the drainage system – the pattern that the lakes, river, and streams in the watershed make. Reviewing information about the volume and rate at which water travels through the system before, during and after rain events can help us understand how the hydrology of the Cass River Watershed affects water quality.

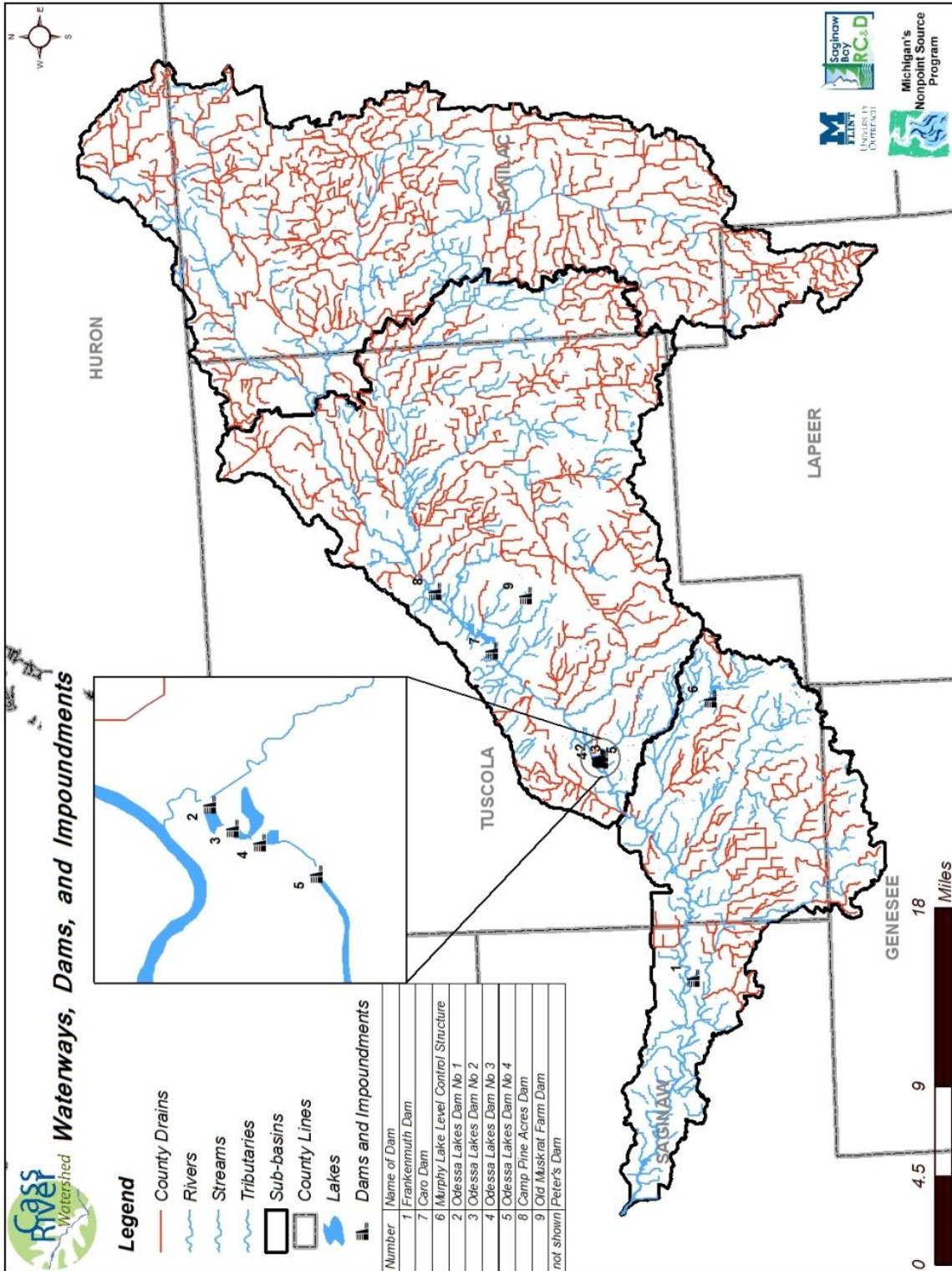
Streams receive water in two general ways including overland flow, also known as runoff, from the earth's surface and from base flow –the infiltration that seeps directly into the stream channel via groundwater. Land use changes in a watershed redistribute the amount of water that is delivered to the stream by these two processes. In most cases human interactions tend to increase the amount of water entering the stream from direct runoff while reducing the water available for base flow. This change in the hydrology is measured by two variables: the coefficient of runoff (the amount), and the concentration time (the speed). Landscape changes including land clearing, deforestation and the introduction of impervious surfaces increase the coefficient of runoff. Concentration time is shortened by activities such as installing ditches, constructing storm sewers and removing wetlands.

The increases in runoff and concentration times, the time it takes rainwater to reach the stream channel, associated with land use changes and channel alterations results in significant impacts on water quality. Changes in these two variables directly impact the aquatic habitats of the stream system. In addition they affect the magnitude and frequency of flooding events, increase erosion and the delivery of non-point source pollutants to the stream. The reduction in base flow negatively impacts the stream by reducing the water available for human and animal uses.

There are several factors in the Cass River Watershed that contribute to changes in runoff and concentration time. The impact of these changed variables can be seen mainly in the headwaters of the watershed. Here the streams are relatively unstable due to the installation and maintenance of ditches and dikes. Ditches are man-made depressions in the Earth's surfaces that are meant to hold and channel water. Often times, ditches are used as surface drains for flooded fields and lands. This is true for the Cass River Watershed. On the other hand, dikes are natural or artificially made slopes that serve to regulate water levels. These can often be in association with ditches and typically run parallel to the edge of a river or stream. The presence of ditches and dikes in the watershed alter the runoff and concentration time. This causes local streams to react to rain events and snowmelt in a short time. This correlation logically relates the stability of the headwaters, which have a large number of ditches and dikes, to the level of stability that they have. On the other hand, the concentration time for the main branch is not altered as significantly, and remains stable most of the time.

The presence of ditches is very prominent in the Cass River Watershed due to the high level of agriculture and the poorly drained soils in the watershed. Therefore, for the lands to be available for agriculture there must typically be the presence of artificial drainage. In fact, the Cass River Watershed is home to 269 drains in all. The most prominent type of drains are surface drains or ditches. The drains in this watershed are often very old and used to drain miles of agricultural lands. This not only makes large contributions to the concentration time of the waters, but adds to the pollution in the waters as well. The agricultural runoff (sediment) that finds its way into these drains is often lead straight to the Cass River tributaries. This leads to an increase in the non-point source pollution in the river and often times the nutrient and sediment levels. There are also numerous private field tiles in place throughout the watershed that undoubtedly alter the flow of water in the watershed. Removal of field tiles is often considered an option when wetland restoration is feasible and desirable.

Map 2.4: Waterways, Drains, and Impoundments



Not only do the drains in the watershed modify hydrology, but the presence of dams does as well. Dams are often used as a means of water retention, distribution management, and flood control. On the Cass River there are nine dams. The two largest are the Frankenmuth Dam and the Caro Dam. These dams pose some potential problems including fish passage and sediment distribution. Fish passage is important to the spawning habits of several species of fish, some of those located in the Cass River. Recently, the Frankenmuth Dam will be adding a rock rapid fish passage that will extend the accessible walleye and sturgeon spawning habitats, reconnecting 73 miles of stream. Dams can also cause sediment distribution problems because they create a break in the sediment flow. Sediments behind the dam build up while there is a decrease in sediments downstream of the dam. This can change turbidity and temperature of the waters causing a change in the environment for aquatic species. As of 2012 the City of Vassar is securing funding to fully remove the Vassar dam from the Cass River to restore recreational opportunities, fish passage during low water and downstream sediment transport. The Caro Dam is the largest dam on the Cass River, and is privately owned. Several locals would like to see the Caro Dam removed while others enjoy the recreation the impoundment (lake) provides. In the interim a canoe portage is being discussed to allow paddlers in canoes and kayaks to traverse around the dam safely.

The impact of dams on flow can be seen in the following graphs detailing USGS stream gauges at three locations in the Cass River. The USGS maintains stream gauges at three locations along the mainstem Cass River in Frankenmuth, Cass City, and Wahjamega shown in Figures 2.1-2.3. Figure 2.1 at Frankenmuth illustrates a lower spread between low flow and high flow volumes, illustrating the role dams play in regulating stream flow during dry and wet weather periods. The three graphs also show the Cass River's flow in relation to precipitation. For example, there was a period of extensive dry weather starting in the year 1960, and a period of extensive wet weather in the early 1980's.

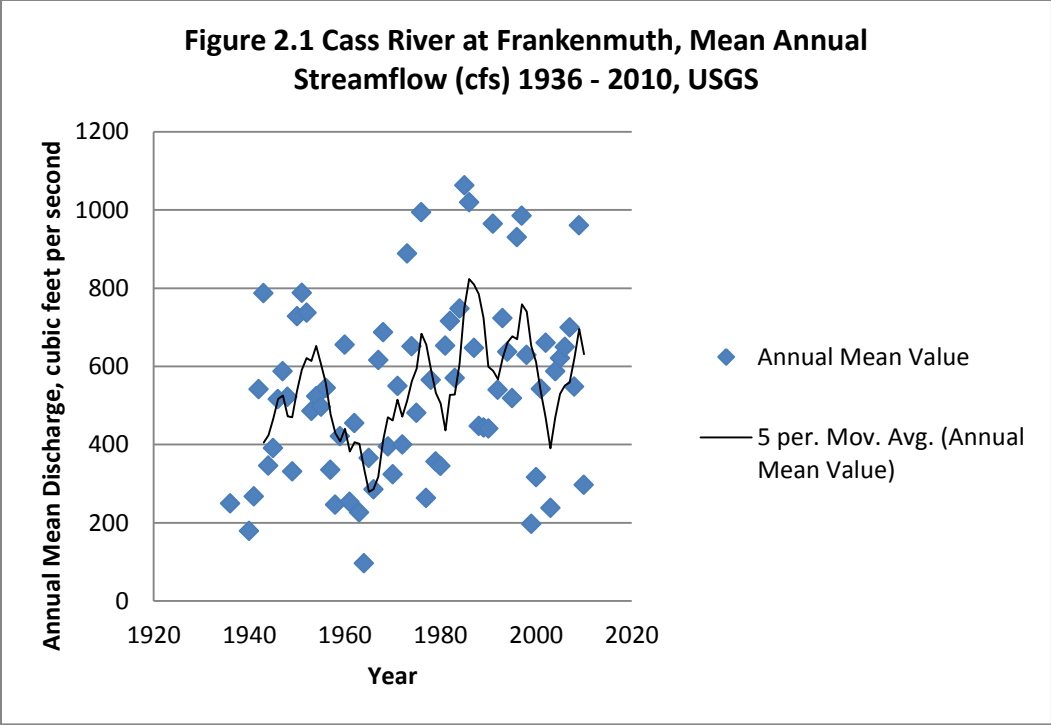


Figure 2.1 Caption: Streamflow data is presented in cubic feet per second (cfs) and is available from the USGS in Frankenmuth from 1936 – 2011. Daily discharge statistics show a minimum flow of 54 cfs in 1941 and a maximum flow of 2,110 cfs in 1996. The mean (average) flow is 305 cfs for the Cass River in Frankenmuth (USGS).

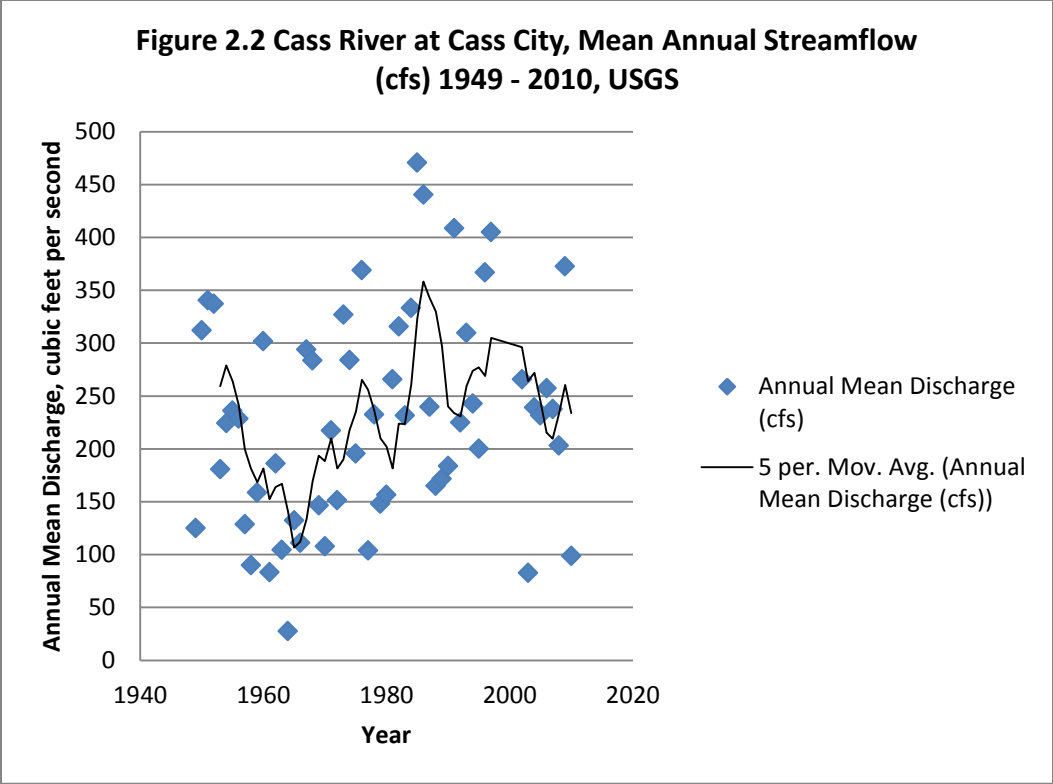


Figure 2.2 Caption: Streamflow data is presented in cubic feet per second (cfs) and is available from the USGS in Cass City from 1949 – 2011. Daily discharge statistics show a minimum flow of 6.6 cfs in 1949 and a maximum flow of 1,060 cfs in 1962. The mean (average) flow at this location is 106 cfs. This USGS gauge will presumably be discontinued in October 2011 due to lack of funding support and partners.

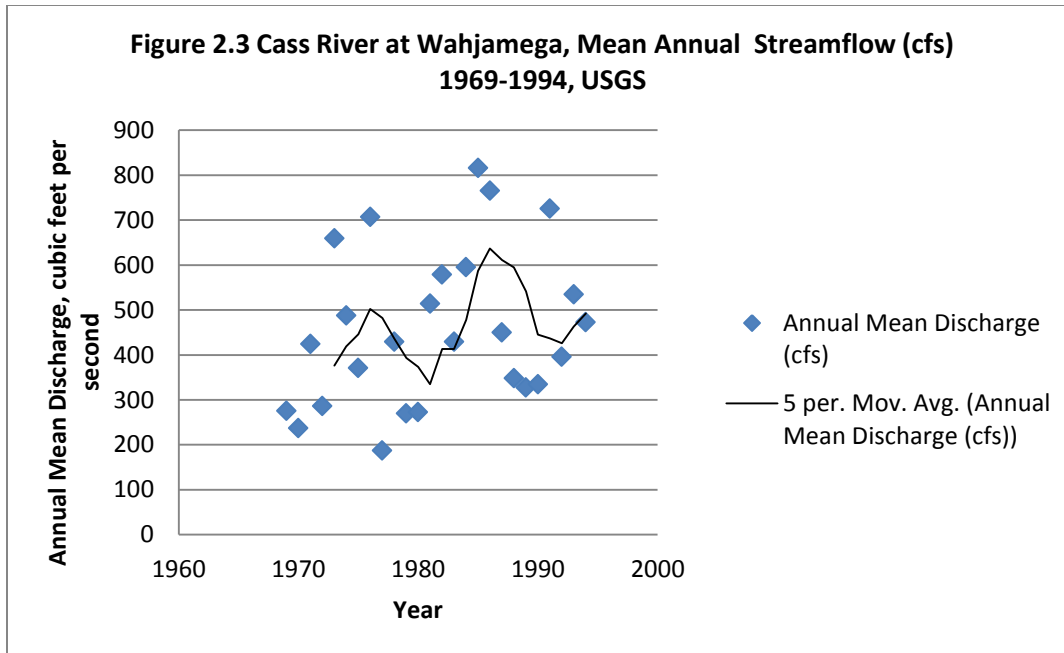


Figure 2.3 Caption: Streamflow data is presented in cubic feet per second (cfs) and is available from the USGS in Wahjamega from 1969 – 1994. Daily discharge statistics are not available for this site from the USGS website.

2.5 Land Use and Cover

The type and intensity of the watershed’s land use and cover can indicate the amount of nonpoint source pollution added to the Cass River if no preventative measures are in place. This is why understanding land use is important to a Watershed Management Plan; it helps to find trends between land use and water quality degradation so that action can be taken. The increase in human development in the Cass River Watershed is causing an increase in demand for natural resources. The Cass River is currently being used for industrial water supply, agriculture production, navigation, and warm water fishing. In order to accommodate the increase in human activity forests, riparian land, and open spaces are being changed into homes, roads, and spaces for commercial use (RC&D pg. 2).

Determining the land use and cover in the Cass River Watershed was done using an existing dataset from the National Oceanic and Atmospheric Association’s Coastal Change Analysis Program (C-CAP). The C-CAP dataset is updated every five years and is derived from satellite imagery. The most recent data used was from 2010. There are 18 different classifications found in the Cass River Watershed. Each of the classifications is described in appendix E.

To determine the land use and cover according to these classifications the watershed was examined on the sub-watershed level – there are 25 sub-watersheds and 3 sub-basins in the Cass River Watershed. **There are two dominant land uses in the Cass River Watershed – agricultural and natural.** Agricultural land use includes cultivated crops, pastures, and hay. These uses account for about 59.3 percent of the total watershed. Natural land use includes

many uses or covers such as Evergreen Forest, Palustrine Forested Wetlands, Mixed Forests, Palustrine Emergent Wetlands, Deciduous Forests, and Palustrine Scrub/Shrub Wetlands. Natural land use makes up about 36.5 percent of the total watershed. While these percentages are for the total watershed, looking at sub-basin breakdowns and sub-watershed breakdowns we can see many different variations of land use breakdowns.

At the sub-basin level the average land use or cover is much different than at the watershed level. The Upper Cass River is predominantly made of agricultural land use, at about 71.2 percent. This sub-basin's natural land use accounts for about 26.6 percent of the watershed; it is much more agricultural than looking at the watershed as a whole. This tells us that a large portion of the Cass River Watershed's agriculture takes place in the Upper Cass River. In the Middle Cass River it can be seen that the land use and cover is fairly evenly distributed between agricultural and natural land use. The approximate percentage of this sub-basin's agricultural land use is 49.3 percent; at the same time, its approximate percentage of natural land use is 46.6 percent. The Lower Cass River reflects the average land use of the entire watershed. This sub-basin's agricultural land use is about 54.4 percent and its natural land use is about 37.8 percent.

By looking at the land use data we can separate the sub-watersheds that have a dominant natural land use from those with a dominant agricultural land use. This data will aid us in distinguishing which dominant land use is associated with impaired waterways as listed by the MDEQ. This information can then be used to determine ways to improve the impaired waterways.

Six of the 25 sub-watersheds are dominated by natural land use. Most of which are located in the Middle Cass River. One of the sub-watersheds in the Cass River Watershed is dominated equally by both agricultural and natural land uses. Finally, there are 18 sub-watersheds that are dominated by agricultural land use; half of these, nine, are located in the Upper Cass River sub-basin.

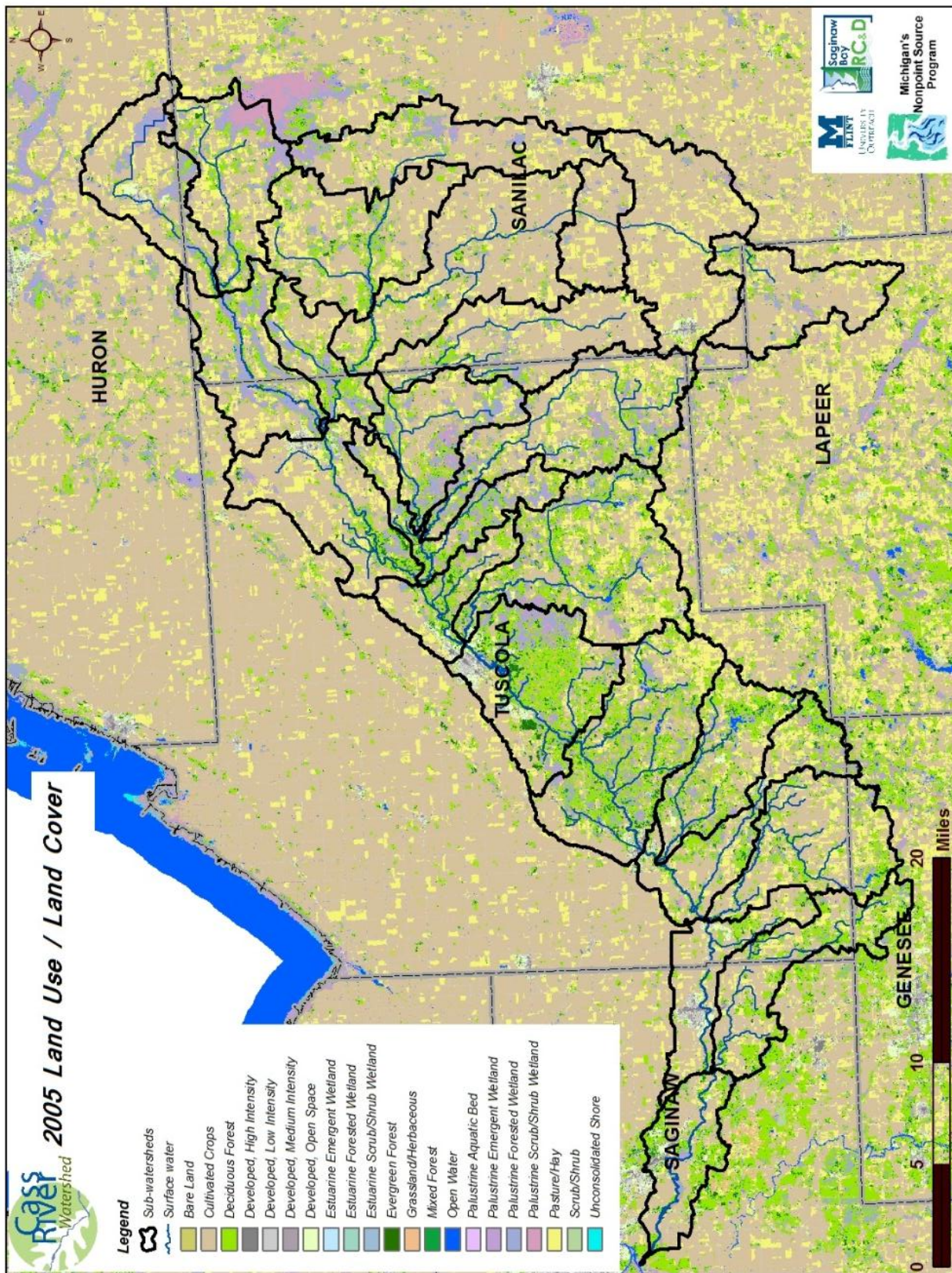
Of the dominant agricultural land use, there are a few that are extremely dominated by agriculture. There are a total of five sub-watersheds that have 80 percent or higher agricultural land use. Four of them are located in the Upper Cass River. They are: Duff Creek – Cass River, Gerstenberger Drain South Branch – Cass River, Spring Drain South Branch – Cass River, and Stony Creek South Branch – Cass River. The fifth sub-watershed is in the Middle Cass River and is Clark Drain North Branch White Creek – Cass River. In addition there are two sub-watersheds that are more than 60 percent natural land use; they are: Scott Drain – Cass River, and White Creek – Cass River.

The following data tables break down the land use according to dominantly agricultural, dominantly natural, and equally distributed.

Table 2.2: Dominant Land Use by Sub-watershed

Agricultural Dominant				
Sub-Basin	HUC Code	Name	Agricultural Percent	Natural Percent
Lower	040802050306	Cass River	46	41
Lower	040802050305	Cole Creek - Cass River	66	18
Lower	040802050304	Dead Creek - Cass River	57	39
Lower	040802050303	Millington Creek - Cass River	53	43
Lower	040802050302	Perry Creek - Cass River	65	31
Middle	040802050207	Butternut Creek - Cass River	47	46
Middle	040802050205	Cedar Run White Creek - Cass River	69	26
Middle	040802050203	South Branch White Creek - Cass River	56	41
Middle	040802050201	Clark Drain North Branch White Creek - Cass River	81	18
Upper	040802050109	North Branch - Cass River	54	44
Upper	040802050108	Tyre Drain North Branch - Cass River	67	29
Upper	040802050107	South Fork - Cass River	54	45
Upper	040802050106	Stony Creek South Branch - Cass River	83	15
Upper	040802050105	Middle Branch - Cass River	72	28
Upper	040802050104	Hartel Drain Middle Branch - Cass River	73	27
Upper	040802050103	Gerstenberger Drain South Branch - Cass River	90	8
Upper	040802050102	Duff Creek - Cass River	90	5
Upper	040802050101	Spring Drain South Branch - Cass River	80	16
Natural Dominant				
Sub-Basin	HUC Code	Name	Agricultural Percent	Natural Percent
Lower	040802050301	Goodings Creek - Cass River	40	55
Middle	040802050209	Moore Drain White Creek - Cass River	37	57
Middle	040802050208	Scott Drain White Creek - Cass River	24	66
Middle	040802050206	Sucker Creek - Cass River	45	52
Middle	040802050204	White Creek - Cass River	37	63
Middle	040802050202	North Branch White Creek - Cass River	48	50
Equally Dominant				
Sub-Basin	HUC Code	Name	Agricultural Percent	Natural Percent
Upper	040802050110	South Branch - Cass River	49	49

Map 2.7: Land Use



2.6 Political Landscape

Determining the political landscape of the Cass River Watershed is an important step toward enacting a Watershed Management Plan. The political landscape of a watershed is the layers of government and governing bodies that have an influence on the water management practices, other land practices, and community involvement that occur in the watershed. Understanding and involving each layer and group in the WMP is imperative because it creates a cohesive environment in which tasks are achieved. In the Cass River Watershed the layers of government involved range from the federal and state level to counties, townships, cities, and villages. Below is a list and description of what each layer of government involved in the Cass River Watershed does.

Township/City/Village – This is the most local level of government involved in the Cass River Watershed. At this level land use planning occurs and bonds are passed. There are a total of 39 townships, three cities, and six villages.

Townships in the Cass River Watershed include: Almer, Arbela, Argyle, Austin, Bingham, Birch Run, Bridgeport, Burnside, Custer, Dayton, Denmark, Elkland, Ellington, Elmer, Elmwood, Evergreen, Forest, Frankenmuth, Flynn, Fremont, Greenleaf, James, Juniata, Kingston, Koylton, Lakefield, Lamotte, Marlette, Millington, Minden, Moore, Novesta, Paris, Thetford, Tuscola, Vassar, Watertown, Wells, Wheatland.

Cities in the Cass River Watershed include: Frankenmuth, Marlette and Vassar.

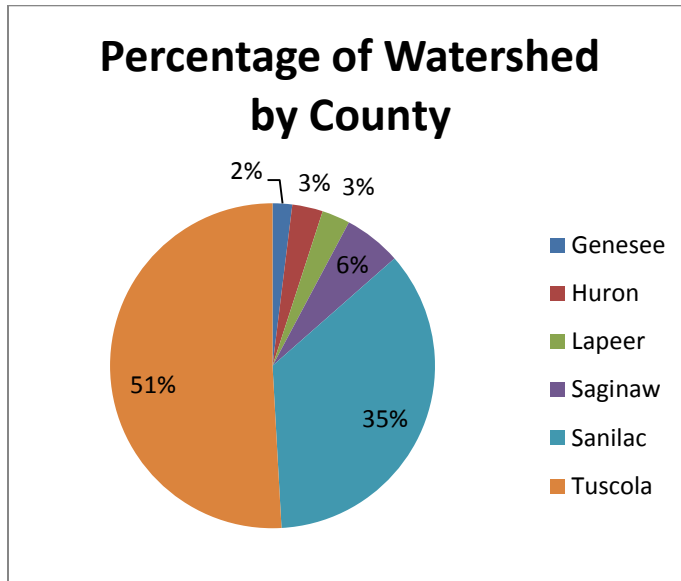
Villages in the Cass River Watershed include: Cass City, Caro, Kingston, Mayville, Millington, and Ubyly.

County – The next level of government involved is the county level. At the county level there are a number of branches that need to be involved in a WMP. For our purposes we will need to involve each county's drain commissioner, health department, road commission, and the local conservation districts.

The purpose of the drain commissioners is to monitor and manage all established drains, and to run the legal proceeding and hearings for drains, dams, dikes, levies, water and sewage projects, lake level control structures, and pumping stations. The health departments monitor bacteria levels at public swimming beaches, which are an important indicator of waters quality and is involved in determining the designated uses. They are also involved in permitting and inspection of septic systems, sewer management, and public health overall – including public education. The road commission is involved in regulating culverts and road-related ditches. They have standards in which must be met to ensure that water can pass road crossings adequately. In addition, the road commission regulates road salting and grading which can contribute to pollution problems.

Counties in the Cass River Watershed include: Genesee, Huron, Lapeer, Saginaw, Sanilac, and Tuscola. Figure 2.5 shows the percentage of the watershed in each county. By area, Tuscola and Sanilac, are the most influential counties in the watershed comprising 51% and 35% total watershed area (respectively).

Figure 2.5: Cass River Watershed Percent Area by County



Each county has a local conservation district, also known as Soil and Water Conservation Districts. These were originally Michigan state government, but now receive limited state funding. These districts work to aid residents in managing their natural resources and educate citizens about valuable conservation practices. This is important because education plays a key role in implementing a watershed management plan. Conservation Districts are typically housed in offices with federal agencies including the United States Department of Agriculture, Natural Resource Conservation Service that administer federal Farm Bill programs.

In addition to the road commissions, drain commissioners, and health departments from each county, there are national farm organizations that have local offices in each county. The Farm Service Agency, one of the farm organizations, has county level offices that monitor and regulate farm practices. A second agency, which is optional is the Farm Bureau, they encourage better management practices and aid farmers with farm plans. Both agencies have county level offices, and then grow to the state and eventually the national level.

To achieve our goals of improving water quality in the Cass River Watershed the unity and involvement of each level of government is needed. Knowing such details allows us to involve the governing bodies in the process of developing the Cass River Watershed Management Plan. This allows the different levels of government to become invested in the project and support implementation.

2.7 Designated Uses

A stream or site in the watershed is listed as impaired if it is failing to meet one or several designated uses as defined by the State of Michigan. Designated uses include:

- **Agriculture** – Irrigation water for crops or water for livestock
- **Public Water Supply** – Surface water for drinking water at a designated point of intake (not to confuse with well water and aquifers)
- **Wildlife and Other Indigenous Aquatic Life** –Aquatic life and wildlife can thrive and reproduce. (Comment: Minimum Flows and levels should be maintained in order to sustain environmental conditions and wildlife throughout the year. (Water balance)
- **Total and Partial Body Contact** – Recreational (swimming, fishing, boating) all waters protected for recreation shall not exceed specific levels of E.coli from May to October.
- **Navigation** – Water is navigable by watercraft remaining free of obstructions and pollutants that may impede boat function
- **Warm Water Fishery** – Water supports warm water fish species including reproduction and sustainability,
- **Industrial** – Water is usable by industry and able to pass through intakes
- **Cold Water Fishery** - Water supports cold water fish species reproduction that can thrive and reproduce

Designated use impairments are discussed for each sub-basin (upper, middle, lower) in chapters 7, 8, and 9 respectively.

CHAPTER 3: WATERSHED INVENTORY AND CONDITIONS

3.1 Summary of Previous Studies (continued in appendix B)

Several studies were reviewed for the Cass River Watershed Management Plan. A summary and key findings from each study is provided below. A majority of this work was completed by the Saginaw Bay Resource and Conservation Development Council in 2008 during the completion of the Cass River Rapid Watershed Assessment, a project funded through the United States Department of Agriculture (USDA) – Natural Resource and Conservation Service (NRCS).

Cass River Rapid Watershed Assessment (RC&D, 2008)

Nonpoint source pollution is the primary pollution threat facing the water resources of the Cass River Watershed. Nonpoint source pollution is any pollutant carried off the land by water or wind and deposited into surface water.

The most common nonpoint source pollutant in nearly every rural river system is sediment. Sediment degrades habitat for fish and aquatic insects and contributes to the widening of the stream channel and the associated increase in stream temperature. Sources of sediment typically include roads, road stream crossings, agricultural operations, eroding streambanks, impervious surfaces, improperly managed construction sites, and eroding shorelines.

Excessive quantities of nutrients, particularly phosphorus, are also a pollutant of concern in watersheds and are often the major pollutant impacting lake ecosystems. High concentrations of nutrients contribute to excessive algae and aquatic plant growth. As these plants die off, they can consume dissolved oxygen and degrade fish habitat. Nutrient inputs are often tied to agriculture production and residential development, and can come from such sources as fertilizer use, septic systems and animal waste. Often protective shoreline vegetation is removed as a result of development or agricultural production. Loss of the natural shoreline can contribute to erosion, accelerate nutrient runoff, reduce the effectiveness of nutrient uptake by root systems, and eliminate wildlife habitat. Other common watershed pollutants include thermal pollution, pathogens, oils and greases, fluctuating water levels, salts, metals, animal waste, and organic matter. (RC&D 2008)

Michigan Department Natural Resources Fisheries Reports

The 1985 MDNR Cass River Status Report (Leonardi) classifies the Cass River as a second quality, warm water stream. Sections of the Cass River's mainstem were sampled in 1985 and 1988 using rotenone sampling techniques. The fish surveys indicated that large game fish: smallmouth bass, northern pike and rock bass are present in the river. Large numbers of young smallmouth bass and rock bass were also found. Dominate species in the river are non-game species and include carp and sucker species. The study concluded that the Cass River is relatively productive in producing fish though non-game species comprised 84 percent of the total catch.

Key Findings of 1985 MDNR Report

Degradation to the watershed is caused by agricultural run-off, poor municipal waste water treatment, irrigation withdraw, and channel dredging and straightening. Impacts include water level fluctuation, sediment filled pools, nuisance aquatic vegetation, reduced water clarity, and reduced in-stream fish habitat.

Bacterial Monitoring

The Michigan Department of Environmental Quality collected data in 2010 and 2012 to document exceedances of E. coli for total body contact use in the Lower Cass River. The Total Maximum Daily Load (TMDL) report shows that tributaries of the Cass River including Cole, Perry, Dead, and Millington exceed acceptable levels of E. coli for total body contact and occasionally exceed acceptable levels of E. coli for partial body contact. The main branch of the Lower Cass River exceeds acceptable E. coli levels for body contact primarily during and after wet weather events (MDEQ, 2013). E. coli sampling sites in the Lower Cass River are shown in Figure 3.1 and summarized in Table 3.1. The TMDL area is shown in Figure 3.10 with full results detailed in the TMDL.

Figure 3.1: E. coli Sampling Locations, MDEQ

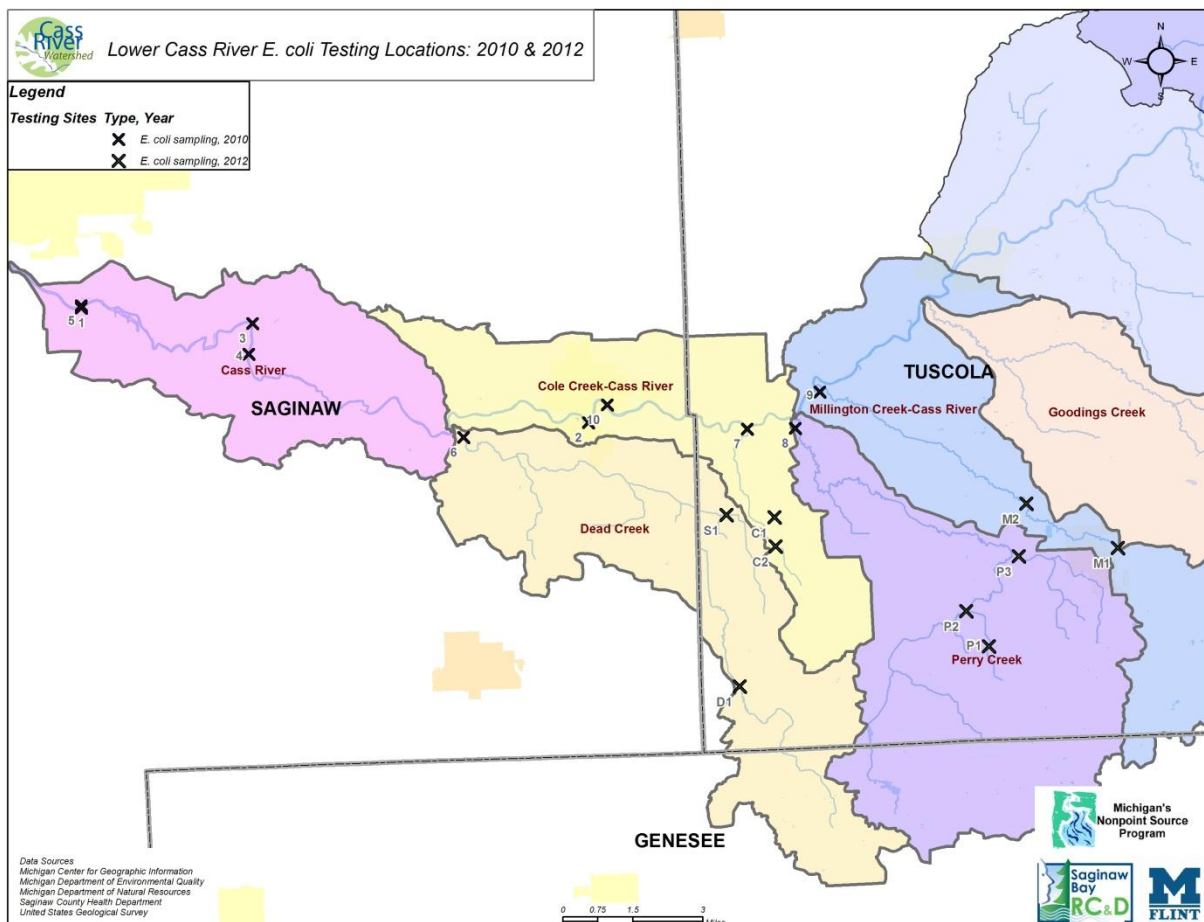


Table 3.1: MDEQ E. Coli Monitoring Locations and Results

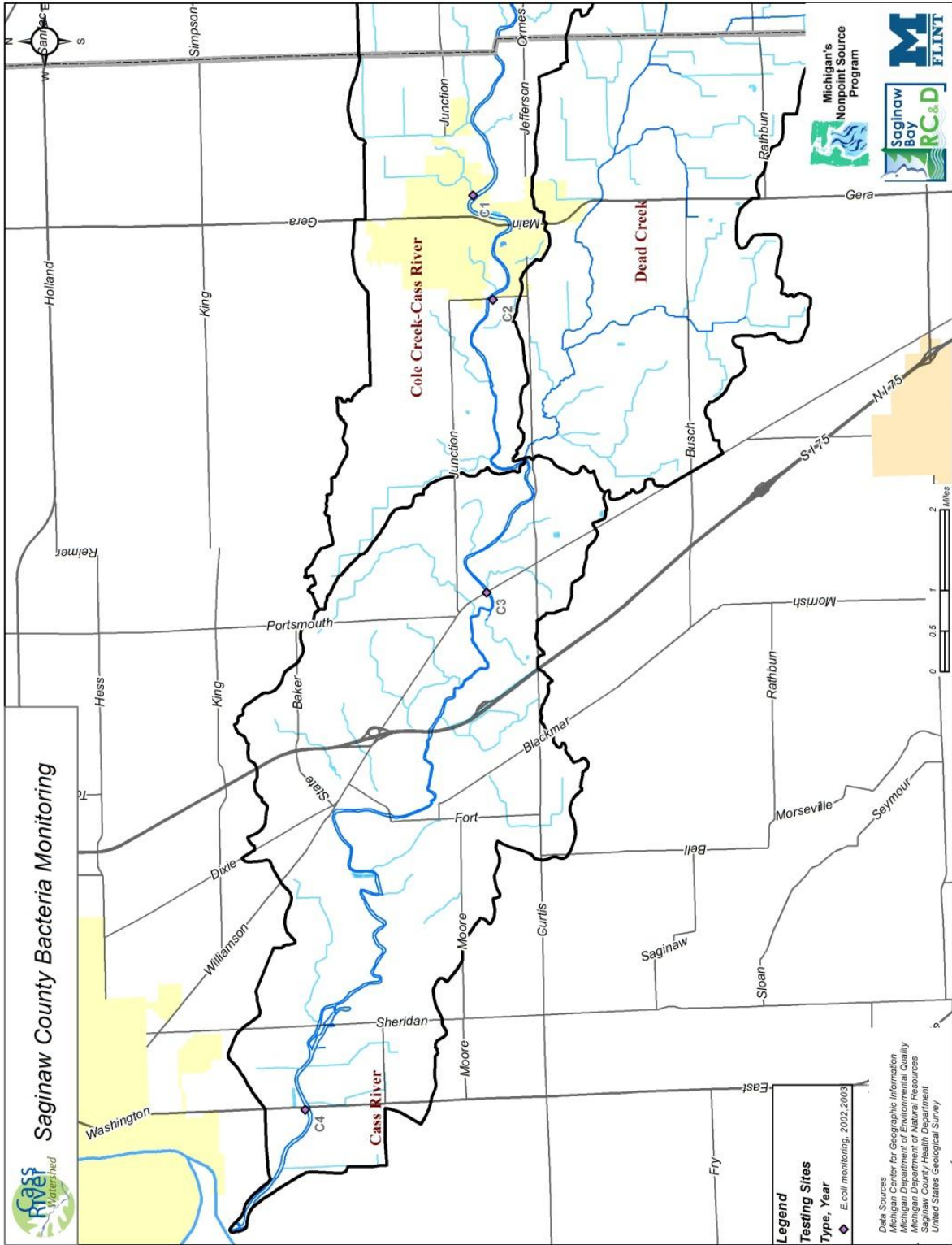
Site ID	Location	AUID	30-day mean	Geometric	Partial Contact exceedences	Body	Total Contact exceedences	Body
C1	Cole Creek @ Bray Rd. (north)	040802050305-05	253		1		1	
C2	Calkins Drain @ Bray Rd. (south)	040802050305-05	1981		4		5	
S1	Smith Drain @ Murphy Lake Rd.	040802050304-01	2344		5		5	
D1	Dead Creek @ Lewis Rd.	040802050304-01	480		0		5	
P1	Burns Drain @ Birch Run Rd.	040802050302-01	253		0		2	
P2	Perry Creek @ Vassar Rd.	040802050302-01	254		1		5	
P3	Pedlow Drain / Perry Creek @ Irish Rd.	040802050302-01	544		1		5	
M1	Millington Creek @ Millington Rd.	040802050303-01	920		2		5	
M2	Millington Creek @ Murphy Lake Rd.	040802050303-01	399		1		3	
1	Cass River @ Bray Rd.	040802050305-01	104.71182		0		0	
2	Cass River @ Main St.	040802050305-03	55		0		1	
3	Cass River @ Dixie Highway	040802050306-01	132.10813		0		1	
4	Cass River @ Fort Rd.	040802050306-01	85		0		1	
5	Cass River @ M-13	040802050306-03	58		0		0	
6	Zehnder/Dead Creek @ Curtis Rd.	040802050304-01	463.24078		2		14	
7	Cole Creek @ Ormes Rd.	040802050305-05	470.43757		2		11	
8	Perry Creek @ Ormes Rd.	040802050302-01	340.36529		0		9	
9	Millington Creek @ Loren Rd.	040802050303-01	375.51515		1		11	
10	Unnamed Tributary @ Van Cleve (Tuscola) Rd.	040802050305-04	1017.0277		7		9	

“The Saginaw County Health Department conducted weekly sampling beginning in June 2002 through October 2003 to assess water quality for bacterial contamination. There were four stations sited on the Cass River (Heritage Park, Dehmel Road, Dixie Highway, East Road). Of the 49 sampling events monitored, the number of events above total body contact recreation water quality standards were: 7(14%) at Heritage Park; 7(14%) at Dehmel Road; 10(20%) at Dixie Highway; and 5(10%) at East Road. Bacteria levels were found to be higher following significant rain events.” (RC&D 2008). Full results can be in the 2003 Surface Water Quality Report for Saginaw County, Department of Public Health, Environmental Health Services Division. Figure 3.2 shows the four sampling locations in Saginaw County where e.coli levels were elevated following sampling during a 26-week testing period.

Table 3.2: Saginaw County Surface Water Monitoring Results

Site	Road Crossing	Max E. Coli Value (MPN E. coli per 100 ml)	Date
C1	Cass River at Heritage Park	➤ 1,000	Sep 23-24, 2003
C2	Cass River at Dehmel Road	➤ 1,000	July 9-10, 2002
C3	Cass River at Dixie Hwy	➤ 1,000	July 9-10, 2002; Oct 1-3, 2002
C4	Cass River at East Road	➤ 800	June 25-27, 2002

Figure 3.2 Saginaw County Surface Water Monitoring



The Michigan Department of Environmental Quality sampled four sites in the Duff Creek subwatershed and two sites in the South Branch Cass River in 2002 for the creation of the Total Maximum Daily Load (TMDL) report for *Escherichia coli* in 2004. The TMDL identified that stretch of water from the confluence of Duff Creek and the South Branch Cass River, shown in Figure 3.3 as not attaining the designated uses for partial and total body contact. Since 2004, a majority of the impairment sources have been remediated in the vicinity of Marlette and the Marlette Wastewater Treatment Plant.

Michigan Department of Environmental Quality (MDEQ) bio-surveys

The MDEQ conducted biological surveys in 1996 in watersheds with the least amount of stream habitat alteration. “Previous surveys in the Cass River reported fair to good macroinvertebrate and fish populations with some exceptions in areas where sections of the Cass River or its tributaries had been recently channelized. Sedimentation was reported as the greatest contributor to stream habitat reduction (Morse, 1992). The 1992 report concluded that overall water quality was slightly improved when compared to surveys done by Grant (1976) and Taft (1989)” (Cooper 2000).

Key Findings of 2006 MDEQ Testing

Water chemistry along the main branch indicated a steady increase in nutrients from Cass City to Bridgeport. Phosphorous levels approached problematic levels though excessive amounts of vascular plants or algae were not observed presumably due to the turbidity of the water preventing sunlight reaching the substrate of the river (MDEQ, 2007).

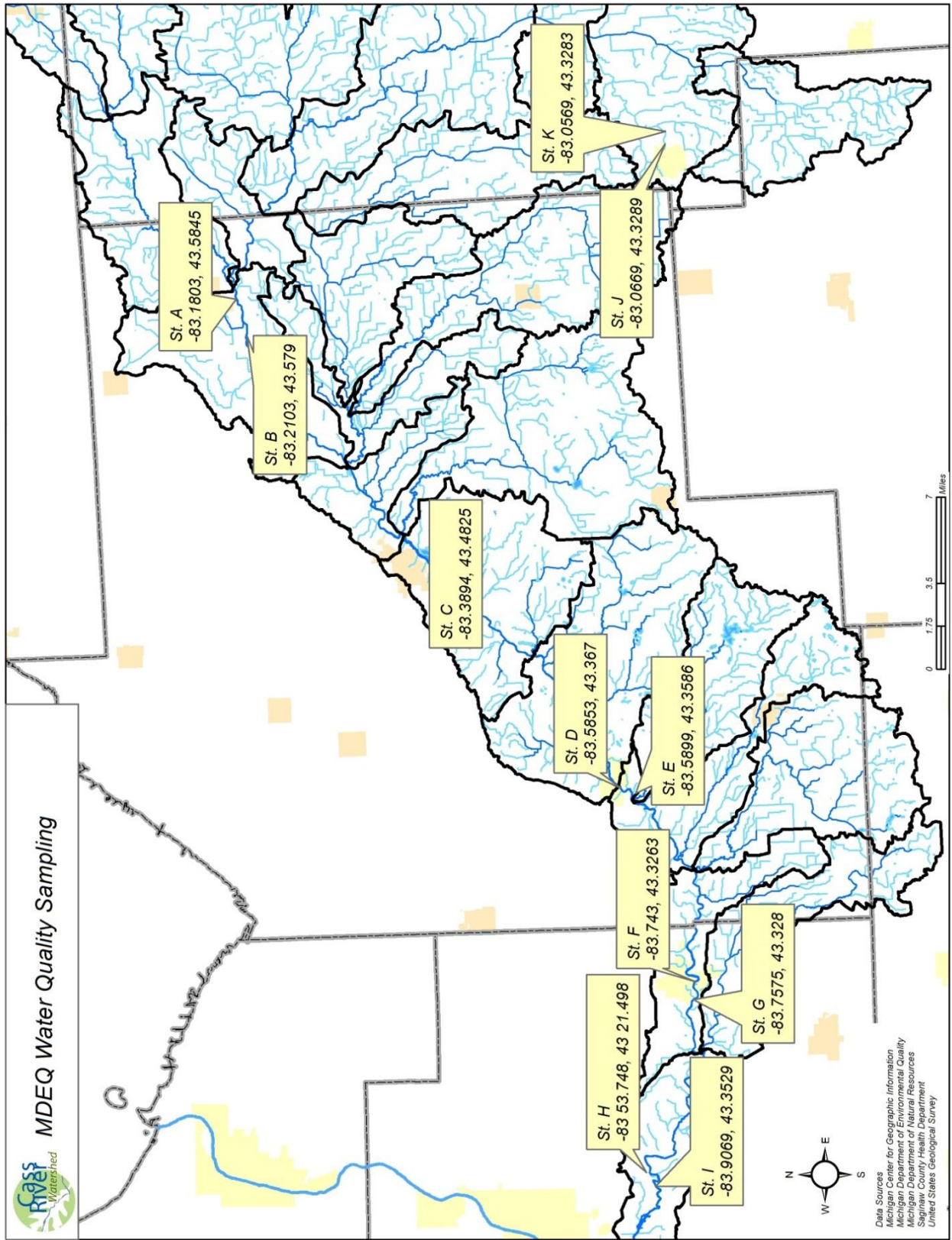
Greatest impacts to the Cass River Watershed appear to be from channel - modification and dredging. The diversity and density of macroinvertebrates are limited by a lack of hard stable substrates and loss of habitat due to siltation and sedimentation.

Nutrient sampling locations are shown in Figure 3.3. Selected data for each site is shown below in Table 3.3.

Table 3.3 Selected Nutrient Sampling Data, Cass River, 2006

Parameter	St. A	St. B	St. C	St. D	St. E	St. F	St. G	St. H	St. I	St. J	St. K
Nitrate + Nitrite (mg/L)	0.49	0.43	1.77	1.87	1.89	1.62	1.63	1.33	1.48	0.44	0.27
Nitrite (mg/L)	0.008	0.007	0.034	0.011	0.009	0.018	0.020	0.028	0.021	0.052	0.006
Nitrogen-Kjeldahl (mg/L)	0.76	0.76	0.83	0.62	0.58	0.82	0.76	0.94	0.90	0.52	1.04
Sol. Reactive Phos. (mg/L)	0.29	0.024	0.025	0.014	0.019	0.010	0.012	0.025	0.006	0.026	0.30
Phosphorous – Total (mg/L)	0.060	0.057	0.060	0.040	0.048	0.060	0.065	0.080	0.070	0.046	0.40

Figure 3.3 2006 Nutrient Sampling Locations, MDEQ



3.2 Watershed Inventory Rationale

The Cass River watershed planning process occurred at a scale larger than typical watershed planning efforts. For this reason the Cass was prioritized at the sub-basin level to assist in prioritizing and organizing information. The Cass River has three sub-basins and a total of 25 subwatersheds. Information is displayed at the sub-basin level: Upper, Middle, and Lower. A majority of the known information about the Cass River was gathered by the Michigan Department of Natural Resources (MDNR) and Michigan Department of Environmental Quality (MDEQ). Within each table, subwatersheds with an asterisk (*) beside them indicate that it is identified by the MDEQ as having an impairment. These subwatersheds were inventoried in 2011 during the watershed planning phase to identify projects that would help achieve water quality restoration goals.

Upper Cass River

Subwatersheds that are listed as impaired by the MDEQ are Spring Drain, Duff Creek, and Stony Creek. Spring Drain and Duff Creek, shown in Figure 3.4, were included in a 2004 TMDL for *E. coli* that identified pollutant source stemming from the Marlette Wastewater Treatment Plan and illicit sanitary connections in the vicinity of the creek. Stony Creek, shown in Figure 3.5, has a TMDL planned to be completed in 2018 for *E. coli* and impacts from ditching and tiling.

Figure 3.4: Spring Drain and Duff Creek, Impaired Reaches

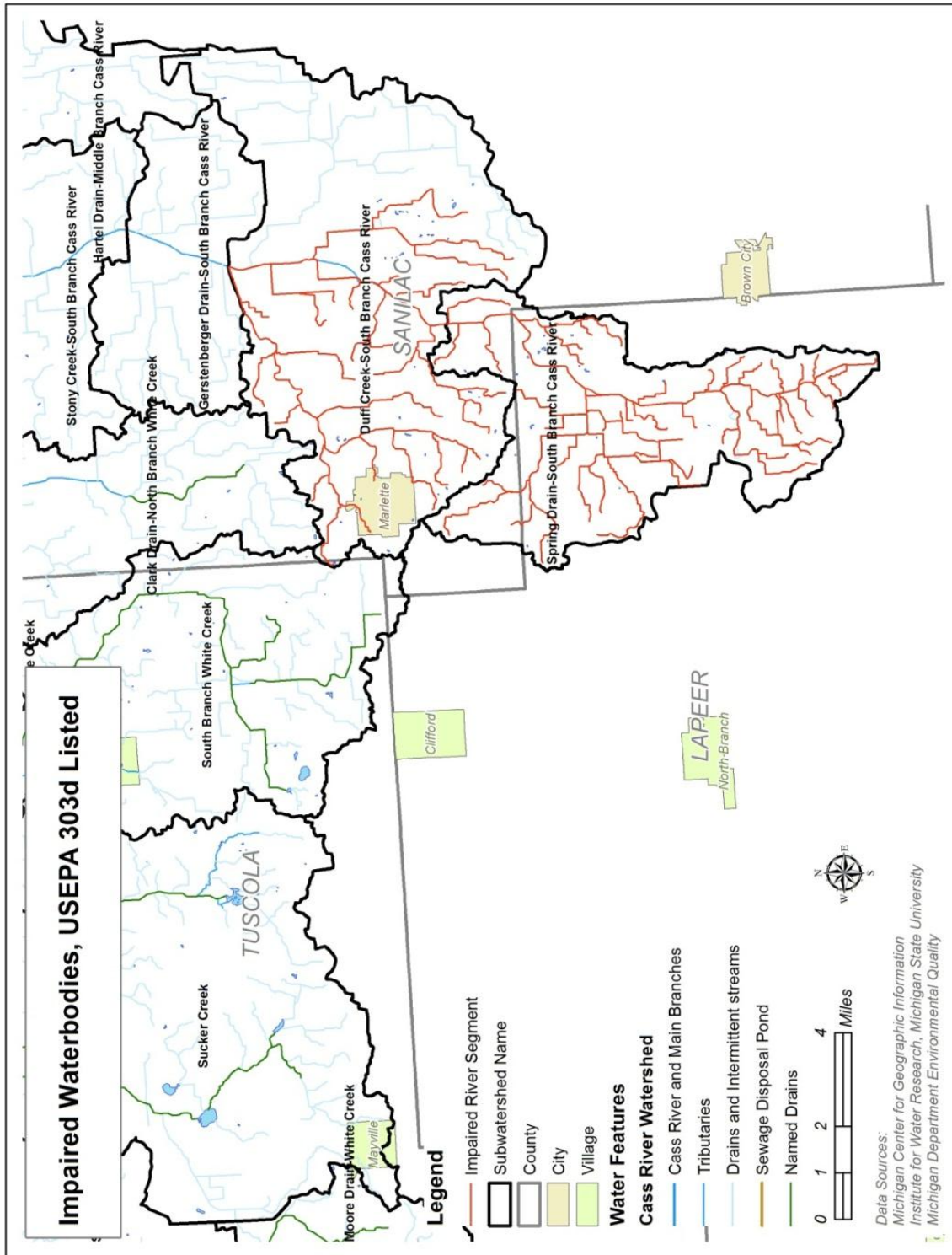


Figure 3.5: Impaired Reaches of Stony Creek, Upper Cass River

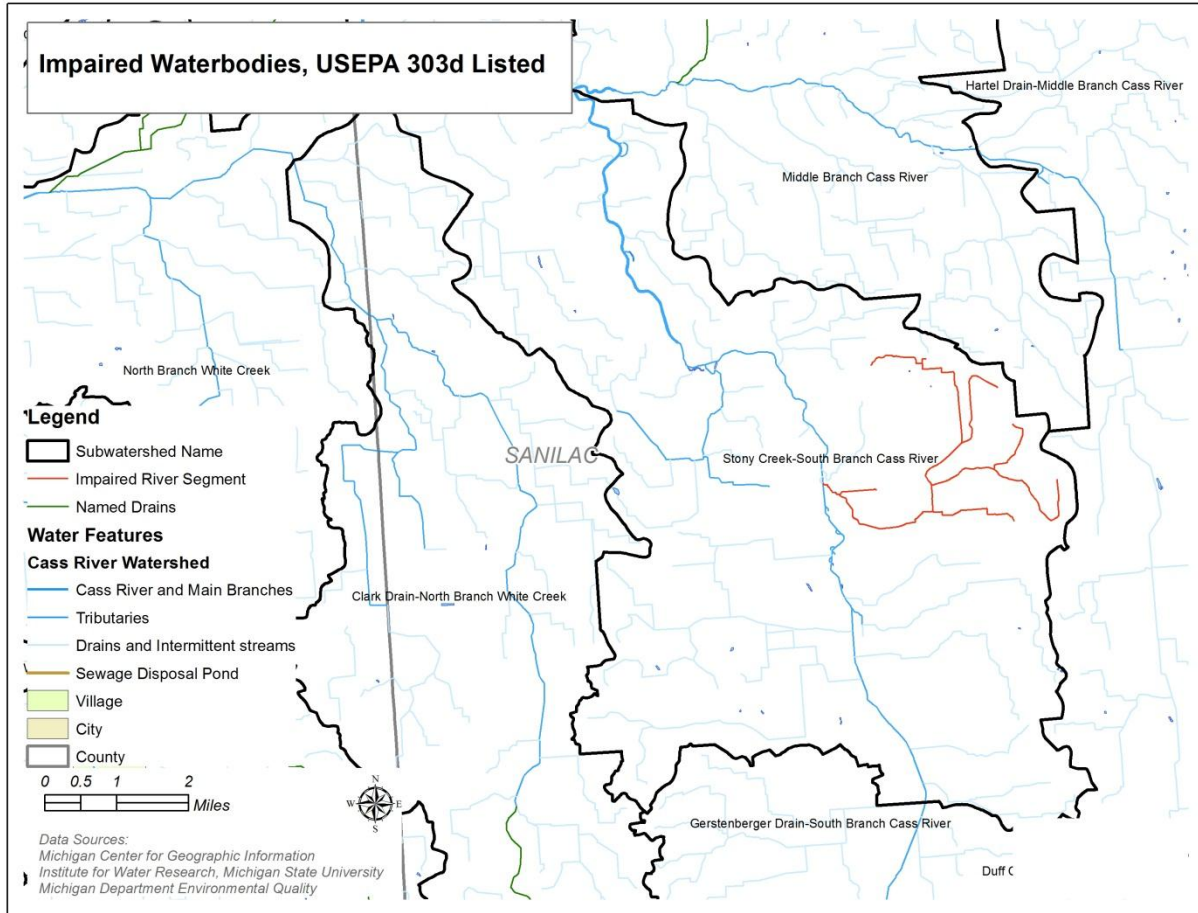


Figure 3.6 and Table 3.4 summarize data that was available for the Upper Cass River prior and during the watershed planning phase. A total of 47 sampling sites are included in the summary spanning years 1985-2006. A majority of the data is from 2006 showing varying ranges of impairment. No data was available for Gerstenberger Drain or Hartel Drain. Duff Creek and Stony Creek have the most data available, presumably due to the known impairments there since 2004 and 2001 respectively.

Figure 3.6: Upper Cass River Location of Testing Sites

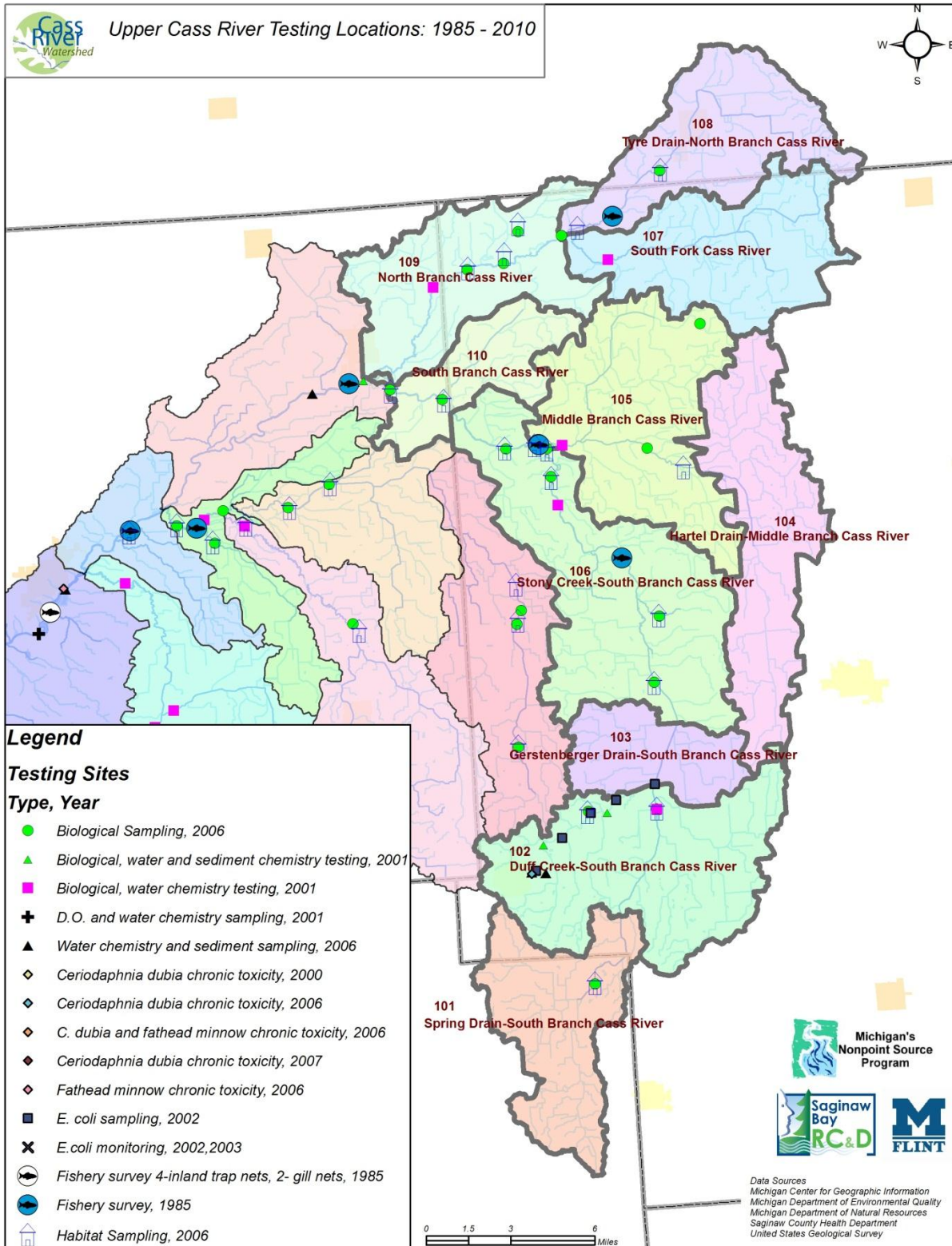


Table 3.4 Upper Cass River Summary of Biological, Chemical, and Habitat Sampling

Sub-basins	Watershed Area %	Total Sites	Site Details (#, type, year, agency)	Results Summary
Upper Cass	39.7	47		
101-Spring Drain*	3.4	2	1-Biological, 2006, MDEQ 1-Habitat, 2006	Marginal(moderately impaired) in-stream habitat, acceptable macroinvertebrate community;
102-Duff Creek*	5.4	16	2-Biological, 2006, MDEQ 2-Habitat, 2006 2-Water & Sediment Chemistry, 2006 1-Chronic Toxicity, 2006 6-E. coli, 2004 TMDL	Marginal (moderately impaired) in-stream habitat, acceptable macroinvertebrate community; 2002 TMDL notes high E. coli levels; Marlette WWTP effluent not toxic to C. dubia
103-Gerstenberger Drain	1.9	0		Not assessed by MDEQ
104-Hartel Drain	4.3	0		Not assessed by MDEQ
105-Middle Branch Cass River	5.0	4	2-Biological, 2006, MDEQ 1-Habitat, 2006 1-Biological & Chemistry, 2002	Slight to moderate impairment of in-stream habitat; Poor to acceptable ratings of macroinvertebrate community
106-Stony Creek*	6.3	10	6-Biological, 2006, MDEQ 6-Habitat, 2006 1-Biological & Water Chemistry, 2001 3-Fishery Survey, 1985, MDNR	Moderate to severe impairment of in-stream habitat; acceptable macroinvertebrate community; High fish productivity: smallmouth bass, northern pike, rock bass; and large amount of non-game species: carp and suckers
107-South Fork	3.9	1	1-Biological & Water Chemistry, 2001	Poor in-stream habitat; acceptable macroinvertebrates

Sub-basins	Watershed Area %	Total Sites	Site Details (#, type, year, agency)	Results Summary
108-Tyre Drain	3.6	6	2-Biological, 2006, MDEQ 2-Habitat, 2006 1-Biological & Water Chemistry, 2001 1-Fishery Survey, 1985, MDNR	Non-impaired and Moderately impaired stretches of in-stream habitat; acceptable macroinvertebrate communities; High fish productivity: smallmouth bass, northern pike, rock bass; and large amount of non-game species
109-North Branch Cass River	3.9	4	3-Biological, 2006, MDEQ 3-Habitat, 2006 1-Biological & Water Chemistry, 2001	Slight to moderate impairment of in-stream habitat; acceptable macroinvertebrate communities
110-South Branch Cass River	2.0	4	2-Biological, 2006, MDEQ 2-Habitat, 2006	No to slight impairment of in-stream habitat; Acceptable macroinvertebrate communities

Middle Cass River

The Middle Cass River subwatershed has the least amount of impaired waterways when compared to the Upper and Lower sub-basins. The water quality information gathered by MDEQ and MDNR note that the majority of the streams in the middle Cass River are attaining designated uses and support acceptable ratings for macroinvertebrate communities. A total of 46 sampling sites are included in the summary and span the years 1985-2006. Butternut Creek (Figure 3.7) and Moore Drain (Figure 3.8) are the two subwatersheds that are listed by the MDEQ as having water quality impairments. Butternut Creek was inventoried to identify projects to restore the warm-water fishery designation while Moore Drain inventory information identified projects to restore the indigenous aquatic life and wildlife designated use. Clark Drain was inventoried due to the density of agriculture, and identified potential pollutions sources and causes. The main stem of the Cass River was also inventoried due to the suspicion of water quality impacts from eroding streambanks.

Figure 3.7: Impaired Reaches of Butternut Creek, Middle Cass River

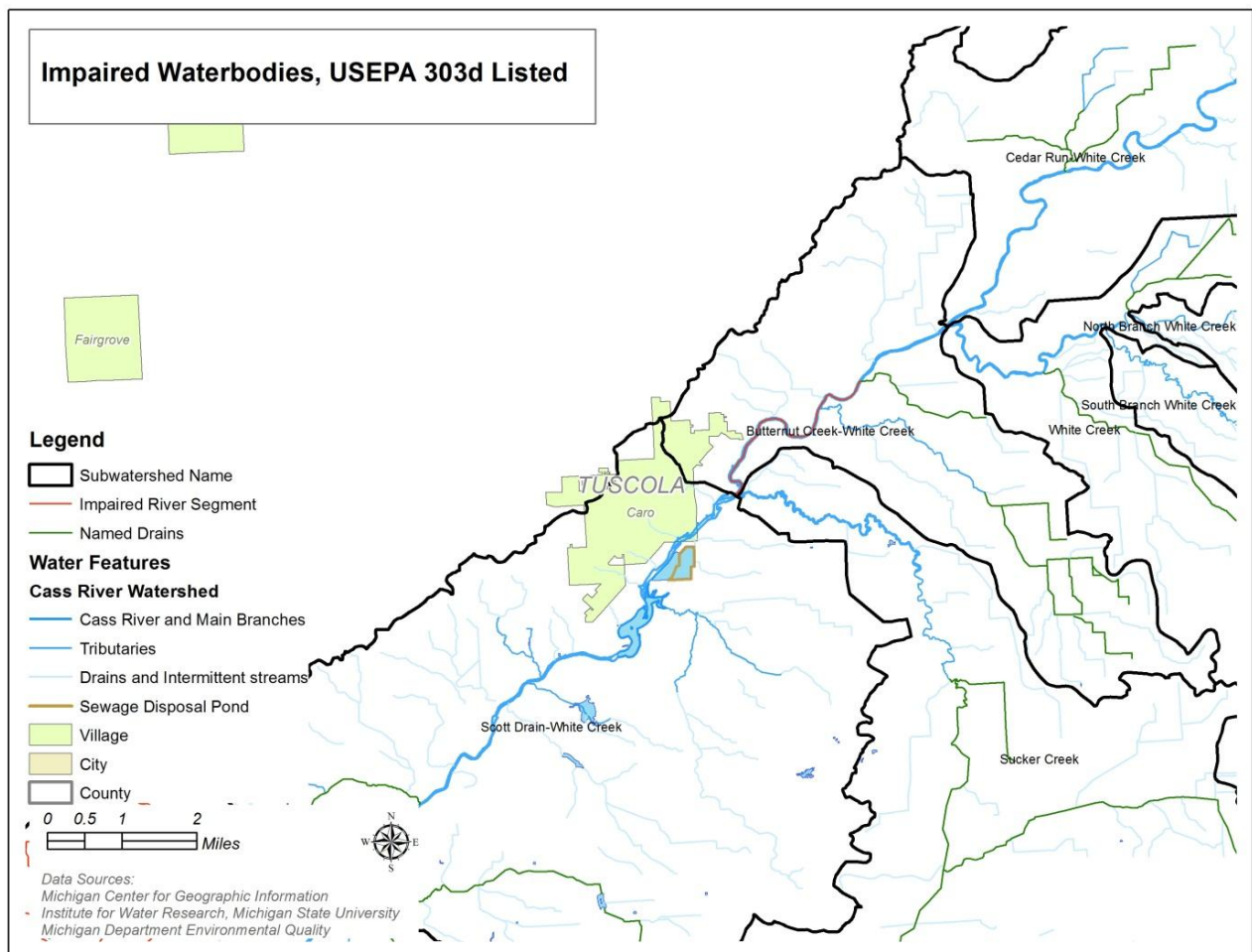


Figure 3.8: Impaired Reaches of Moore Drain, Middle Cass River

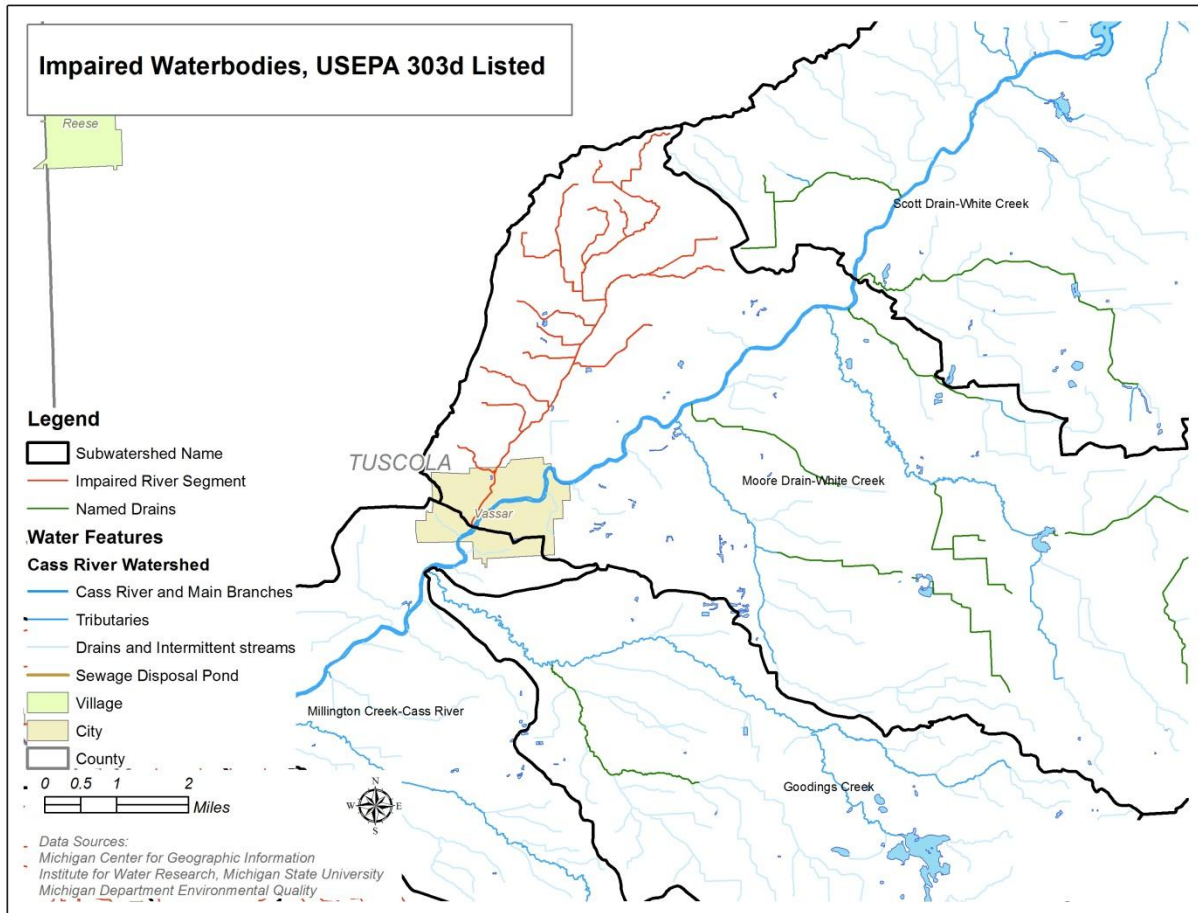


Figure 3.9 and Table 3.5 summarize data that was available for the Middle Cass River prior and during the watershed planning phase. A majority of the data is from 2006 showing varying ranges of impairment.

Figure 3.9: Middle Cass River Testing Locations

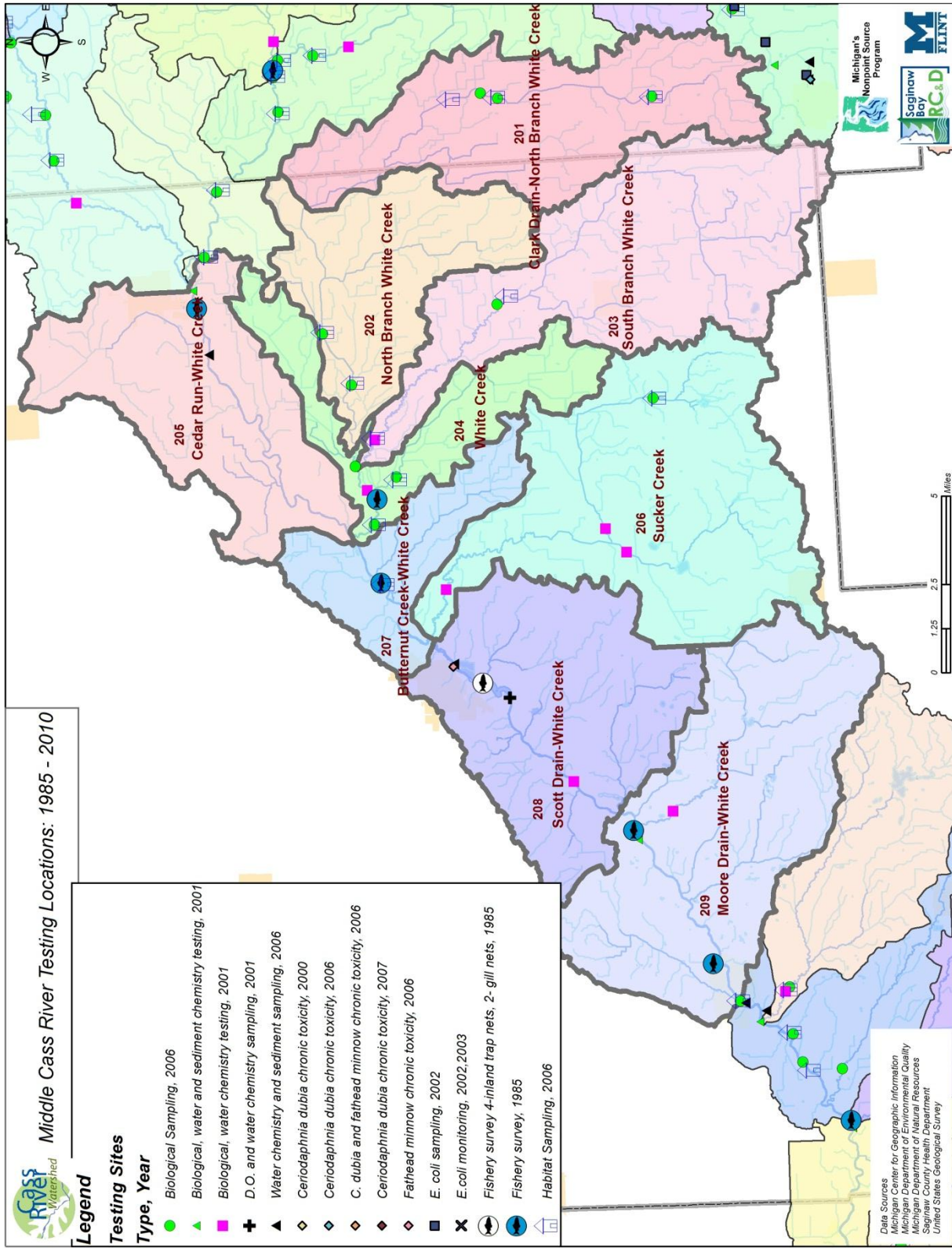


Table 3.5 Middle Cass River Testing Sites by Subwatershed

Sub-basins	Watershed Area %	Total Sites	Site Details (#, type, year, agency)	Results Summary
Middle Cass River	39.9	46		
201-Clark Drain	4.5	6	3-Biological, 2006, MDEQ 3-Habitat, 2006	Moderately impaired in-stream habitat; acceptable macroinvertebrates
202-North Branch White Creek	3.3	4	2-Biological, 2006, MDEQ 2-Habitat, 2006	Slightly impaired in-stream habitat; acceptable macroinvertebrates
203-South Branch White Creek	5.6	5	2-Biological, 2006, MDEQ 2-Habitat, 2006, 1-Biological & Chemical, 2001	Slightly to moderately impaired in-stream habitat; acceptable macroinvertebrates
204-White Creek	2.4	6	2-Biological, 2006, MDEQ 2-Habitat, 2006 1-Biological & Chemical, 2001 1-Fishery Survey, 1985, MDNR	Slightly impaired in-stream habitat; acceptable macroinvertebrates
205-Cedar Run	4.3	4	2-Water & Sediment Chemistry, 2006, MDEQ 1-Biological & Chemical, 2001 1-Fishery Survey, 1985, MDNR	Acceptable nutrient levels – meet water quality standards
206-Sucker Creek	6.6	5	1- Biological, 2006, MDEQ 1-Habitat, 2006 3-Biological & Chemical, 2003	Moderately impaired in-stream habitat; acceptable macroinvertebrate community; extremely low concentrations of nutrients
207-Butternut Creek*	2.0	5	1- Biological, 2006, MDEQ 1-Habitat, 2006 2- Chemical, 2001 1-Fishery Survey, 1985, MDNR	Slightly impaired in-stream habitat; acceptable macroinvertebrate communities; low dissolved oxygen and abundant macrophytic vegetation

Sub-basins	Watershed Area %	Total Sites	Site Details (#, type, year, agency)	Results Summary
208-Scott Drain	5.0	5	1-Water & Sediment Chemistry, 2006, MDEQ 1-Fathead minnow Chronic Toxicity, 2006 2-Biological & Chemical, 2001 1- Fishery Survey, 1985, MDNR	Acceptable nutrient levels; Caro WWTP effluent not toxic to fathead minnows
209-Moore Drain*	6.2	6	1-Biological, 2006, MDEQ 1-Habitat, 2006 2-Biological & Chemical, 2001 2-Fishery Survey, 1985, MDNR	Slightly impaired in-stream habitat; poor macroinvertebrate community; acceptable nutrient ratings; direct habitat alterations

Lower Cass River

Data available for the Lower Cass River is available from 2010 and 2012 for counts of e. coli from the recent draft TMDL that was completed for sections of the Lower Cass River (Figure 3.1, Table 3.1). Dead Creek, Cole Creek, and Cass River subwatersheds are all listed as having impairments to the partial and total body contact designated uses primarily due to high levels of *E. coli* (Figure 3.10). Information available from a water quality consultant working on behalf of the Cass River Greenway committee indicates that levels of fecal coliform are not traceable in the mainstem Cass River.

Figure 3.10: Impaired Reaches of the Lower Cass River

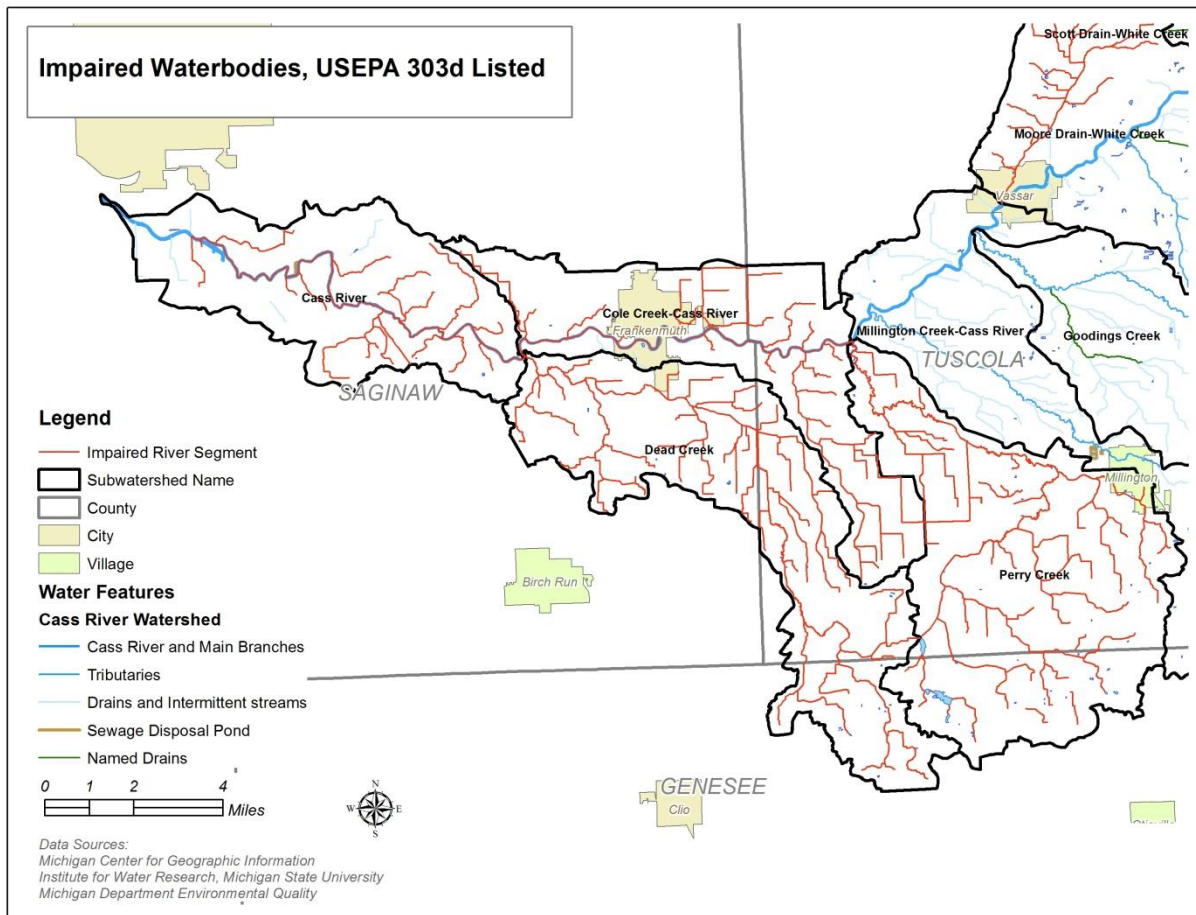


Figure 3.11 shows testing locations and Table 3.6 describes results for each test site. A total of 64 sampling sites are in the Lower Cass River, with the majority taking place in impaired waterways. Data included in the summary spans from 1985-2012.

Figure 3.11: Lower Cass River Testing Locations

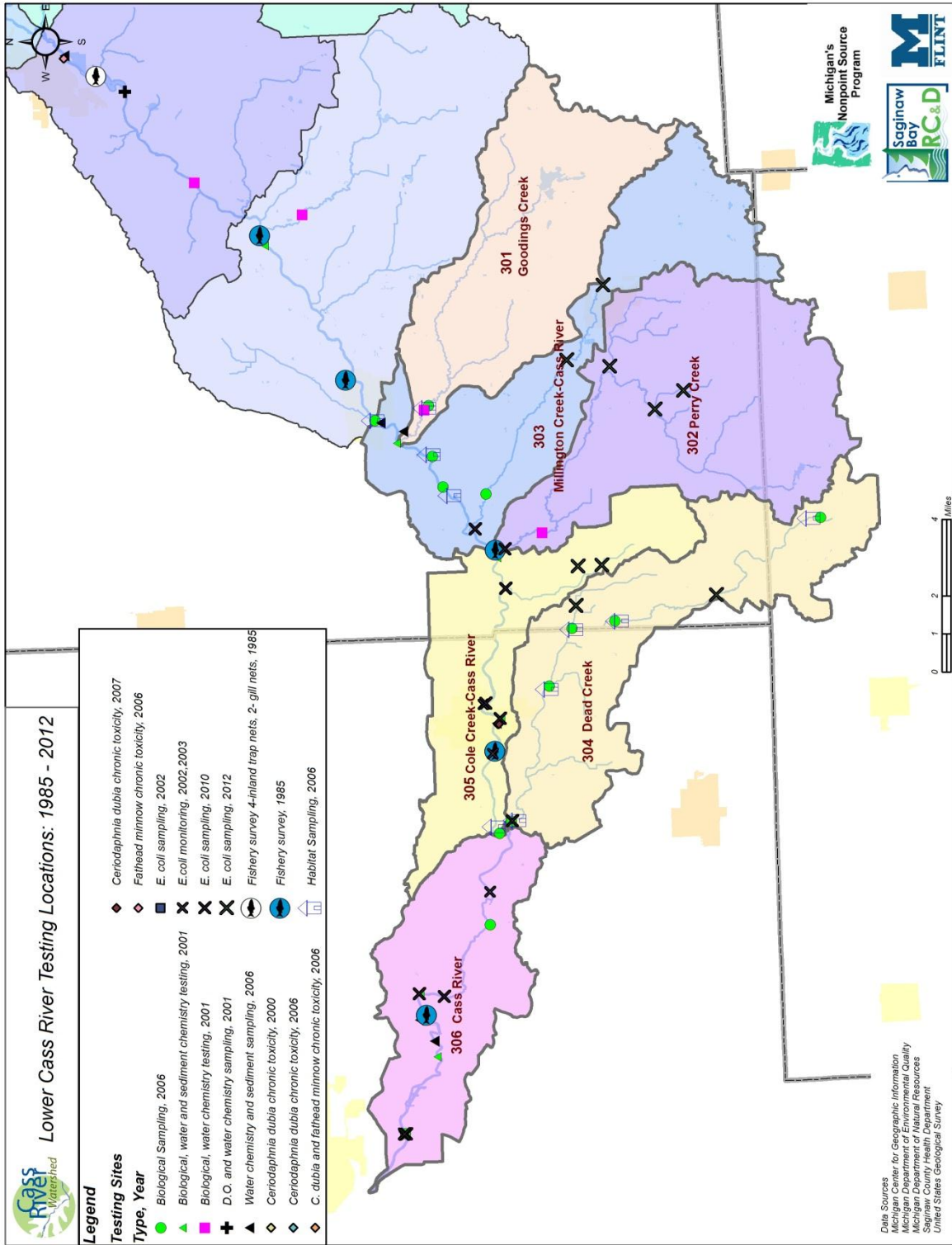


Table 3.6 Lower Cass River Testing Sites by Subwatershed

Sub-basins	Watershed Area %	Total Sites	Site Details (#, type, year, agency)	Results Summary
Lower Cass	20.4	64		
301-Goodings Creek	3.4	3	1-Habitat, 2006, MDEQ 1-Biological, 2006 1-Biological & Chemical, 2001	Slightly impaired in-stream habitat; excellent macroinvertebrate community; acceptable nutrient ratings
302-Perry Creek*	4.4	5	3-E. coli monitoring, 2012, MDEQ 1-E. coli monitoring, 2010 1-Biological & Chemical, 2001	E. coli levels exceed total body contact water quality standard; 5 th highest geometric mean of all sites sampled for E. coli in 2010; Acceptable nutrient ratings, good in-stream habitat, acceptable macroinvertebrate community
303-Millington Creek*	3.5	11	2-E. coli monitoring, 2012, MDEQ 1-E. coli monitoring, 2010 2-Habitat, 2006 3-Biological, 2006 2-Chemical, 2006 1-Biological & Chemical, 2001	E. coli levels exceed total body contact water quality standard; 4 th highest geometric mean of all sites sampled for E. coli in 2010; slightly impaired in-stream habitat; acceptable-excellent macroinvertebrate communities
304-Dead Creek*	3.7	13	2-E. coli monitoring, 2012, MDEQ 1-E. coli monitoring, 2010 5-Habitat, 2006 5-Biological, 2006	E. coli levels exceed total body contact water quality standard and one site exceeds partial body contact water quality standard; 3 rd highest geometric mean of all sites sampled for E. coli in 2010; slightly to moderately impaired in-stream habitat; acceptable-poor macroinvertebrate communities

Sub-basins	Watershed Area %	Total Sites	Site Details (#, type, year, agency)	Results Summary
305-Cole Creek*	2.7	18	2-E. coli monitoring, 2012, MDEQ 2-E. coli monitoring, 2010 1- C. dubia chronic toxicity, 2007 1- Fathead Minnow chronic toxicity, 2006 1-Biological, 2006 1-Habitat, 2006 2-Chemical, 2006 2-E.coli monitoring, 2002-2003, Saginaw County 2-Biological & Chemical, 2001, MDEQ 2-Fishery Survey, 1985, MDNR	E. coli levels exceed total body contact water quality standard; 2 nd highest site geometric mean of all sites sampled for E. coli in 2010; Slightly impaired in-stream habitat; excellent macroinvertebrate community; Frankenmuth WWTP effluent not toxic to fathead minnow or acutely toxic to c. dubia;
306-Cass River*	2.7	14	4-E. coli monitoring, 2010, MDEQ 2-E.coli monitoring, 2002-2003, Saginaw County 2-Biological, 2006, MDEQ 2-Chemical, 2006, 2-Biological & Chemical, 2001 1-Ceriodaphnia dubia chronic toxicity, 2000 1-Fishery Survey, 1985, MDNR	No exceedences of e. coli standards for partial body contact in 2010; upstream sites exceed total body contact water quality standards; acceptable macroinvertebrate community; Bridgeport WWTP effluent not toxic to c. dubia;

3.3 Streambank Erosion Inventory of Corridor

A streambank erosion inventory was conducted along the main stem of the Cass River from Cass City to the National Saginaw Wildlife Refuge boundary at M-13 during the 2008 field season (Figure 3.8). Interns from the National Park Service, Rivers Trails and Conservation Assistance Program and the United States Fish and Wildlife Service (USFWS) were trained by USFWS Field staff to assess the erosion conditions along the Cass River and scored each site using a standard streambank erosion severity index.

For each erosion site the following were recorded: condition of the toe and streambank, human impacts, natural impacts, potential causes, obstructions. Streambank erosion sites prioritized for restoration are mapped and described in Chapter 8 for the Middle Cass River and in Chapter 9 for the Lower Cass River. No streambank erosion sites were identified in the Upper Cass River.

Over 204 sites were documented with erosion problems during the 2008 field season. Each site was assigned a score based on the condition of the bank, the physical characteristics of the bank and water, cause of erosion, and problem trend. The physical characteristics of the bank and water includes: slope, height of bank, length of bank, depth of water, water velocity, shade cover, and bank soil type. Each score was then associated with a rating of minor, moderate, or severe.

This study found that the majority of the erosion sites were rated as minor - 108 sites, 75 were rated as moderate and 21 were rated as severe. In addition, only three of the sites examined were existing access sites. These ratings can be examined even further to see common trends that appear within the minor, moderate and severe sites.

The 108 minor sites (Figure 3.12) in this study are located in Saginaw and Tuscola County – 44 are in Saginaw County and 64 are located in Tuscola County. This is reasonable due to the location of the main stem of the Cass River, the majority of which lies in Tuscola County. Of the 108 minor sites, 52 had an average depth of less than 2 feet and 43 sites had a water velocity that were deemed “medium” or “fast”. Those sites rated as minor had some potential causes that were common. Thirty of the minor sites shared a river bend as a potential natural cause, while 26 sites had dropped sediments indicating channel widening as a shared potential cause. Most notably, 52 of the minor sites in this study shared high waters as a potential cause indicating flashy flows occur at this location.

Throughout the collection of this data only 21 sites, 15 in Tuscola County and 6 in Saginaw County, were rated as severe (Figure 3.14). All of these sites have some significant aspects in common. For example, all of the 21 severe sites have an increasing problem trend. In addition, 16 of the sites have banks that are eroding and 18 sites have unstable toes or undercutting occurring. The number of sites that are rated as severe make up only 10 percent of the total number of erosion sites surveyed. While this is a low percentage, there is definitely room for improvement to these severe sites.

In addition to the 204 sites that were documented with erosion problems, there were another 14 sites documented based on other concerns. The majority of these sites were recorded as other sites of concern based on the presence of drains or water pumps. Six of the 14 sites were recorded as having water pumps while 4 of the 14 sites were noted as having drains. Although these sites are not noted for erosion in this study, they still pose concerns to water quality.

75 sites located in Saginaw and Tuscola Counties were rated as moderate (Figure 3.13). Fifty of these moderate sites are located in Tuscola County, while 25 are in Saginaw County. Of the 75 moderate sites, the majority (59) have a slope of 1:1. Another noticeable trend among the majority of these moderate sites is that they often have a clay soil texture; 42 of these sites fit into this majority. Like the sites rated as minor, these sites have some similar potential causes. Both river bends and dropped sediment are thought to be potential causes at approximately the same number of sites – 23 sites and 22 sites respectively. In addition, high water seems to be the largest potential cause for moderate sites as well – having been noted at 43 sites.

Figure 3.12: Minor Streambank Erosion Sites

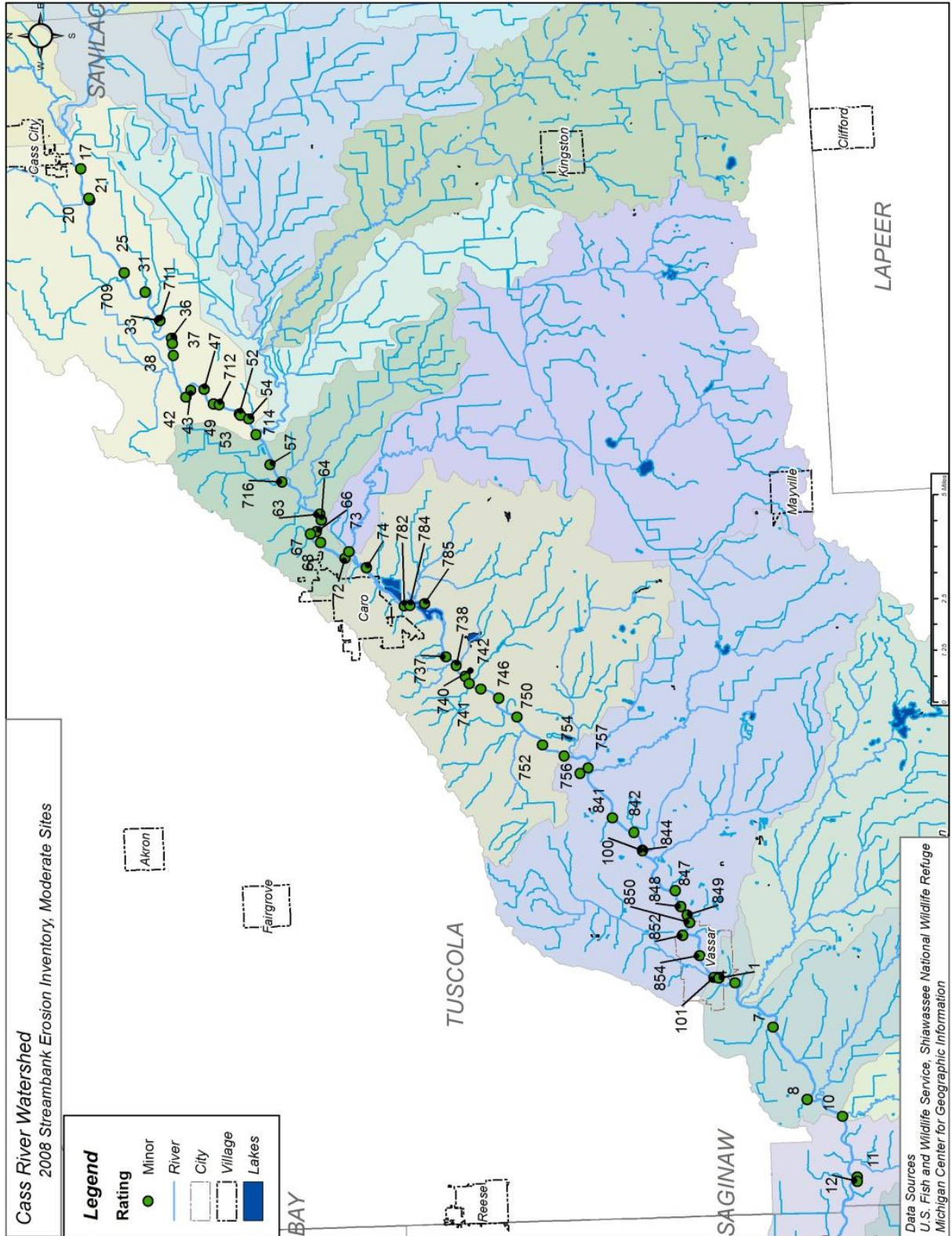


Figure 3.13: Moderate Streambank Erosion Sites

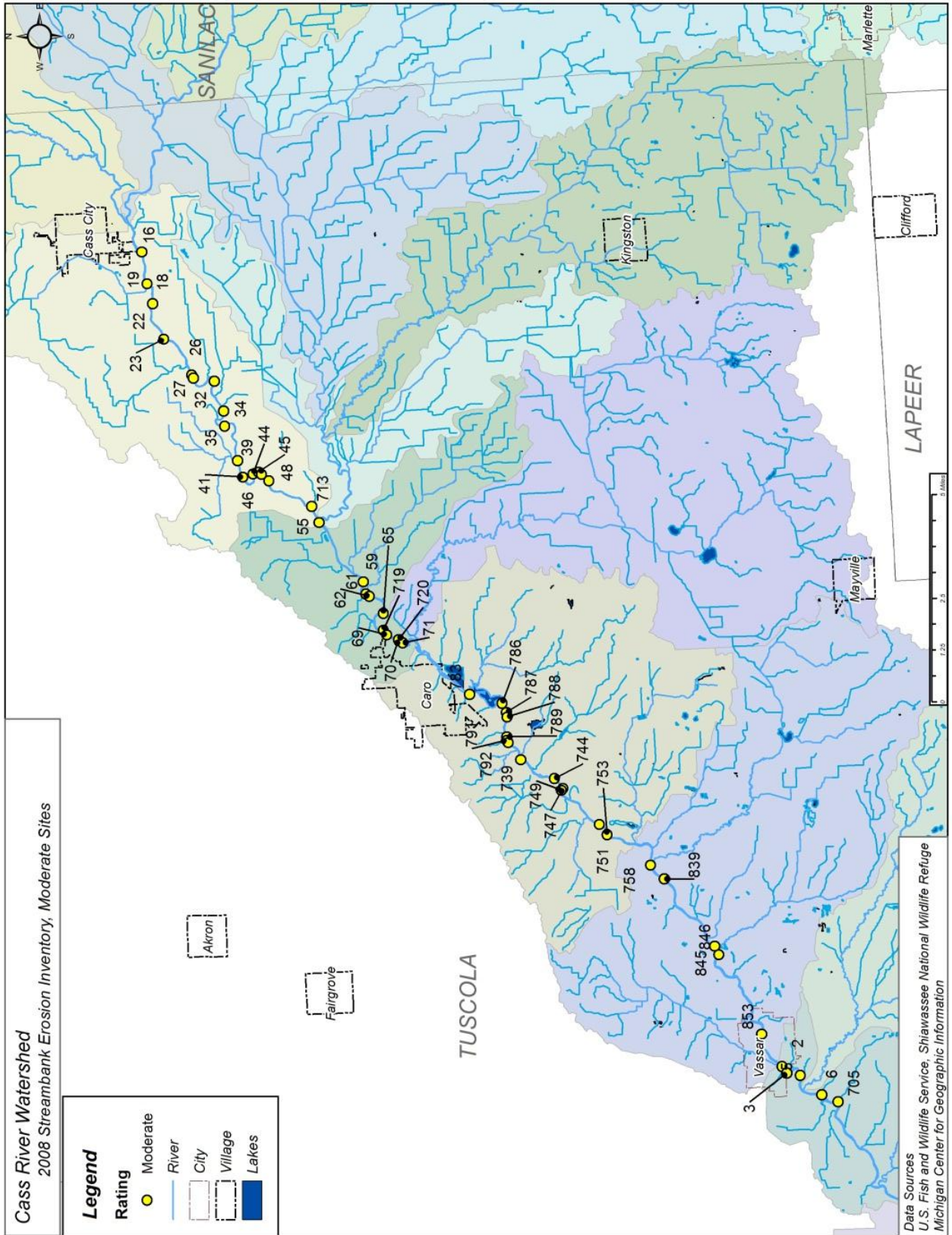
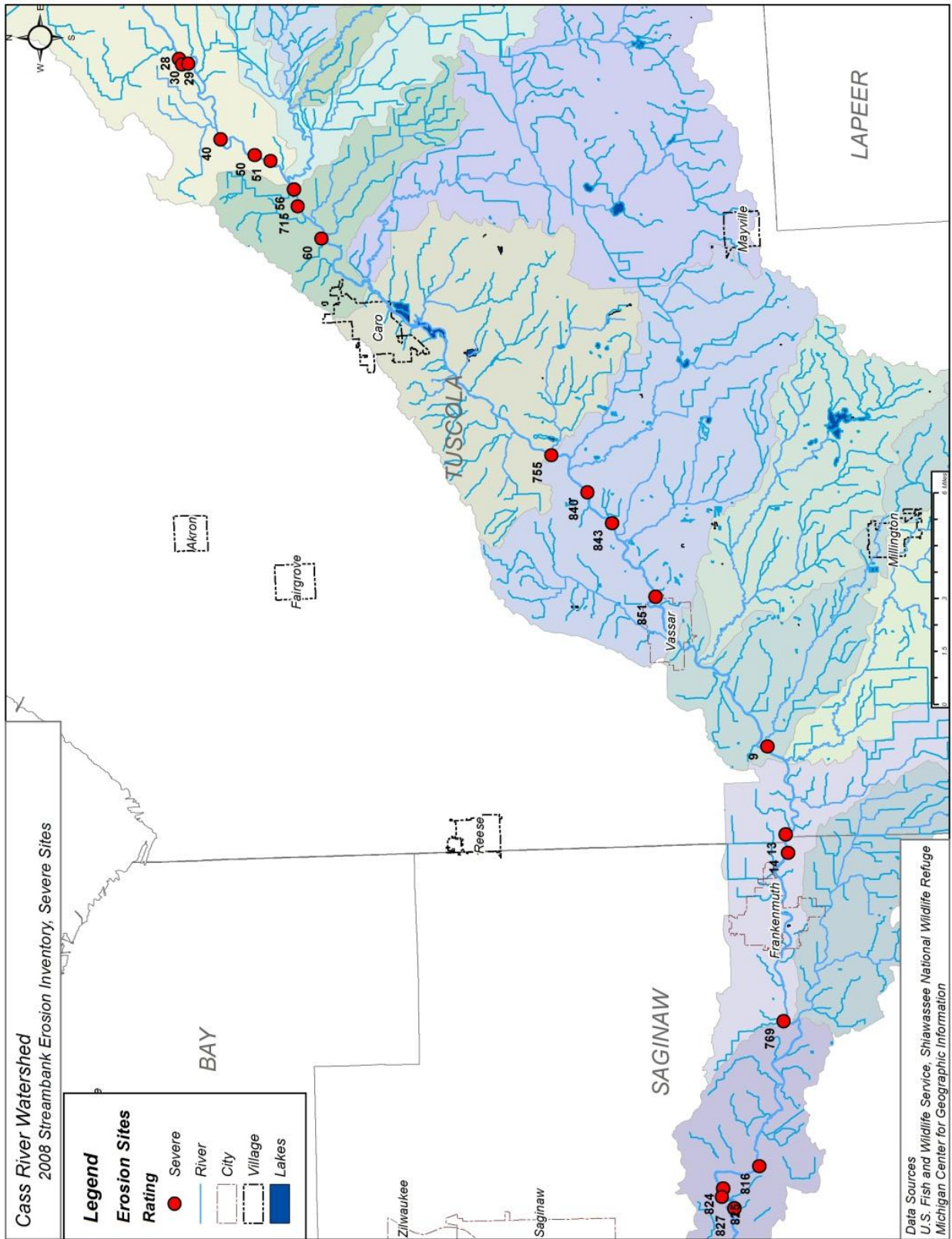


Figure 3.14: Severe Streambank Erosion Sites



3.4 In-Stream Watershed Inventory

In-stream Inventory

Impaired reaches identified by previous MDEQ monitoring were identified as the priority for the walking inventory. Impaired reaches were inventoried by the Tuscola and Saginaw Conservation Districts during the 2011 field season. Below is a listing of impaired reaches that were waded:

- Spring Drain – South Branch, Figure 3.4
- Duff Creek – South Branch, Figure 3.4
- Stony Creek – South Branch, Figure 3.5
- Butternut Creek – White Creek, Figure 3.7
- Moore Drain – White Creek, Figure 3.8
- Dead Creek, Figure 3.10

Table 3.7 provides an overview of the types of impairments that were identified in the watershed during the in-stream inventory. A majority of in-stream impairments identified stem from non-point agricultural sources (field runoff, etc.) Maps and tables showing the locations of pollution sources are shown at the subwatershed scale for the Upper Cass River in Chapter 7, the Middle Cass River in Chapter 8, and the Lower Cass River in Chapter 9.

Table 3.7 In-Stream Inventory Summary

Type	No. of Sites
Non-point Ag. Source	331
Gully Erosion	23
Streambank Erosion	13
Livestock Access	3
Urban/Residential (Includes Yard Waste)	3
Stream Crossing	2
Tile Outlet	2
Rill Erosion	2
Debris/Trash Obstructions	1
Sedimentation	1
Other (Phragmites)	1

3.5 Windshield Watershed Inventory

Two initial criteria were looked at to determine which sub-watersheds should be inventoried for agricultural NPS pollution sources and causes.

1. **Does the subwatershed contain an impaired waterway** (as listed in the 2010 Integrated Report)? Yes / No
2. **What percentage of the subwatershed is comprised of agricultural lands?**
(Visually estimated, 2006 land use/land cover statistics)
Greater than 75%
Between 74-50%
Between 49-25%

Each subwatershed was then assigned a priority between one and three, with priority one subwatersheds having both impaired waterways and agricultural land use at 75% or greater.

Priority One

Impaired Listing and greater than 75% Agriculture

Spring Drain – South Branch (040802050101)

Duff Creek – South Branch (040802050102)

Stony Creek – South Branch (040802050106)

Priority Two

Impaired Listing and between 50-74% Agriculture

Dead Creek (040802050304)

Cole Creek (040802050305)

Impaired Listing and between 25-49% Agriculture

Butternut Creek – White Creek (040802050207)

Moore Drain – White Creek (040802050209)

Cass River (040802050306)

Priority Three

Greater than 75% Agriculture

Gerstenberger Drain – South Branch (040802050103)

Clarks Drain – North Branch White Creek (040802050201)

The windshield survey gave precedence to subwatersheds that were identified as impaired by the MDEQ. Additional subwatersheds surveyed also had a high percentage of agricultural land use. A total of seven subwatersheds were surveyed: Spring Drain – South Branch (040802050101), Duff Creek – South Branch (040802050102), Stony Creek – South Branch (040802050106), Moore Drain-White Creek (040802050209), Dead Creek (040802050304), Cole Creek (040802050305) and Cass River (040802050306).

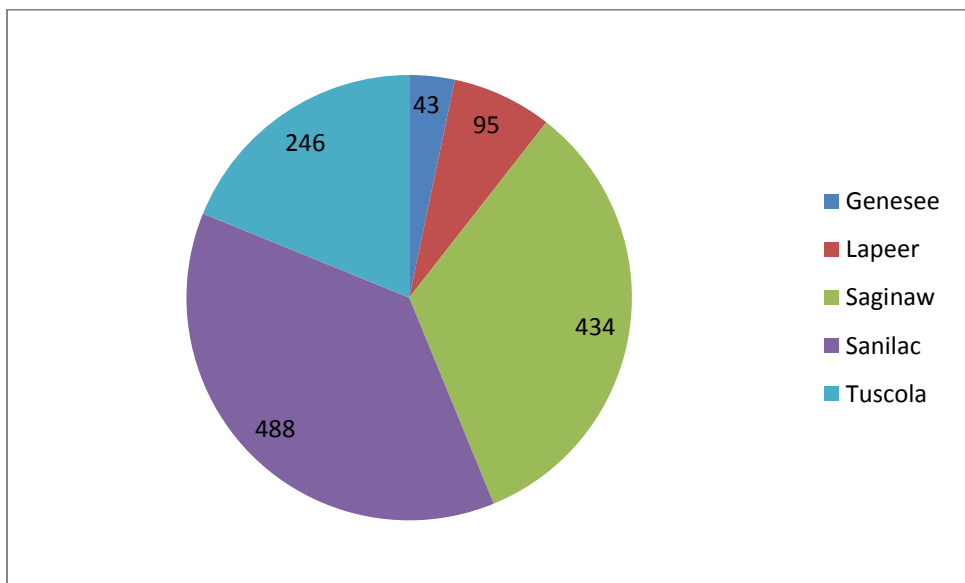
Staff from the Saginaw Bay RC&D, and volunteers affiliated with MDEQ spent much of the 2011 field season conducting the driving inventory to quantify the amount of agricultural NPS occurring in the watershed. The driving inventory focused on documenting impacts agricultural practices (or lack of) have on water quality in the watershed.

Each agricultural site was surveyed for the following practices and/or pollution sources:

1. Tilling: No-till, Minimum or Conventional
2. Percent Residue on Field
3. Crop Planting Method: Cover crop, CREP Land, Contour Farming, Conservation Crop Rotation or Other
4. Application of Waste Nutrients
5. Wind Erosion Potential and Prevention
6. Water Erosion Evidence from Rills/Gullies, Temporary V-ditches, or Exposed Roots
7. Presence of Livestock and Potential Impact on Water Quality
8. Evidence of Manure Storage
9. Type of Land Drainage: Tiled, Surface Drain, or Grassed Waterway
10. Presence of Buffer Strip
11. Evidence of Bank Erosion

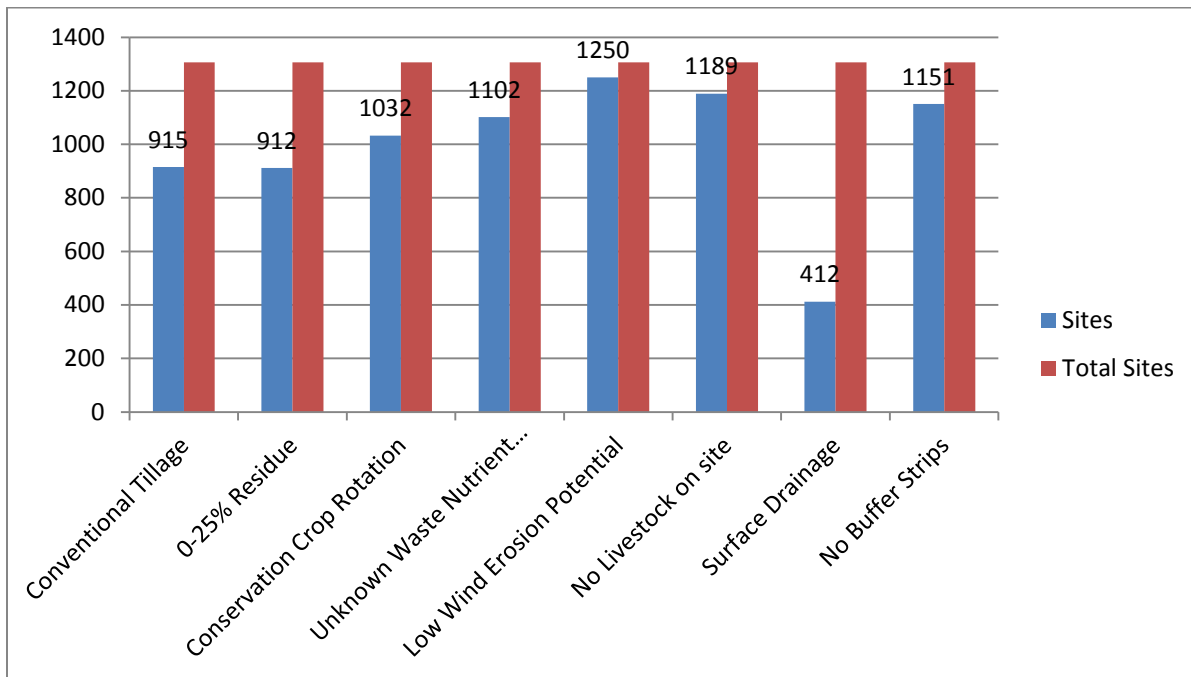
A total of 1,306 sites were identified through the windshield survey. The number of sites per county is shown in Figure 3.15 demonstrating that most NPS problems occur in Sanilac County followed by Saginaw County.

Figure 3.15 Agricultural NPS Inventory, Summary by County



It is important to note that not all 1,306 sites were inventoried for each type of practice that was included on the inventory data collection sheet. It must be assumed that data omissions for certain practices were not recorded out of random error, that the type of practice could not be observed, or that overall visibility was poor at the site. Figure 3.16 summarizes the sites by practice, note how none of the totals equal 1,306.

Figure 3.16: Total Number of Sites for each Practice



When summarized by each *type* of practice, the data show that the majority of growers are using Conventional Tillage (915), and the majority of fields have 0-25% residue on them (912). The most common type of crop planting is Conservation Crop Rotation (1032). In regards to Waste Nutrient Application, the majority (1102) of the sites were unknown to use that practice. The most common Wind Erosion Prevention practice in use are Tree Lines (458); and most sites were identified as having low wind erosion potential (1250). Most sites did not have livestock (1189), of the 78 producer sites that raise livestock, only 7 were identified as having an impact on water quality. There was little to no evidence presented on impacts from Manure Storage and Polluted Runoff. The most common type of Land Drainage was Surface Drain (412). The majority of sites do not have Buffer Strips (1151), however 44 out of the 49 sites that do have buffer strips have well-established vegetation. A listing of each site by subwatershed is presented in a Microsoft Excel table as a part of the chapters for each sub-basin (Chapters 7-9).

3.6 Prioritizing Watershed Restoration Opportunities

Adapted from Ko’olaupoko Watershed Restoration Action Strategy (HI)

Due to the large extent of the Cass River watershed and the amount of impaired sites denoted during the inventory, the steering committee felt it useful to employ a framework to score and rank sites for restoration. Numerous variables can be taken into account; the most realistic factors to rank sites in the Cass River watershed can be done by answering the following questions:

1. Does the Community support the project?,
2. Is the project effective at addressing the source(s) of pollutant(s)?,
3. Is the project technically feasible?, and
4. How severe is the Site ranking in terms of pollutant loading?

1. Does the Community support the project?

Community support is needed to implement restoration projects, whether it is to secure funding, perform outreach, or direct volunteer hours. Various segments of the population should be consulted for support and stakeholder buy-in.

Community Support Metrics	Score
Problem is meaningful to a variety of stakeholders and a plan is being developed by several professionals, agencies, and landowners. Plan includes feedback mechanism and public comment period and/or public meetings	3
Problem is relevant to many and plan circulated and reviewed by citizens, landowners, resource agencies and elected officials	2
Problem is meaningful only to project sponsor with little other public involvement	1

2. Is the project effective at addressing the source(s) of pollutant(s)?

For each project, it should be determined if the source of the pollutant will be removed or reduced. For example, sediment is entering the stream from an adjacent farm field. The recommended practice is to install a vegetated buffer between the drainage ditch and field. The effectiveness of this project depends on the length and width of the buffer along the ditch.

Pollutant Source Metrics	Score
Directly addresses source in a reach with an approved TMDL plan	3
Directly addresses source in a reach without an approved TMDL plan	2
Obliquely addressing source	1

3. Is the project technically feasible?

Project implementation practices can vary widely from innovative and experimental to highly studied and proven techniques. Cost effective projects that utilize highly successful methods are more desirable than experimental or large-capital projects.

Technical Feasibility Metrics	Score
Basic technology such as BMP's could easily be used to solve problem	3
Standard technology can be used and is acceptable to address the problem	2
Technology exists but not widely demonstrated or accepted	1

4. How severe is the Site in terms of impairments and pollutant loading?

The MDEQ has developed Total Maximum Daily Load requirements for several reaches in the Cass River Watershed. These reaches are ranked highest for site severity, along with the extent of pollutant loading being contributed to the waterbody.

Site Severity Metrics	Score
Designated use is impaired and high pollutant loading	3
Designated use is impaired and relative pollutant loading	2
Designated use is impaired and unknown amount of pollutant loading	1

Table 3.8: Project Restoration Ranking

Metrics	Description	Ranking	Score
Community Support	Problem is meaningful to a variety of stakeholders and a plan is being developed by several professionals, agencies, and landowners. Plan includes feedback mechanism and public comment period and/or public meetings	3	
	Problem is relevant to many and plan circulated and reviewed by citizens, landowners, resource agencies and elected officials	2	
	Problem is meaningful only to project sponsor with little other public involvement	1	
Pollutant Source	Directly addresses source in a reach with an approved TMDL plan	3	
	Directly addresses source in a reach without an approved TMDL plan	2	
	Obliquely addressing source	1	
Technical Feasibility	Basic technology such as BMP's could easily be used to solve problem	3	
	Standard technology can be used and is acceptable to address the problem	2	
	Technology exists but not widely demonstrated or accepted	1	
Site Severity	Designated use is impaired and high pollutant loading	3	
	Designated use is impaired and relative pollutant loading	2	
	Designated use is impaired and unknown amount of pollutant loading	1	
Total Score			

Projects that are scored can then be ranked and placed into one of three categories.

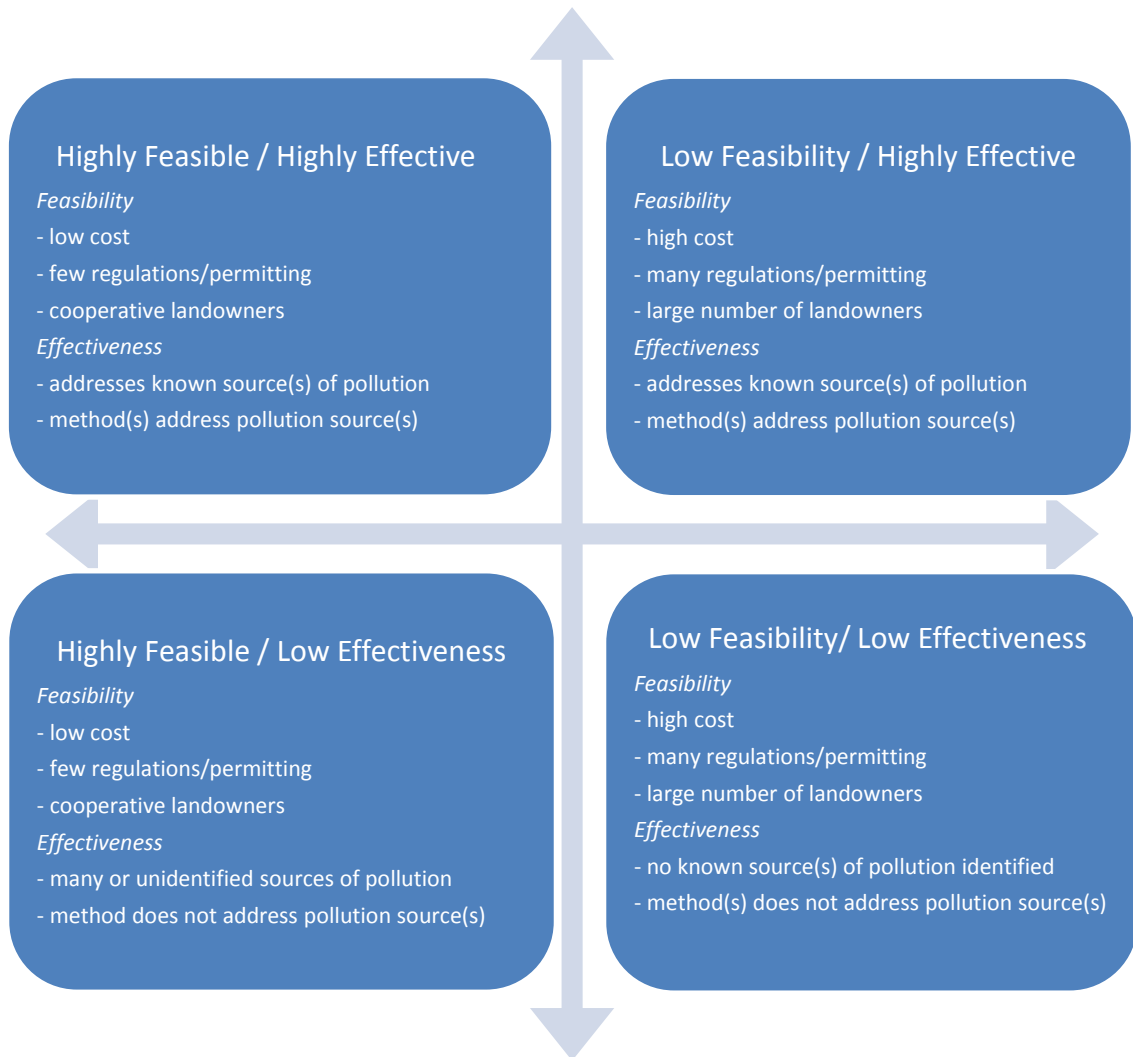
High Priority: 12-8 Points

Medium Priority: 7-4 Points

Low Priority: 3-1 Points

Additional factors to be included in prioritizing projects are their cost, amount of regulations and permitting, and the number and disposition of landowners. The following matrix serves as an additional tool for ranking restoration projects.

Figure 3.17: Site Prioritization Matrix



Chapter 4: Urban Areas Analysis

4.1 Introduction to the Evaluation of the Cass River Urban Areas

In the Cass River Watershed a decision was made to determine the effects of the urban areas in this rural watershed. The majority of the landuse in the watershed is agriculture (57%), the urban/residential area accounts for 7.6% of the landuse. The urban areas selected to be studied were (in upstream to downstream order) Village of Cass City, City of Caro, City of Marlette, City of Vassar, Village of Millington, City of Frankenmuth, and Bridgeport Charter Township. The communities of Ubly and Tuscola were not considered in this section of the report because of their location at the headwaters of the watershed and small urban area impact, respectively. The assessment of the effect of urban areas on the Cass River was done by use of EPA-SWMM and a Survey of managerial and structural BMPs in the selected communities.

The computer models would provide an opportunity to determine the hydrologic and hydraulic impacts to the river at the urban locations or in the drains that lead from the urban area to the river as is the case with Marlette and Millington. They would also provide a simulation tool to determine stormwater impacts from urban areas.

The survey of managerial and structural best management practices was done to provide a baseline for what practices were existing in the watershed. After assessment the opportunity is then present to determine what additional, low cost practices could be used to decrease urban stormwater impacts on the Cass River and its watershed.

4.2 Hydrologic and Hydraulic Model Development

One goal of the Cass River Watershed Management Plan (WMP) was to determine the impact developed areas had on the watershed. By defining the stormwater contributions of these developed areas within the watershed, a relative level of impact could be ascertained. To create such an analysis, models were constructed to estimate outflow hydrographs for each of the developed areas within the watershed under various precipitation scenarios. The following sections outline the methodology used to develop these models.

a. Available Data

Key to any model is the data used to create it. For the Cass River WMP, the first step in model development was identifying what information was available. Information for communities in the Cass River Watershed included USGS topographic information, aerial photography, and drainage maps. Table 4.1 shows what information was available for each of the communities analyzed.

Table 4.1: Available background information for communities in the Cass River Watershed.

Developed Area	Available Data		
	USGS Maps	Aerials	Drain Maps
Bridgeport	Yes	Yes	Digital
Cass City	Yes	Yes	Paper
Caro	Yes	Yes	Paper
Frankenmuth	Yes	Yes	Digital
Mayville	Yes	Yes	No
Millington	Yes	Yes	No
Vassar	Yes	Yes	No

In those areas without drainage maps, field visits were conducted to identify the approximate location and size of main-line storm sewers and outfalls. It is important to note that pipe invert elevations were not readily available for any of the communities examined. Furthermore, the amount of field survey required to obtain pipe inverts in all of the developed areas was found to be prohibitively expensive. Modeling decisions and assumptions were made to compensate for incomplete data. The following section outlines the process used to select a computer model capable of estimating stormwater runoff from developed areas in the Cass River Watershed.

b. Model Selection

There are several computer programs which can be used to calculate runoff from urban development. A list was compiled of hydraulic and hydrologic models which could be considered for calculating urban runoff. This list, shown below in Table 4.2, compared each of the programs based on their individual capabilities. These capabilities were broken down into individual aspects of urban runoff calculations which included hydrology, flow routing, hydraulics, and infiltration.

Table 4.2: Capabilities of computer modeling programs.

Capability	Microsoft Excel Spreadsheet	HEC-RAS	Culvertmaster & Flowmaster	HY-8	EPA SWMM	Civil 3D Storm & Sanitary Analysis
Hydrology	Modified Rational	N/A	Rational	N/A	SCS Curve Number	Rational
			Peak Discharge		Excess Precipitation	Modified Rational
			SCS Curve Number			DeKalb Rational
						SCS Curve Number
						Excess Precipitation
						TR-20
						TR-55
Flow Routing	Steady Flow	Steady Flow			Steady Flow	Steady Flow
		Kinematic Wave			Kinematic Wave	Kinematic Wave
					Dynamic Wave	Dynamic Wave
Hydraulics	Manning's	Manning's	Manning's	Manning's	Manning's	Manning's
		Weir	Darcy-Weisbach	Weir	Weir	Weir
		Energy	Hazen-Williams	Energy	Darcy-Weisbach	Darcy-Weisbach
		Momentum	Kutter's Formula		Hazen-Williams	Hazen-Williams
			Energy		Energy	Energy
					Momentum	Momentum
Infiltration	N/A	N/A	N/A	N/A	Green-Ampt	Green-Ampt
					Horton	Horton

To select a model, a set of criteria was developed which could be used to rank each of the computer programs listed in Table 4.2. These criteria included model flexibility, available hydrology methods, hydraulic and flow routing capabilities, ease of use, familiarity and acceptance by the professional community, ease of system alteration, applicability to future projects, output quality, ease of comprehension by the public, and ability to incorporate available data. These criteria were then ranked on a scale of 1-10 as shown below in Table 4.3.

Table 4.3: Selection criteria for available urban stormwater models.

Criterion	Microsoft Excel Spreadsheet	HEC-RAS	Culvertmaster & Flowmaster	HY-8	EPA SWMM	Civil 3D Storm & Sanitary Analysis
Flexibility	3	3	1	4	8	10
Hydrology Methods	1	1	1	1	8	10
Hydraulics/Routing	1	6	8	8	10	10
Familiarity/Acceptance	8	10	7	8	10	6
Ease of Alteration	8	3	10	9	7	8
Future Applicability	3	1	2	2	10	8
Output Quality	1	5	2	3	7	9
Ease of Comprehension	4	5	7	7	8	8
Data Incorporation	4	1	7	7	9	10
Total	33	35	45	49	77	79

Based on the selection process outlined above in Table 4.3, AutoCAD Civil 3D Storm and Sanitary Analysis (AutoCAD SSA) was selected as the optimum program for developing stormwater models for developed areas in the Cass River Watershed. This program used the EPA SWMM platform and expanded it to include additional hydrologic computation methods. Furthermore, AutoCAD SSA provided a simpler graphical user interface than SWMM and

allowed for simple integration of AutoCAD files as design base maps. This allowed existing CAD storm sewer maps to be easily scaled and included in the model development. An added benefit is that the AutoCAD SSA file could be saved in a SWMM format. This would allow virtually anyone to view the models using EPA SWMM which is available free from the Environmental Protection Agency (EPA).

c. Model Parameters

Development of stormwater models required certain key parameters be identified which impact runoff from storm events. The most obvious of these was rainfall data. The AutoCAD SSA model allowed for user-defined rainfall hyetographs to be input and converted to runoff on a time-varied basis. Total runoff volumes were contingent on the area over which rainfall was applied and the imperviousness of the land surface. Imperviousness and subsequent runoff volumes can be computed in several different ways as shown in Table 4.2. Next, AutoCAD SSA required individual sub-basins to be identified. These sub-basins were then assumed to convey overland flow to a specific design point such as a catchbasin inlet. Flow was then routed through the system via a pipe network developed from a combination of site inspections and available storm sewer maps. The following sections provide a more detailed explanation of the processes used for calculating runoff.

d. Hydrology

AutoCAD SSA, like EPA SWMM, calculated runoff based on excess rainfall. This was done by calculating an infiltration rate for a specific catchment and subtracting the infiltration rate from the rainfall rate. The difference in these values was assumed to be converted to runoff. Therefore, the two key factors which impacted runoff were rainfall rate and soil infiltration rate. For the Cass River Watershed, a 24-hour SCS Type II rainfall distribution was selected as is commonly used in Michigan. Total rainfall volumes for each of the storms analyzed was taken from Midwestern Climate Center, Bulletin 71 titled "Rainfall Frequency Atlas of the Midwest." Rainfall was converted to runoff volume using the SCS curve number method. Runoff volume was then applied to a dimensionless unit hydrograph to obtain an outflow hydrograph. The standard SCS unit hydrograph used a peaking factor of 484 however, this peaking factor has been shown to be lower in Michigan due primarily to the flat slopes prevalent in the lower part of the state. The unit hydrograph selected for the Cass River Watershed was obtained from the Michigan Department of Environmental Quality (DEQ) spreadsheet for estimating high flow hydrographs in Michigan waterways. When entered into the AutoCAD SSA program, the peaking factor was shown to be 367.81 with 28.5% of total rainfall volume occurring on the rising limb of the hydrograph.

It is important to note the manner in which AutoCAD SSA utilized the DEQ unit hydrograph. In each sub-basin, separate SCS calculations were performed for each time step and for each incremental rainfall volume in the rainfall hyetograph. Each of these incremental rainfall volumes was then applied to a unit hydrograph. The composite of all of the unit hydrographs was then produced as the outflow hydrograph for that particular sub-basin. The difference between total rainfall volume and runoff volume was assumed to be infiltration. This calculation was performed simultaneously for all sub-basins in the model. Outflow hydrographs

were then routed through the conveyance system constructed in the model to determine a composite hydrograph at the outlet. Note this method of applying the SCS method for individual sub-basins as opposed to determining a composite curve number for an entire watershed, tends to over-predict peak flows. However, this method was used as it can be easily adjusted to include infiltration best management practices (BMPs).

The routing calculation in AutoCAD SSA incorporates travel time into its determination of runoff volume. This travel time to a given point, also known as the "time of concentration," was determined based on the length of the longest flow path to the outlet. In rural areas, time of concentration was based on an average velocity of 1.0 ft/sec. For urban areas, the average velocity was increased to 2.0 ft/s and in those areas that were only partially urbanized, a velocity of 1.5 ft/s was used. Travel time in hydraulic conduits (e.g. - pipes and open channels) was calculated based on AutoCAD SSA's hydraulic calculations.

e. Hydraulics

AutoCAD SSA is capable of performing complex hydraulic calculations for large systems of pipes and channels. Flow and depth calculations in the models created for the Cass River WMP utilize the hydrodynamic wave equation (a.k.a. - full set of Saint-Venant equations). This is one of the most robust methods of calculating flow as it accounts for both energy and momentum when water surface elevations and slopes. In systems where water may split and flow in multiple directions, momentum is used to determine the relative amount of flow in each direction. In cases where pipes became pressurized, the model used the Hazen-Williams equation. Despite the precision of the equations used to calculate system hydraulics, model accuracy was ultimately limited by the data available and the assumptions made in regions where data were lacking.

f. Assumptions

Models developed for the Cass River Watershed Management Plan used the best data available. When possible, data gaps were filled through field verification and inspection. However, in some instances, project constraints made data gathering impractical. In such instances, assumptions were made to simplify the models while still maintaining model quality.

Pipe slope and invert data were not readily available for communities in the Cass River Watershed. Therefore, pipes were assumed to run at minimum slopes as outlined in Table 4.4. This method would tend to under predict hydraulic capacity during low-flows. However during large events where pipes were surcharged, hydraulic head would dictate pipe capacity and therefore, slope would have a less substantial impact on overall capacity. Also, in instances where field observation or available profile data made it obvious that slopes were steeper than the minimum, slopes were increased accordingly.

Table 4.4: Minimum pipe slopes.

Pipe Diameter (in)	Minimum Slope
6	0.0056
8	0.0044
10	0.0032
12	0.0026
15	0.0020
18	0.0016
21	0.0014
24	0.0012
>24	0.0010
Open Channel	0.0010

Another key assumption in the Cass River WMP models dealt with ground elevation and surface ponding. The ground surface was assumed to be 6.0 feet above the lowest pipe invert at a particular node. In instances where the pipe size or channel depth was greater than 6.0 feet, the ground elevation was assumed to be at the top of the pipe or channel. During large runoff events, flow often exceeded the capacity of drainage systems and water rose above the established ground surface elevation. If ponding were ignored in AutoCAD SSA, flow which surcharged above the ground surface would have been lost and would never have re-entered the system. Additionally, by ignoring ponding, the water surface elevation (hydraulic grade line) would never have been permitted to exceed the surface elevation. Therefore, as a typical assumption, ponding was allowed in the AutoCAD SSA models in an area of 300 ft² which is roughly equivalent to a circular area of 20 feet in diameter. Water was allowed to create head by rising within this 300 ft² above the ground surface (15 feet). The exception to this was when it was obvious a low area or detention pond provided storage for surcharged pipes. In these locations, a depth-storage relationship was developed based on visual observation and measurements on aerial photographs.

Assumptions also had to be made regarding the hydraulic characteristics of conduits within each drainage model. First, all conduits were assumed to be in good condition and unobstructed. Pipes were assumed to be concrete and have a Manning's coefficient of 0.013. Since most of the pipes in the models were part of municipal storm sewer systems rather than culvert crossings, corrugated metal pipe was uncommon. Though some small pipes were plastic, their Manning's coefficients were assumed to have relatively little deviation from that of concrete. Furthermore, large pipes which have the greatest impact on overall system discharge are generally concrete. For open channels, a Manning's coefficient of 0.035 was assumed. This indicated that channels were relatively well-maintained and did not have significant flow obstructions. All open channel banks were assumed to slope at 2 horizontal to 1 vertical. Based on visual observation, these assumptions appeared to have been accurate in most locations.

In addition to friction losses in conduits, head loss also occurs at entrance and exit locations. An entrance loss of 0.5 was assumed for all conduits which was typical of square-edged inlets and was estimated to be an average headloss situation. Exit losses were taken to be 1.0 at all junctions. This assumption meant that flow was assumed to stagnate in each junction and kinetic energy was not carried from one conduit to the next. This is generally true in areas where flow is not transferred in a straight line either due to turbulence, a bend, or backwater. Due to the complexity of the urban systems in the Cass River Watershed, it was reasonable to assume that multiple inlet pipes in manholes generally caused turbulence sufficient to create exit losses near 1.0. Additionally, backwater was prevalent in high-flow scenarios which would have impeded flow from one conduit to the next.

At locations where urban drainage systems connected to receiving waterways (e.g. - Cass River), outfalls were assumed to function at normal depth. By making this assumption, tailwater conditions were allowed to rise and fall with changing flows. It was important to note that some of the outfalls from communities located immediately adjacent to the Cass River have flap gates. When the Cass River is high at these locations, the flap gates will be closed and therefore, stormwater would not be able to exit the system by the force of gravity. For the purposes of developing general models for urban communities however, high tailwater conditions were not considered. Because small urban areas convey stormwater flows more quickly than large rural areas, it would be likely peak flows from urban areas would have passed into the Cass River before the river itself reached its peak. This is because the Cass River has a large contributing area relative to urban communities within its watershed and a similarly large time of concentration.

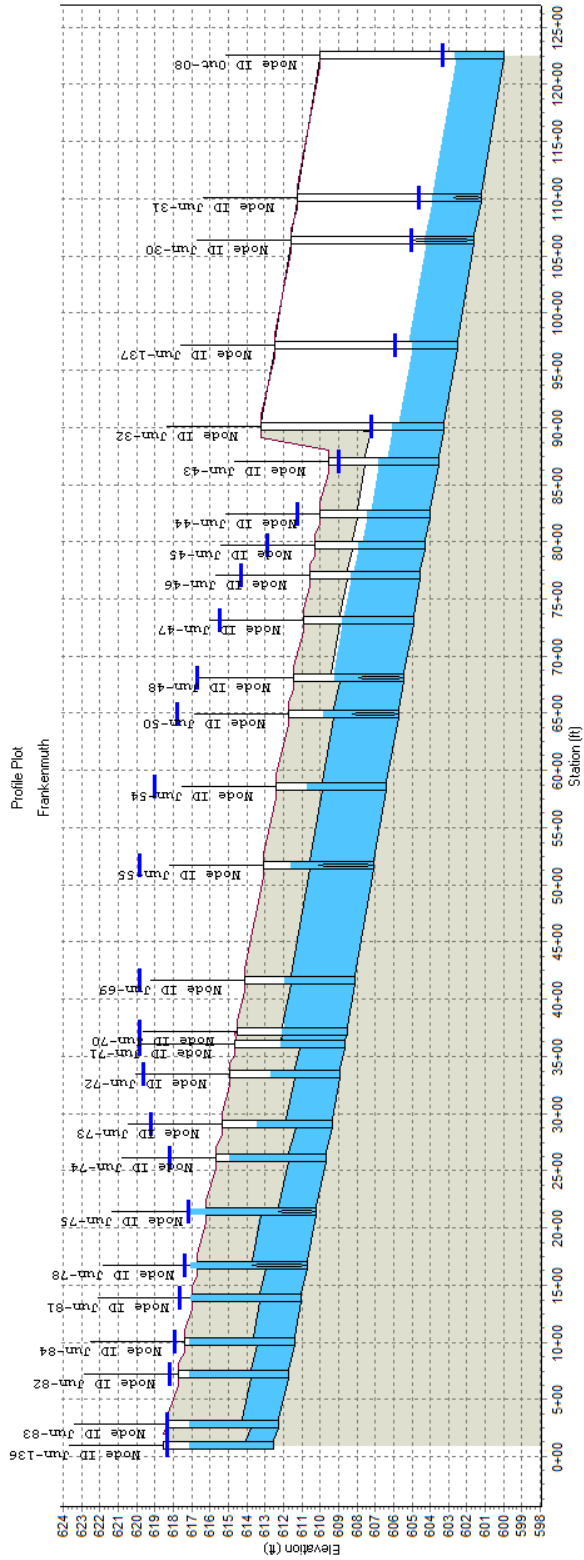
4.3 Model Results

With these assumptions and the methodology outlined above, stormwater models were developed using AutoCAD SSA. Specific results of this analysis are outlined in the following sections.

a. Hydraulic Profiles

As discussed previously, the intent of the AutoCAD SSA model was to show the relative level of stormwater impacts from each of the communities evaluated. Assumptions were made regarding pipe slopes and ground surface elevations were approximated. Therefore, hydraulic profiles generated in AutoCAD SSA do not accurately represent field conditions. They are, however, useful for determining locations where pipe restrictions are likely to cause flooding or to identify areas where high hydraulic head is needed to pass certain storm events. Additionally, hydraulic profiles can be used to verify the model is properly permitting nodes to surcharge and build hydraulic head. An example of a hydraulic profile generated by AutoCAD SSA is shown in Figure 4.1.

Figure 4.1: Sample hydraulic profile from AutoCAD SSA.



b. Urban Impact

There are three major factors impacting the volume and rate of runoff generated from urban areas: watershed area, hydraulic connectivity (time of concentration), and portion of water infiltrating (runoff curve number). These factors aggregate to create an outflow hydrograph from a given urban area. Table 4.5 shows the first of these factors: drainage area.

Table 4.5: Drainage area comparison.

Modeled Drainage Area (Acres)						
Bridgeport	Caro	Cass City	Frankenmuth	Mayville	Millington	Vassar
1,406	1,329	1,169	2,364	398	863	1,330

The second factor contributing to cumulative outflow from a community is time of concentration. Areas with high levels of hydraulic connectivity cause runoff from various subwatersheds to quickly coningle and create high peak flows that occur over a short period of time. Conversely, areas with low connectivity, such as those with significant amounts of overland flow and meandering natural channels, have subwatershed peaks which generally do not coincide. Therefore, these systems with low connectivity will generally have a high time of concentration and reduced peak flow.

Figure 4.2 and Figure 4.3 show a comparison of a community with low connectivity (Bridgeport) and a community with high connectivity (Millington). The thin, light colored lines represent outflows from subwatersheds within the community and the thick dark colored lines represent composite community outflow hydrographs.

Figure 4.2: Subwatershed hydrographs (light lines) and composite outflow hydrograph (dark line) for Bridgeport.

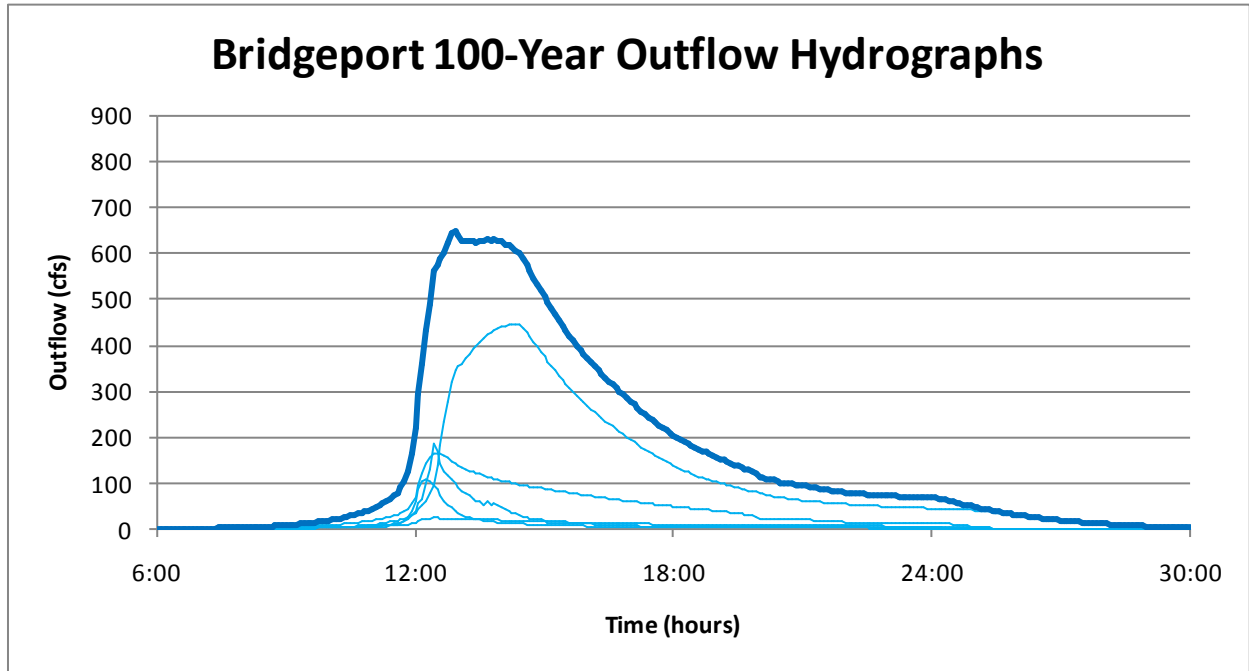
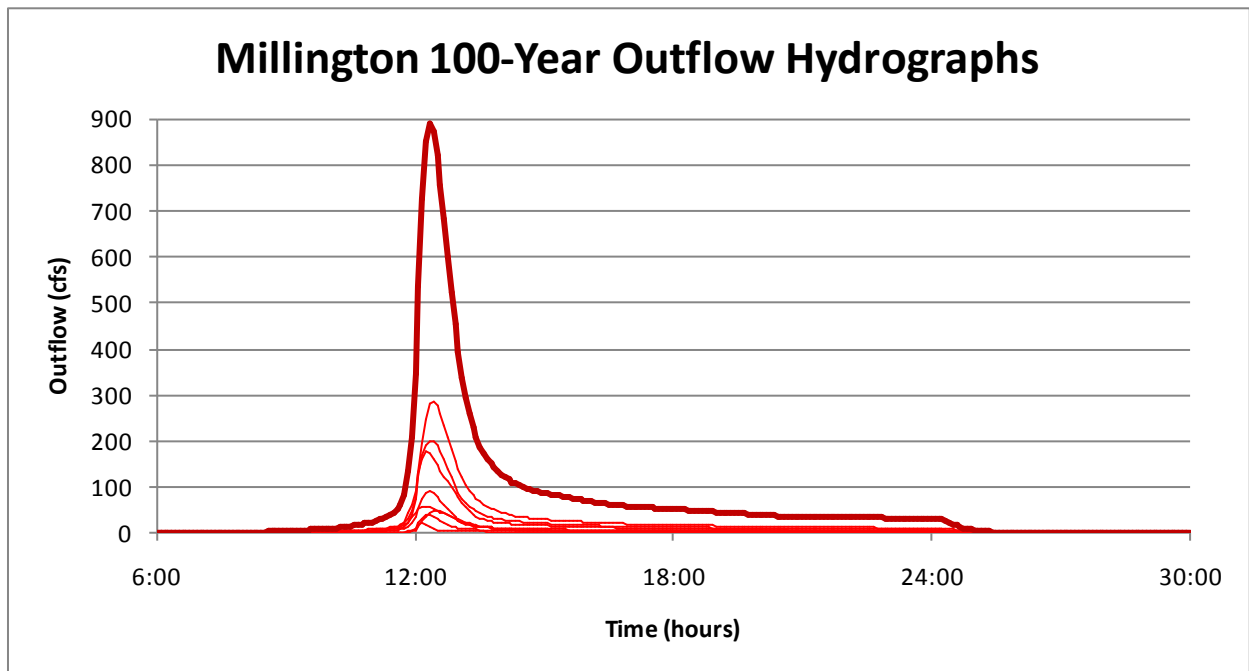


Figure 4.3: Subwatershed hydrographs (light lines) and composite outflow hydrograph (dark line) for Millington.



As shown in Table 4.5, Bridgeport has a drainage area nearly double that of Millington and also produces a greater total volume of runoff as demonstrated by the area under the composite hydrograph. Despite these facts, the storm water models show a higher composite peak flow rate for Millington than Bridgeport. Since subwatersheds in the Millington model all have relatively short times of concentration, peaks occur at roughly the same and contribute to a higher overall peak flow rate.

The other factor contributing to both peak flow rate and runoff volume is the portion of rainfall that is allowed to infiltrate. Table 4.6 shows a comparison of runoff curve numbers which account for both impervious area and soil type. The curve numbers shown are a composite of subbasin curve numbers assigned throughout each community model.

Table 4.6 Runoff Curve number comparison

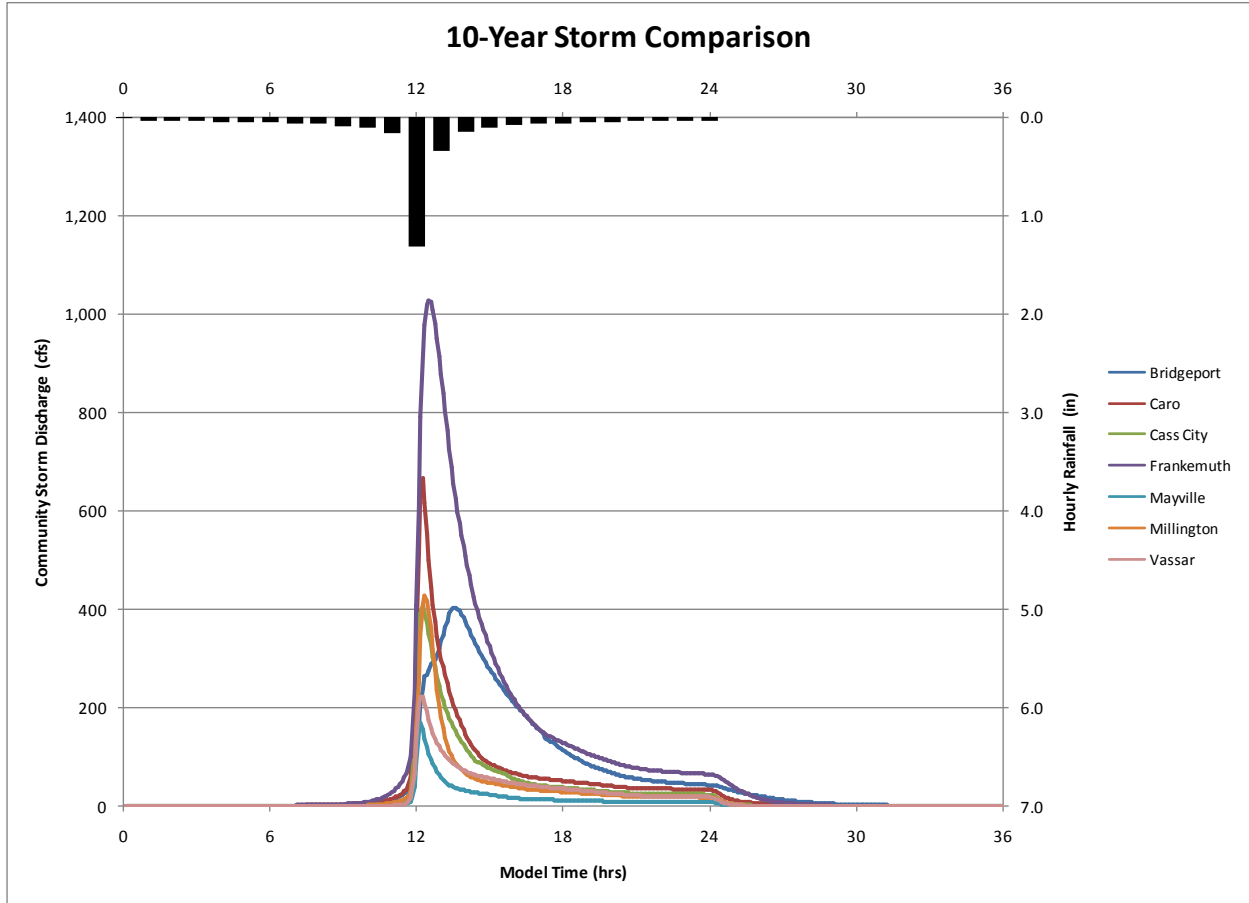
Composite Runoff Curve Number						
Bridgeport	Caro	Cass City	Frankenmuth	Mayville	Millington	Vassar
82.3	73.9	70.7	80.8	68.6	71.3	60.6

NOTE: The soils around Bridgeport are primarily from hydrologic soil groups C/D so impervious changes in percentage have little effect on the percent of stormwater runoff. Hydrologic soil groups of C & D are heavy soils that do not allow for much infiltration of stormwater runoff. Where as soil groups of A and B soils can readily absorb soils

c. Outflow Summary

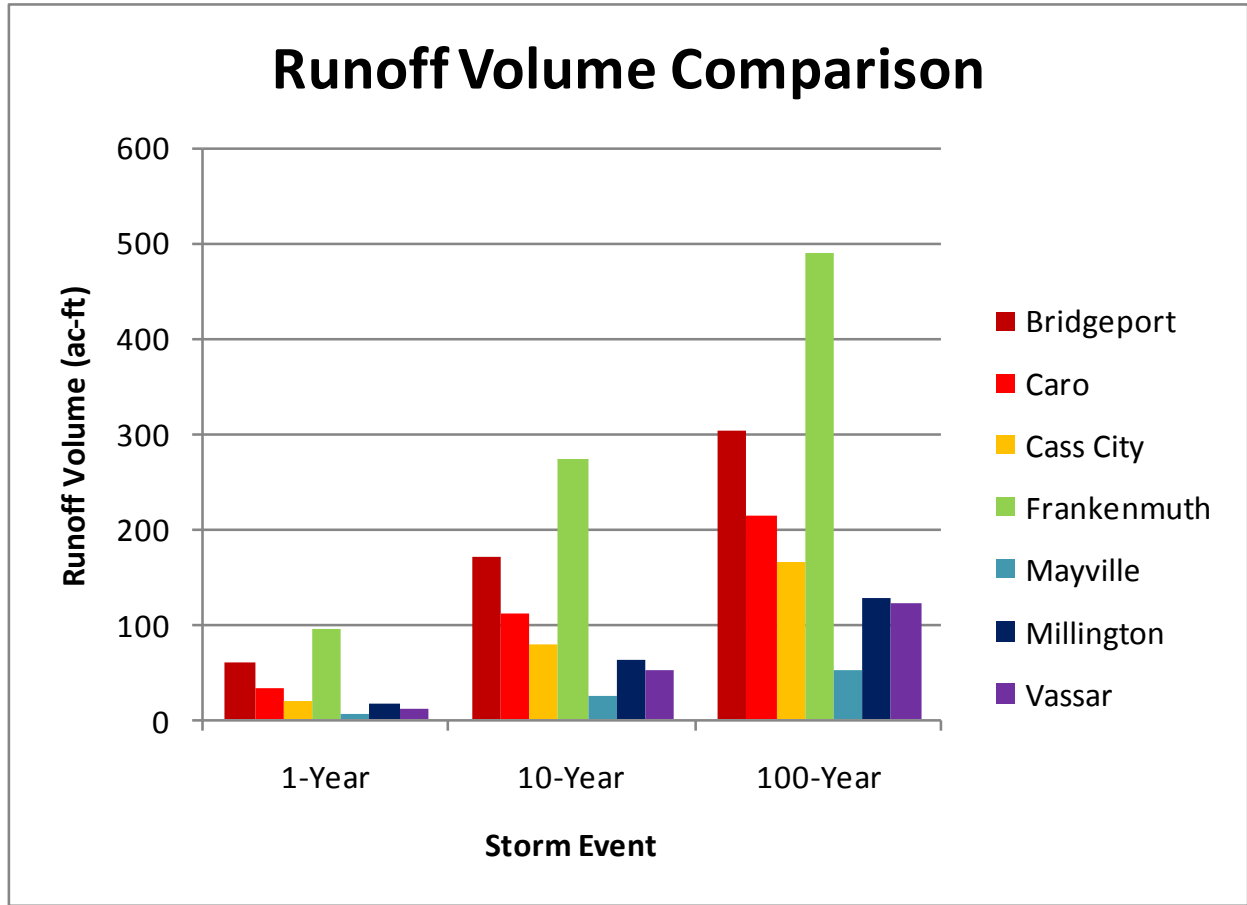
Overall outflow hydrographs for each community were generated by summing calculated discharges of all stormwater outfalls in a given community. The result of this analysis produced system-wide hydrographs for each of the communities. Hydrographs for the 10-year storm are shown to express the relative runoff of each of the municipalities evaluated. The remaining hydrographs are located in appendix D.

Figure 4.4: 10-year storm hydrographs from AutoCAD SSA.



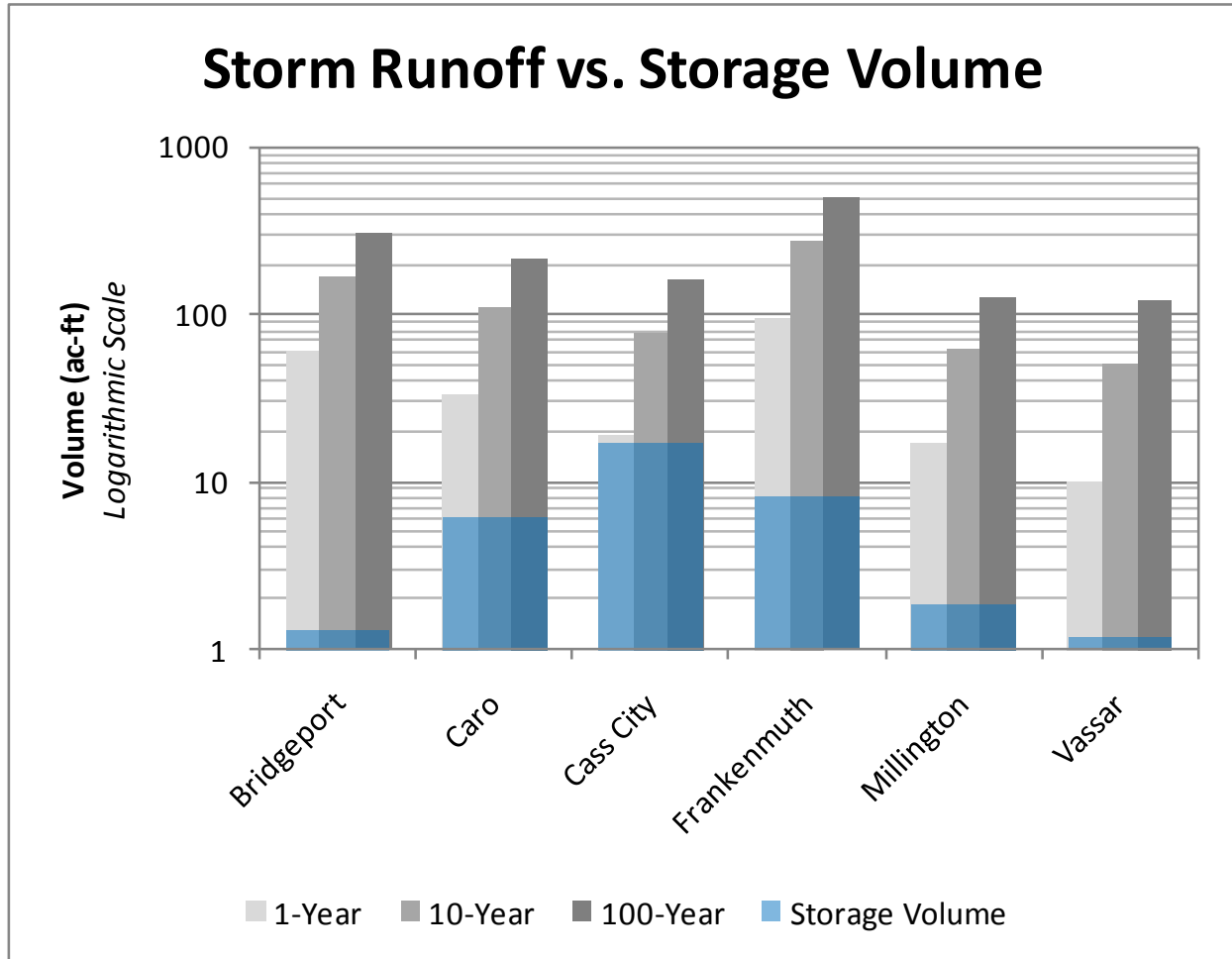
When evaluating the relative impact of each of the communities modeled, the hydrographs shown in Figure 4.4 demonstrate differences in peak flow (highest point on each curve) and total runoff volume (area under each curve). Figure 4.5 was developed to better show the relative volume of stormwater runoff from each community.

Figure 4.5: Comparison of runoff volumes from Cass River communities.



A field review of detention facilities allowed for an estimated volume of stormwater detention to be calculated for six (6) of the communities modeled. Figure 4.6 shows a comparison of various storm runoff volumes to estimated available detention volumes. In this figure, it is important to note the storage volume available in Cass City does not service all of the stormwater outfalls. Therefore, the amount of stormwater actually detained will be less than the total volume of storage available.

Figure 4.6: Comparison of modeled stormwater runoff to estimated detention capacity.



4.4 Urban Area Survey of Existing Managerial and Structural Best Management Practices

The urban areas surveyed were established communities in rural areas of the Cass River Watershed. The municipalities to be surveyed were determined by the steering committee. These communities were established in the mid to late 1800s and their populations range from 1,200 to 7,800 residents with the average of population of 3,600. The smallest community surveyed was Millington at 1,200 residents and the largest was Bridgeport Charter Township. Caro and Frankenmuth had the larger urbanized areas of the communities.

The survey included two phases, the first phase was a phone survey to discuss managerial practices in a community. The questions posed were to determine if there was a site review process in place that dealt specifically with storm water management. Results are summarized in Table 4.7.

- Did every site have a plan review for storm water management before construction?
- Was there an inspection of the site after construction by an engineer or the communities building or public works staff?

- Was there a specific ordinance or established regulatory procedure in place within the community?

The second phase consisted of a windshield survey of the community with a checklist sheet to determine which sites had storm water management practices in place when they were constructed. This portion of the survey was completed by a professional civil engineer with experience in developing storm water management plans for communities, reviewing site development plans for storm water management, and performing site inspections of storm water management plans after construction. The checklist for the survey was developed for the steering committee and presented for review and comments. The comments were incorporated into the survey sheet and then a field trial was completed and modifications to the form were completed based on field use and application. The survey forms, when completed for a community, then had the data placed into GIS to develop a map of the community showing the location of storm water BMPs and detention areas. Results are summarized in Table 4.8.

Table 4.7: Summary of storm water review process.

Urban Area	Review & Approval Process	Post Construction Inspection	Written Design Standards MDOT - Michigan Dept. of Transportation TCDC - Tuscola County Drain Commissioner SCT - Saginaw Charter Twp.	Established discharge rate and detention volume
Cass City	No (Yes for MDOT & TCDC)	No	Only MDOT & TCDC	Yes
Caro	Yes	Yes	City, MDOT, TCDC	Yes
Marlette	Unknown	No	Unknown	Unknown
Millington	Yes	No	MDOT; TCDC	Yes
Vassar	Yes	No	MDOT; TCDC	Yes
Frankenmuth	Yes	Yes	Yes - ordinance	Yes
Bridgeport	Yes	Yes	MDOT; SCT	Yes

Table 4.8 Summary of Urbanized Areas Windshield Survey, Cass River Watershed

Community (n)	Percent Impervious	Grading	Catch basins w/sumps	Vegetated swales	Inlet grates marked ⁶	Erosion protection	Detention Basins	Storage Volume (ft ³)	Bio Swale/ Rain Garden
Bridgeport (92)	70%	95%	46% ⁵	51%	1%	35%	10%	58,000	1%
Caro (43)	69%	98%	72%	70%	12%	65%	56% ¹	263,600	Yes ⁴
Cass City (29)	51%	100%	72%	38%	3%	28%	24%	752,300 ²	No
Frankenmuth (79)	77%	99%	100%	19%	18%	87%	57%	349,300 ³	No
Marlette (26)	26%	96%	81%	38%	23%	15%	35%	102,000	No
Millington (14)	72%	86%	57% ⁵	64%	0%	14%	29%	80,000	1%
Vassar (54)	73%	98%	38% ⁵	49%	11%	32%	17%	51,000	No

¹ Included two retention basins that use infiltration practices on their sites.

² This number is high because of a discharge into a man-made lake with a lot of storage capacity; site could become a regional basin.

³ Frankenmuth has a long history of storm water management planning and a significant amount of development since the planning has been in effect.

⁴ Spicer Group designed one for a site in Caro; it was in residential area that was not surveyed.

⁵ Many sites did not have catchbasins on them; they were small areas and were graded to drain to the street storm drains or to an offsite drainage system.

⁶ Indicative of older vs newer development, the marked inlet grates did not make an appearance until after 2003, since approximately 2009 most inlet grates now have at least “Dump No Waste” as part of the casting. Therefore if a community has 0% it probably indicates little to no new development.

a. Existing managerial BMPs

The urban areas surveyed were familiar to the person completing the survey. There was existing knowledge of the procedures in place for new development or redevelopment in the communities that were assessed. In this review of new development and redevelopment in urban areas, it must be determined who has jurisdiction over the outlet for the area being developed. For example, if a development is along a state highway with a storm drain system; then the Michigan Department of Transportation (MDOT) has jurisdiction over the point source to assure the design capacity of the storm drain is not exceeded. If the stormwater discharge is to an established county drain, then the county drain commissioner, county public works commissioner or their designee has jurisdiction over the point source and can enforce their design guidelines to assure the design drain capacity is not exceeded. If within city or village

limits and the site discharges to a municipal separated storm sewer system (MS4) then the city or village can invoke their established design guidelines. Some communities and counties have a Civil Engineering Consultant perform a review of plans to assure the storm water design criteria are met at the site. This review is typically done with an established written design guideline procedure; some reviews are completed based on “established engineering practices” which can vary widely based on the review engineers experience with stormwater reviews, knowledge of urban area, and other variables.

b. Structural Best Management Practices

These urbanized areas in the Cass River Watershed were basically all similar in the establishment of the best management practices for each community. The communities had a central urban core with a storm water collection system based on grading and collecting storm water runoff and moving it away from the commercial district. The systems were generally older drainage systems and probably nearing life expectancy. Some of the systems would be considered undersized by today’s design standards, but appeared to be functioning for most low frequency storm events.

Typically, what was visualized in the central urban areas were catch basins, with sumps to collect larger particles of sediment, the inlets were grated to prevent larger debris from entering the drainage system and being discharged to the river or county drain. Those communities that were in close proximity to the river, discharged directly to the river with no concerns for water quality, as that was not a concern when these areas developed their urban footprint. The river served as a means to convey the storm water away from the municipality. The portions of the communities that developed in the late 1980s/early 1990s to present times displayed additional best management practices being utilized. The BMPs were providing a site plan review process for development for planned community growth. By implementing a storm water component in this site plan review process the following practices would become part of the review procedures:

- Establishing an allowable discharge rate for the site with outlet structures or restrictors in place.
- Establishing standard design criteria and a minimum design storm standard, e.g. 10yr (10% recurrence interval), 25yr (4% recurrence interval), 50yr (2% recurrence interval) or the 100yr (1% recurrence interval) design storms.
- Providing a standard method for determining detention/retention volumes to be stored on sites.
- Design standards for type of pipe, slopes and pipe sizing to assure conveyance of design storms.

These BMPs were primarily to assure drainage of new developments and to prevent flood or drainage problems as development occurred in the community. Some additional benefits to this type of planning occurred as the National Flood Insurance Program (NFIP) was implemented; communities could use their storm water planning to obtain discounts on flood insurance rates for their residents.

The newer construction from 2000 to the present demonstrates the use of more BMPs at sites. These site developments are on the approaches to the urban areas in the “outskirts” of the municipalities and tend to have grassed swales, more restrictive outlet structures for longer holding times, and the inlet grates that have “Dump No Waste”, “Drains to River” in the casting as a permanent feature. Additionally, these newer sites tend to use more grading and additional catchbasins with sumps to capture and route storm water from the site to the collecting MS4. Some sites tend to use grading of parking lots that discharge to vegetated swales before entering the detention areas. The majority of these newer developments have completed a review process either from a municipal engineer, Tuscola County Drain Commissioner’s office or the MDOT. There are some infiltrative practices in place but only two rain gardens were known to exist, one in Bridgeport and the other in Caro. See community maps in appendix D.

During this windshield survey for storm water BMPs, the detention basins were visible at the larger sites; some sites utilized parking lot detention if space for storage volume was at a premium. There were some sites that implemented underground storage, although these were in a community with high property values and an established storm water management ordinance in place for over 20 years. Underground storage is a good option when space is at a premium. The cost can be considerable and the developer needs to determine the economics of the site application. For example, the typical “open” detention basin has a cost of approximately \$2.00 / cubic foot of storage volume; where as the underground system can range from \$7.00 to \$12.00 / cubic foot of storage.

4.5 Recommended BMPs for Storm Water Management

Communities go through great effort to manage their water and sanitary systems to assure they are developed in a manner consistent with future growth. However, stormwater is a forgotten utility, in many communities it is not planned adequately and is usually treated as an after-thought in site development. Many communities are now paying the price of having severely undersized stormwater conveyance systems or systems with mismatched pipe diameters or capacity issues. Engineers have experienced situations where a new development is discharging from a site with a 12 inch outlet into an 8 inch storm drain in the public street. Suddenly, there is flooding where none was present in the past.

The City of Frankenmuth addressed these issues in the 1990s and mapped the entire storm sewer system and determined the flow capacities of the existing system and their outlets to the Cass River. This planning effort has provided a detailed map of the community so when development occurs they know how much the development can safely discharge into the existing MS4 and how much stormwater must be detained on site and released slowly to prevent flooding. Many other communities are taking this approach as development has exceeded the capacity of existing MS4s.

a. Managerial BMPs

Municipalities and their planning commissions need to adapt storm water management guidelines for their community. There are many examples of basic managerial plans available, and an example of a storm water management plan and design guidelines is available in appendix D. Some local governments feel these guidelines hinder development. However, many communities have learned the hard way that unsupervised / unplanned development can quickly assure the utility infrastructure of a community is overwhelmed and inadequate for future growth.

In the watershed it is important for communities to develop a strategic growth/redevelopment plan for the older urban areas of a community. This provides opportunities to develop and implement storm water quality best management practices as redevelopment occurs in the downtown areas. This type of planning can help to wisely redevelop the business areas of small communities and address drainage problems that are present.

It is important that the communities have an active planning commission or a trained planning consultant who is familiar with watershed planning and how a community can impact a watershed. Additionally, the planning commissions or planning consultant must understand the economic and resource value of the watershed. They must become informed in order to establish a position of less urban area impact on the Cass River or the tributary system discharging into the Cass River.

Urbanized areas in the watershed should determine an allowable discharge rate for new development. This can be accomplished in a number of ways, but it is important to have an easily understood system to implement. It can be as simple as stating that no site shall discharge more than 0.15 cfs / acre and must detain the rest on site to slowly be released. Or, use the MDEQ recommended pre-development hydrology rates for the site as the release rate.

b. Recommended Managerial BMPs

Provide the municipal and township planning commissions with a short educational presentation on why storm water management is important to a community and the watershed.

Each Community should:

1. Plan and implement an Asset Management program for the storm water drainage system of the community. Funding is available for this under PA 511 of 2013 (see also HB 5673 of 2012). There is grant funds available for rural communities up to \$1million with a 10% match
2. Implement a storm water management design guideline or procedures.
3. Develop a site review process that considers storm water quality and quantity; make sure the review process considers the water quality concerns of the Cass River Watershed Management plan. Have the site development or re-development's storm water management plan reviewed by the municipal engineer.

4. Adopt storm water design standards and have them reviewed every 5 years for changes and adaptive management for the urban setting and watershed.
5. Determine the minimum BMP treatment train to improve storm water quality each new or redevelopment must have implemented on a site project to address:
 - a. Quantity of discharge
 - b. Quantity of storage
 - c. Quality of storm water discharge (e.g. 80% sediment removal rate)
6. Have the design standards available on the community's website.
7. Inspect sites after construction is completed.
8. Each site must have an approved stormwater system maintenance plan.
9. Keep records of all site plan reviews.

In the site review process, communities should try to keep the process dynamic and look at some of the new evolving storm water technology developing across the United States. Or, research some of the innovative techniques being used in European urban areas. In Germany, it is typical to have zero discharge criteria for all parcels in a city. In other words the site cannot let stormwater leave its boundaries - it must collect and use the stormwater, not discharge it.

c. Structural Best Management Practices

Basic Best Management Practices

If a community adopts the basic storm water design guidelines then a minimum level of storm water BMPs will be established. Sites will be graded, have catch basins with sumps to collect sediment, inlet grates will have "Dump No Waste", "Drains to River" as part of the forging process. The rate of discharge and quantity stored will become standardized. The community can then look at types of detention structures and treatment systems and catch basin inlet filter systems and determine what an acceptable level of treatment to obtain for storm water runoff quality.

d. Current BMPs in urban areas

There are basic BMPs in use in the watershed for storm water management. All of the communities use grading to direct and collect storm water. They have catch basins with sumps to collect sediment and vegetated swales were common. It appears that most development from the mid 1990s to present have begun to detain storm water runoff on sites. It also appears that most of the development that occurred since about 2000 has gone through a site review process that dealt with stormwater management.

e. Proposed BMPs

On Site Storm Water Collection methods

It is proposed that urban areas look at management of storm water and how it is collected on a site. Proper site grading is essential for collection, however, the grading needs to incorporate more utilization of vegetation to help cleanse the storm water as it is collected. For example, collecting the storm water in parking lot islands or at the end of parking lots can help with

water quality. These vegetated collection areas can then discharge cleaner storm water into a catch basin, with a sump, and then go to a vegetated detention area, or underground storage area for storm water to settle out any remaining sediment before discharge to surface waters.



Design of these types of systems is relatively simple and can be cost saving on a site as one strategy. Curb and gutter systems along streets are efficient collection systems, however they also move large quantities of debris, sediment and floatables that collect at the catch basin inlets, as shown below. Whereas, communities that use street side swales to collect stormwater generally do not have large quantities of debris at the catch basin inlets. The residents also spend time keeping these systems cleaner as they are associated with the residential lawn area. Many communities are now going back to residential areas with no curb and gutter. The catch basins are in the road right of way on either side of the road way.



Detention Basins or Underground storage

Each community should establish a design storm detention requirement for the community. If the community is in the floodplain of the Cass River, this best management practice will help

obtain a discount on flood insurance for those having to purchase insurance. The detention volume should be able to contain the first flush and Bankfull storm events along with the Design storm detention. The detention basins should be vegetated and can either be wet or dry basins. Wet basins can be a good BMP to help reduce phosphorus in a watershed, however, they can become unsightly and can harbor invasive plant species if they are not watched carefully. Wet basins may need additional water quality requirement BMPs such as aerators to keep them aesthetically pleasing for the community.

A “dry” basin can filter out sediment, reducing phosphorus, and be a “mowable” surface that prevents the establishment of invasive species such as phragmites which could discharge seeds into drains and the Cass River Watershed.

Underground storage systems can be used when space is at a premium on a site. These systems are typically under the parking area of a site. They are structurally sound and when installed per specifications they can withstand vehicular loading.



Infiltration BMPs

An option for some storm water systems to explore is for infiltration in some areas for groundwater recharge. There were a few systems in place in the watershed where this infiltration practice was occurring. These areas had gravel veins close to the surface where they could place underground storage or open basin storage and let the stormwater infiltrate and discharge through the groundwater system rather than discharge to the local MS4 and ultimately the river. This helps to attenuate the peak runoff events and prevents drains or the river from experiencing “flashiness” or sudden peak flows.

The communities should look at use of infiltration BMPs whenever possible to help the riverine system with groundwater recharge to maintain a healthy baseflow for the Cass River. Care must be taken when utilizing this practice to assure the stormwater runoff is as clean as possible before infiltration begins. We do not want to inadvertently introduce pollutants to the groundwater table. With underground systems this can be accomplished by use of a stilling

chamber or row to settle out soil particles before the stormwater moves into the chambers for infiltration.

Use of pavers as mentioned above also fit into this category of infiltration. There are numerous types of grass pavers also that can help with ancillary parking while saving green space and reducing heat signatures of urban areas.

Communities should offer incentives to developers that use low impact development techniques. For example, if your community wishes to detain the volume of the 100yr design storm in its standard design. If the developer will put in infiltration systems, bio swales, or rain gardens as part of the treatment train why not use the volume of the 25yr design storm as incentive.

Encourage businesses to run their roof water to a collection cistern to use as water for the landscape irrigation system. This will save the business paying for watering their lawns from municipal water systems. Encourage businesses with roofs close to each other to share in collecting this roof water for irrigation purposes.

Encourage the use of vegetative buffers paralleling waterways or corridors. Studies have shown that a minimum width of ten feet for a vegetative buffer strip can remove up to 70% of total suspended solids. Municipalities with river frontage should implement practices that allow for native plant buffer zones for at least a ten foot width along established county drains or natural watercourses to help with reduction of sediment and nutrient loading to the Cass River. (Kawkawlin Watershed Buffer Study, 2011)

Develop site planning options for shared parking to limit unnecessary impervious surfaces being developed. Determine if sites with historically large parking areas that are not used every day to the maximum extent can use alternative parking surfaces such as grass pavers, paving bricks and other innovative parking surfaces that allow stormwater to infiltrate the surface and not runoff the site. Pervious concrete and asphalt can store the peak runoff event and discharge over longer periods of time and have a long life expectancy.

Some argue that these pervious systems do not work in cold climates and that frost will heave the paving material, however, that is not true, these systems allow the water to pass through them and maintain a drier surface and subsurface than conventional systems. Arguments of pavers not working well for plowing should visit the Keweenaw Peninsula's Superior Block Company and see its entry drive shown below.



This driveway has been in service since the early 1990's and is traveled daily by fully loaded cement trucks and semi's delivering blocks to area construction sites. It is plowed routinely and is holding up very well.

f. Structural Best Management Practices

If a community adopts the basic storm water design guidelines then a minimum level of storm water BMPs and design practices will be established. Sites will be graded, have catch basins with sumps to collect sediment, inlet grates will have "Dump No Waste", "Drains to River" as part of the forging process. The rate of discharge and quantity stored will become standardized. The community can then look at types of detention structures and treatment systems and catch basin inlet filter systems and determine what an acceptable level of treatment to obtain for storm water runoff quality.

An option for some communities and storm water systems to explore is for infiltration in some areas to enhance groundwater recharge and baseflow opportunities for the Cass River. There were a few systems in place in the watershed where this infiltration practice was occurring. These areas had gravel veins close to the surface where they could place underground storage or open basin storage and let the stormwater infiltrate and discharge through the groundwater system rather than discharge to the local MS4 and ultimately the river. The communities should look at use of infiltration BMPs whenever possible to help the riverine system with groundwater recharge to maintain a healthy baseflow for the Cass River. Care must be taken when utilizing this practice to assure the stormwater runoff is as clean as possible before infiltration begins. We do not want to inadvertently introduce pollutants to the groundwater table. Therefore BMPs should be in place for vegetated buffers, waterways and swales. Certain sites such as refueling stations, automotive repair shops, large parking lots should consider the use of catch basin inserts to absorb petrochemicals and hydro-carbons to keep them out of the final detention and recharge areas.

The drainage collection system should have minimum structural BMPs in place such as:

- Stormwater Maintenance plans for each site to assure proper cleaning and care of the system.

- Sumps in all catch basins to decrease sediment loads
- Use of vegetated swales and detention basins to decrease sediment load whenever possible
- Use of absorbent “pillows” in catchbasins to collect and prevent spilled hydrocarbons and other petroleum products from reaching the riverine system.

Incentive Programs for BMP implementation

Communities should offer incentives to developers that use low impact development techniques. For example, if your community wishes to detain the volume of the 100yr design storm in its standard design. If the developer will put in infiltration systems, bio swales, or rain gardens as part of the treatment train why not use the volume of the 25yr design storm as incentive.

Encourage businesses to run their roof water to a collection cistern to use as water for the landscape irrigation system. This will save the business paying for watering their lawns from municipal water systems. Encourage businesses with roofs close to each other to share in collecting this roof water for irrigation purposes.

Encourage vegetative buffers along waterways. Studies have shown that a minimum width of ten feet for a vegetative buffer strip can remove up to 70% of total suspended solids. Municipalities with river frontage should implement practices that allow for native plant buffer zones for at least a ten foot width along established county drains or natural watercourses to help with reduction of sediment and nutrient loading to the Cass River.

4.6 Education Outreach Strategy for Urbanized Areas

Planning Consultants:

There needs to be an Information/Outreach strategy developed for the urban areas within the Cass River Watershed. This strategy should be directed to the planning commissions of each of the urbanized areas and townships within the watershed. The strategy should focus on providing information to each planning commission regarding the importance of the watershed to their respective community. A strategy needs to be developed to provide “Care for the Cass”. The MSU Extension has been working in the Greater Saginaw Bay Watershed and should be involved in implementation with of planning initiatives. The focus should begin with education of consulting firms that provide planning services in the Cass River watershed. As community / county master and recreation plans are being developed or revised the consultants need to understand they must provide focus on the watershed in these plans. When master plans are developed there is usually some grant funded projects that will design an implement new downtown streetscapes. It is during this type of development that watershed principles need to be enforced. Information must be provided to the urban areas and townships that focus on the following points:

1. How to re-develop urbanized mid-town areas that do not have best management practices in place for clean stormwater runoff.
2. Re-use of “brownfield” areas in a community.
3. Use of smart or low impact design techniques.

In this component the planners of a community must be informed to make decisions that have a stormwater strategy that considers what impact the development will have on the Cass River and how that impact can be minimized through careful, responsible planning.

Once the consultants have been provided with information on what should be considered in development of community Master and Recreation Plans it would be best to determine if a formal review and comment process could be developed where an outside agency would review drafts of master and recreation plans and provide comment on how these plans would help improve the watershed. A plan review strategy by a select group would provide focus for the watershed and ensure that the goals established in the watershed management plan would be part of a long term strategy in the watershed.

Community Planning Commissions:

Information/Education sessions need to be developed for community planning commissions to inform them of the impacts of development on the watershed. Some of the urban areas already have stormwater management planning in place, but the impacts of stormwater on the Cass River need to be emphasized. Two information sessions should be developed for community planning commissions. The first one hour session would provide a strategy to educate and inform the community planners to show:

- How development strategies are not a hindrance to development in their community
- How lack of planning can disrupt the watershed
- How planning can bring money into downtown/urban centers and decrease impervious areas
- How proper planning can bring about strategies for shared impervious parking or development of “green” parking ideas of 30% asphalt and 70% grass pavers.

A second session would provide a one hour (or shorter) presentation for community planning commissions describing how to implement review procedures for:

- New site developments in the community
- Site re-development in the community
- Stormwater management planning for site development & redevelopment
- Stormwater system maintenance planning

Finally, in this session include information on how this planning for stormwater will have implications for communities participating in the National Flood Insurance Program by providing additional discounts on flood insurance for residents required to have this insurance. This type of planning is recognized in the Community Rating System to obtain discounts on flood insurance.

4.7 Estimated pollutant reductions from proposed actions

Decreased impervious areas

With the implementation of community planning for storm water impacts from development there will be an opportunity to begin limiting the impervious foot print of the urban commercial

areas and other site developments. The planning for more opportunities for shared parking or use of pervious parking areas would be beneficial to the watershed and should be looked at during site review process. In other words the communities should look at methods to decrease the impervious footprint of the community to decrease storm water runoff to the Cass River or its tributary drainage system.

Some of the urban areas have a potential to increase their detention volumes substantially. Cass City has the largest potential in being able to implement a regional detention area for its industrial area before discharge to the Cass River. There is a large man-made water feature that was a former gravel quarry that would make a good regional detention area for the residential and industrial area in the southern portion of the community. There are opportunities coming in 2013 and 2014 for storm water asset management and planning and implementation of those plans through PA 511 of 2013. This would provide an excellent area to store clean runoff. Care would need to be taken to assure the industrial areas utilize BMPs to clean their storm water discharge to prevent a management problem for the large regional detention area. The increased hydrology for this man-made lake would help during dry weather conditions to improve the water levels.

Other communities should look at ways to increase their storm water detention availability through new and re-development opportunities. Specifically looking at storing first flush volumes and detaining larger storm events than the 10 yr design storms (10% recurrence interval) . Communities such as Frankenmuth and Caro have more aggressive storm water management programs, with Frankenmuth the most aggressive of all. Other communities such as Bridgeport need to be more aggressive in the site planning aspect. However, in defense of these communities there has been little to no development in these communities for quite some time and may not be in the future as Michigan is still loosing population and de-urbanizing.

With increasing detention volumes and the capturing of the first flush events there is also an opportunity to capture and decrease the amount of urban pollutants making their way to the Cass River. The settling of sediment from storm water runoff will help decrease pollutant loading in the river and tributaries. All urban areas should make an effort to implement the first flush BMP on any new and re-development and look for opportunities to retrofit existing systems for this BMP.

Decreasing allowable discharge rates to the River or stormwater conveyance systems
Communities along the Cass River should look at the example set by the City of Frankenmuth in decreasing the allowable discharge rates to the Cass River. Frankenmuth did a study to determine the capacity of its existing stormwater system throughout the city and set allowable discharge rates by drainage districts. This forward thinking planning results in less flooding and prevents development from discharging more storm water from their site than the conveyance system can handle. This ultimately decreases the uncontrolled discharge from an urban area to the Cass.

Again PA 511 of 2013 provides an opportunity for funding a asset management plan with an accompanying hydraulic model of the communities storm water conveyance system. This watershed management plan already has limited hydraulic models in EPA-SWMM (storm water management modeling) for Bridgeport, Frankenmuth, Vassar, Caro, Cass City, Millington, and Mayville. These programs are limited to the information readily available and have basic assumptions made to obtain urban runoff volumes. They are a start and could be used for part of the 10% match, potentially.

Again, the best that can be done for the watershed in general is storm water management planning by the urban areas to lessen their impact on the environment. The communities of the watershed do not have a significant impact, but they have an impact nonetheless. It is time to begin thinking of mitigating the urban impact with the development and implementation of this plan. This type of planning relative to decreasing allowable discharge rates can have benefits to the communities by lowering the risk of localized flooding within the community and by the opportunity to lower the National Flood Insurance Programs premiums for the residents that are in the Cass River floodplain.

4.8 Sustainability Strategy

All plan implementation must have a strategy for sustainability to ensure long term success of the watershed management plan. Communities that are serious about protecting the water resources of this watershed should determine what practices need to become part of their zoning and ordinance procedures for their communities. Once any planning becomes part of the ordinance structure there can be long term benefits for the community and watershed.

It is recommended that every three years an outreach session needs to be developed for all planning commissions in the Cass River Watershed to review progress on the watershed planning goals with the communities in the watershed. Funds should be sought to develop these planning sessions so they will be free to community planning commissions or planning consultants in the watershed.

4.9 Measures of Success

The biggest measure of success for the watershed would be the adoption of a watershed wide effort to assure that stormwater design guidelines are adopted throughout the watershed. These should take into consideration the watershed goals and objectives and be reviewed at least every five (5) years for necessary revisions to adopt current practices or changing watershed goals. Other measures of success would be as follows:

1. The number of information/training sessions for planning commissions or planning consultants in the watershed.
2. The number of planning commission members attending these sessions.
3. The adoption of standard site review process that must address stormwater quality and the number of reviews performed per year.

4. Obtaining grant funding to address the urban central areas of communities in the watershed to adopt BMPs to address stormwater quality and quantity.
5. Adoption of shared parking and green parking BMPs.
6. Number of communities adopting the stormwater design guidelines as an administrative policy or ordinance.
7. Number of community public works personnel attending training related to how urban practices affect stormwater quality.
8. Increase of impervious area in the downtown areas of a community over time.
9. Measurable decrease in peak discharge rates over time.

Chapter 5: Natural Resources

The Cass River Watershed is home to several different species of plants, animals, birds, reptiles and amphibians (threatened and endangered species are listed in the Appendix) along with vast natural resources. This watershed encompasses a total of 53,761 acres of recreational land. This recreational land includes wildlife areas and sportsman clubs as well as part of the Shiawassee National Wildlife Refuge and nine state game areas (RC&D pg. 7). The Shiawassee National Wildlife Refuge is historically one of the largest and most productive wetland ecosystems in Michigan (Shiawassee). This National Wildlife Refuge accounts for 4,094 acres of the recreational land in the Cass River Watershed. Another 31,569 acres of the recreational land in the Cass River Watershed can be attributed to the nine state game areas that are home to this watershed. In total, the recreational land in the Cass River Watershed is an important natural resource (RC&D pg. 7).

5.1 Open Space & Recreational Areas

Map 5.1 shows the recreational lands in the Cass River Watershed. The large red sections show wildlife areas, while the large green section on the west side of the map shows the Shiawassee National Wildlife Refuge. The Conservation and Recreation Lands (CARL) dataset was created by Ducks Unlimited and is updated on an annual basis. Data was also collected from the State of Michigan on planned expansion areas for State Game Areas, these are shown in brown on the map, the most notable expansion plans are for Sanilac, Cass City, and Minden State Game Areas in the north-east region of the watershed. The majority of protected natural lands are in the Middle Sub-basin implying that water quality may be of higher quality in these subwatersheds. This map served as a basis for planning the strategy for long-term protection of natural lands and the integrity of water quality.

5.2 Temperature & Flow Characteristics

The Cass River Watershed is divided into five different flow/temperature characteristic types based on valley segment data created by the Michigan Department of Natural Resources (MDNR) Fisheries Division (Seelbach, Wiley, Kotanchik, and Baker 1997).

1. **Small Warm** (SW) – low volume warmwater headwater streams with insignificant groundwater influence draining a basin less than 40 mi² (40% of Cass River system)
2. **Small Cool** (SC) – small headwater streams with moderate groundwater influence draining a basin less than 40 mi² (18% of Cass River system)
3. **Medium Warm** (MW) – medium sized warmwater streams. Summer flows may be reduced significantly as source flows are of relatively low yield. Drainage area is 41 mi² – 179 mi². (24% of Cass River system)
4. **Large Warm** (LW) – includes larger tributaries and/or portions of the mainstem of a river system. Drainage areas are 180 mi² – 620 mi² and contain large fish species. (5% of Cass River System)
5. **Very Large Warm** (VLW) – Drainage areas are greater than 602 mi² and are likely to be unwadeable. (3% of Cass River System) (Cooper, 2006)

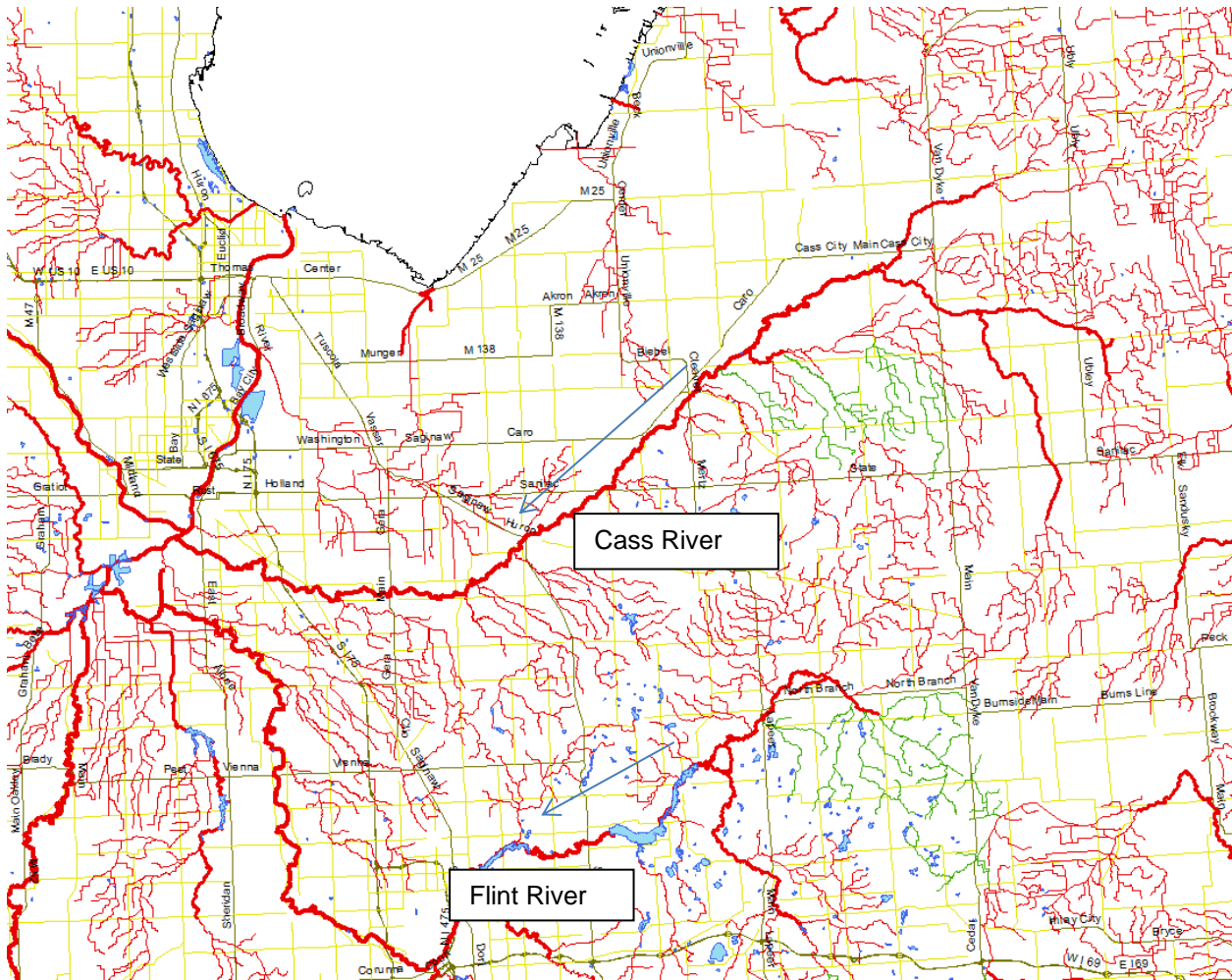
Per discussion with J. Leonardi on Sep 7, 2011 the majority (95%) of the watershed is considered warm water. The groundwater fed portions of the watershed, typically in the cooler headwater reaches, are significant for the fishery in that they provide temperature stabilization. Three sites were sampled in 2011 by the DNR who are interested in looking at wetland restoration sites for temperature control. Map 5.2 shows the temperature classification of streams in the Cass River Watershed.

Michigan DNR Fisheries Division staff Joe Leonardi is the fish biologist for the Cass River Watershed, his comments are below regarding Map 5.2.

“Cass River is almost entirely classified for warm water thermal habitat. The light green shows portions of the Flint River watershed which has some ground water inflow cooling the streams making them “cool or warm transitional” thermal habitat. Protecting the river corridor with shade producing vegetation is of benefit as it keeps summer temperatures lower and non-lethal for fish. However, the fish community will still be typified by warm water thermal conditions. Protecting the headwaters is of benefit as they typically reflect our more pristine waters which benefits everything downstream.”

- Joe Leonardi

Map 5.2: Temperature Regime of Cass River and its tributaries



Map 5.2 Legend

Mid summer temperatures (July)

Blue = cold water < 60F

Dark Green = cold transitional 63-67F

Light Green = cool or warm transitional 67-70F

Red = warm > 70F

5.3 Existing Regional Plans

Three recent reports that involved the natural resources in the Cass River Watershed are the 2000 “Saginaw Bay Watershed Wildlife Habitat Conservation Framework.” This report about the Saginaw Bay Watershed classifies the Cass River as an important corridor for wildlife travel. It recommends that it be considered for designation under the Michigan Natural Rivers program –from Vassar upstream for protection of the watershed – and expanding the seven state game areas that exist in the watershed to safeguard the corridor (RC&D pg. 18-19).

The second report, “A Vision of Green Report”, 2005, determines the Cass River and its’ watershed as a key part of the Saginaw Bay watershed. The Rapid Watershed Assessment done in 2006 explains exactly what the “A Vision of Green Report,” entails:

“The Saginaw Bay Greenways Collaborative (the Collaborative) formed in 1999 to develop the Saginaw Bay Greenways plan “to connect communities to the area’s natural and cultural amenities for the benefits of recreation, transportation, education, health and well-being of its citizens.” The Collaborative’s report, “A Vision of Green”, summarized the green infrastructure plan for the tri-county (Midland/Bay/Saginaw) area and outlined suggested implementation steps. The plan put forth capitalizes on the large tracts of land already protected in the area. The Shiawassee National Wildlife Refuge and the adjoining Shiawassee River State Game Area form a major hub for the region. Most of the green infrastructure corridors identified by the Saginaw Bay Greenways Plan follow the network of rivers that flows into the bay. The Cass River system is one of the key rivers identified in the plan,” (RC&D pg. 18-19).

The Lower Cass River Natural Lands Inventory was completed for the Cass River Greenway committee in 2011 and identifies and prioritizes natural lands for protection in 6 townships along the lower Cass River from Bridgeport to Indian Fields. The study categorizes over 60,000 acres of land as high, medium, or low priority for protection. The full report can be viewed online at www.cassriver.org/publications.

5.4 Priority Lands Inventory

Watershed-wide Natural Lands Inventory

As part of the watershed planning process, natural areas were delineated for the entire Cass River Watershed from an existing land use/land cover dataset developed in 2006 by the National Oceanic Atmospheric Administration’s (NOAA) Coastal Change Analysis Program (C-CAP).

Natural land classes were selected out of the dataset using GIS technology within the Cass River Watershed and within 1-mile of the watershed boundary to allow for inclusion of natural areas that crossed the watershed divide. Road corridors were then extracted from the natural area blocks resulting in a number of discrete natural land classes within the Cass River Watershed. Only natural areas 10 acres or larger were considered for this study. A total of 3,269 unique

natural areas were defined totaling 143,372 acres. Natural areas account for nearly 25% of the Cass River Watershed according to this analysis.

The size of natural areas or Potential Conservation Areas (PCAs) in acres ranged from 10 acres to 3,032 acres. The largest PCAs coincide with State Game Areas located within the watershed including Minden City, Deford, Tuscola, Vassar, Cass City, Sanilac, and Murphy Lake State Game Areas. The Shiawassee National Wildlife Refuge is also partly located within the watershed. Existing protected areas account for 27% of PCA's identified in the watershed.

PCAs were ranked based on scoring criteria developed by MNFI, a final rank was calculated by summarizing the scores for the ten criteria for each natural area and using natural jenks breaks in the distribution of total scores, grouped into five clusters that served as an ecological ranking. The ranking scheme produced a total of 48 possible points. Actual scores varied from 8 – 33 points.

Table 5.1: Scoring Breaks for Prioritization Criteria in the Cass River Watershed

Criteria	Detail	Score
Total Size	20 - 40 ac	1
(Acres)	>40 - 80 ac	2
	>80 - 240 ac	3
	>240 ac	4
Core Area	0 - 60 ac	0
Total area minus 300 ft. buffer from edge of polygon	>60 - 120 ac	2
	>120 - 230 ac	4
	>230 ac	8
Stream Corridor	0	0
Length of stream or river within the polygon	>0 - 400 m	1
	>400 - 800 m	2
	>800 - 1600 m	3
	>1600 - 3200 m	4
	> 3200 m	6
Landscape Connectivity:	0 - 11%	0
Percentage	>11 - 22%	2
% of habitat areas within a 1/4 mile buffer	>22 - 33%	3
	>33%	4
Landscape Connectivity: Proximity	0	0
	1	1
Number of habitat areas within 100 ft.	2	2
	3	3
	4+	4

Table 5.1 cont'd		
Criteria	Detail	Score
Biorarity Score (5 Jenks)	0 - 0.1296	0
Average value of quarter quarter section MNFI ecological value score that intersect with habitat	0.1297 - 0.5147	1
	0.5148 - 0.8750	2
	0.8751 - 1.750	3
	1.7501 - 3.25	4
Vegetation Quality: Total Acres of Unchanged Vegetation	0 - 10 ac	0
	10.1 - 40 ac	1
Percentage of potentially unchanged vegetation, circa 1800 veg / 2000 IFMAP	40.1 - 80 ac	2
	80.1 - 160 ac	3
	> 160 ac	4
Vegetation Quality: Percentage Unchanged Vegetation	1 - 10%	0
Acreage: potentially unchanged vegetation within polygon circa 1800 veg/2000 IFMAP	10.1 - 30%	1
	30.1 - 65%	2
	65.1 - 100%	4
Restorability of Surrounding Lands	0 - 35%	1
	>35 - 65%	2
% agriculture/old fields	> 65 %	3
Conservation and Recreation Lands	0.0 - 0.8%	0
	0.8 - 15.3	1
Percentage of protected lands within a habitat patch	15.4 - 22.9	5
	30.0 - 49.4	7
	49.5 - 100.0	1

Table 5.2: Quick comparison of the two priority lands inventories

Criteria	Corridor Study in 2010-2011	Watershed Study in 2011
Scale	6 townships along mainstem of Cass River corridor	Entire watershed
Minimum mapping unit	10 acres	10 acres
Total number of PCAs	511	3,269
Total number of acres	60,089	143,372
Base Dataset	Created from 2009 aerial photography	2006 NOAA C-CAP Land Use / Land Cover
Number of Criteria	Ten	Ten
Range of Total Scores	1 -33	4 -33

Natural and undeveloped lands within the watershed were identified from an existing land use / land cover dataset developed in 2006 by the National Oceanic Atmospheric Administration’s (NOAA) Coastal Change Analysis Program (C-CAP). These natural lands were then prioritized for permanent private land-protection based on the ecosystem services they provide such as clean air, clean water, and habitat. A computer model developed by the Nature Conservancy, Habitat Priority Planner, was used to develop a scoring criteria to prioritize these area. Figure 3.x shows where these existing natural areas are still in tact in the watershed. This analysis was one of many tools that stakeholders used during the Natural Resources Forum to identify a long term conservation strategy for the watershed. A full description of the individual criteria used in ranking the natural areas is presented in the Appendix while specific recommendations for protection of these areas are presented in *Chapter 5, Section 5.2 Cass River Corridor and Preservation Areas*.

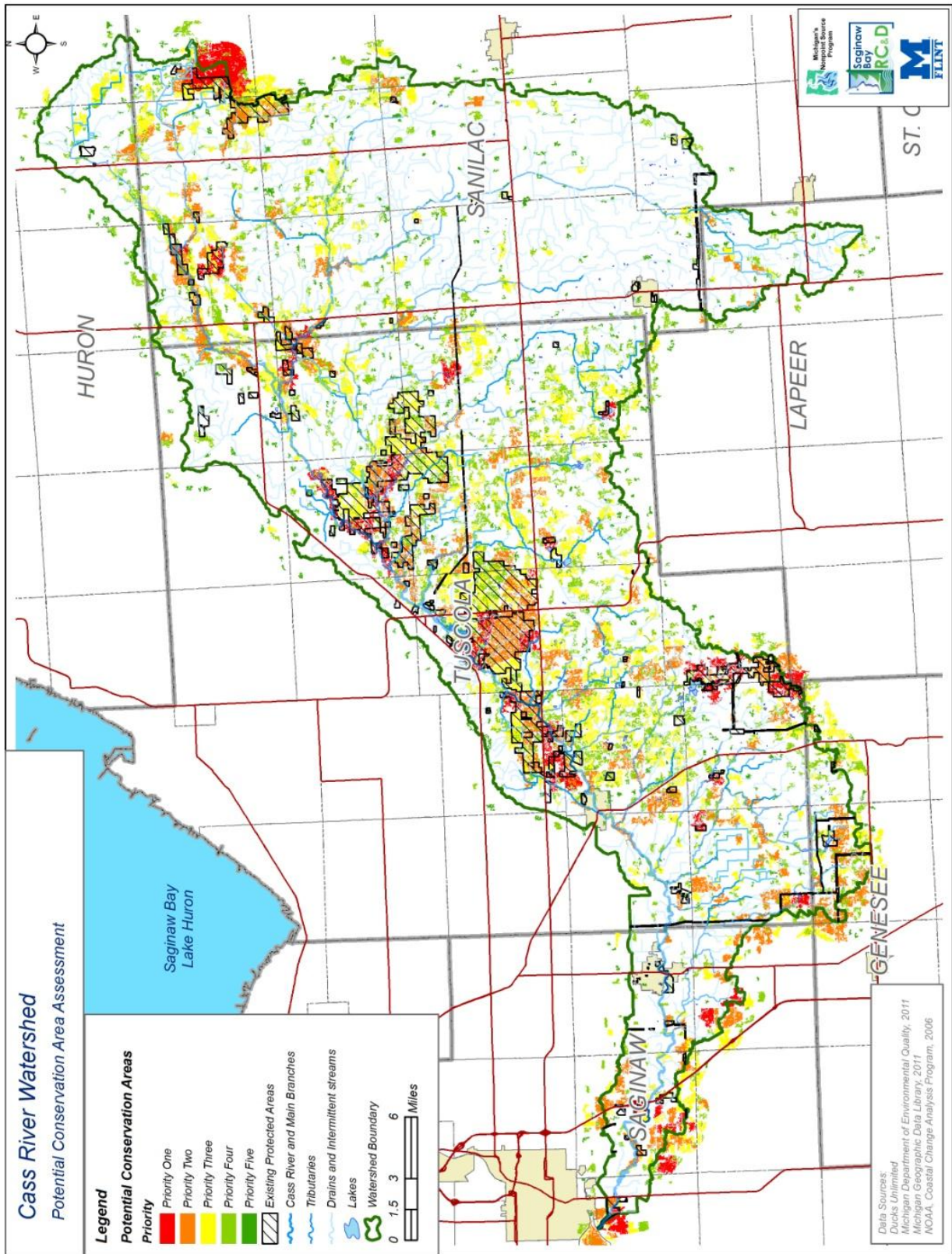
The map below shows priority areas for protection in the Cass River watershed. Priority One (red) areas are those that are the largest in total area and have the highest probability of supporting biodiversity, habitat, and functions that create clean air and water. It is important to note that many of these areas are already protected, primarily via Michigan State Game Areas. Priority Two (orange) areas are those with medium potential to support services mentioned above. Priority Three (yellow) areas are those with low potential to support biodiversity and habitat functions but contribute to ecosystem services.

Table 5.3: Score Distributions for Rankings of Potential Conservation Areas in the Cass River Watershed

Priority	Points	Number of PCAs	Number of Acres
One - High	33 - 23	38	14,810
Two - Medium	22 - 17	255	36,569
Three - Low	16 - 13	691	43,751
Four	12 - 9	1799	39,787
Five	8.0 - 4.0	486	8,453
48 Total Possible Points			

3,269 Total Habitat Patches

Figure 5.3: Potential Conservation Areas for the Cass River Watershed



5.5 Landscape Level Wetland Functional Assessment (Enhanced NWI), Michigan Department of Environmental Quality

The U.S. Fish and Wildlife Service (USFWS) has been conducting the National Wetlands Inventory (NWI) for over 25 years. In the 1990s, the NWI Program for the Northeast Region recognized the potential application of NWI data for watershed assessments, but realized that other attributes would have to be added to the data to facilitate functional analysis. A hydrogeomorphic (HGM) approach to wetland functional assessment provided a method for developing other attributes to expand the NWI database and make it more useful for functional assessment.

A set of HGM-type descriptors have been developed for the NWI to describe a wetland's landscape position, landform, water flow path, and water body type. Working with local and regional wetland experts, the USFWS developed correlations between these wetland descriptors and wetland functions. These correlations reflect the best approximation of what types of wetlands are likely to perform certain functions at significant levels based on the descriptors in the NWI database.

The Cass River watershed is approximately 900 square miles in size and is part of the larger Saginaw Bay watershed. The watershed is located in Huron, Lapeer, Genesee, Saginaw, Tuscola, and Sanilac counties in Michigan. These counties like many areas of Southern Michigan have experienced significant losses of historical wetlands due to extensive drainage and conversion to agriculture.

The Michigan Department of Environmental Quality completed a Landscape Level Wetland Functional Assessment (LLWFA) for the Cass River watershed. The LLWFA is a GIS based tool that can be used to identify and prioritize existing wetlands for protection or enhancement based on the ecological or water quality functions they provide. Similarly, the tool can be used to prioritize historic wetland areas for restoration based on the functions they would then provide.

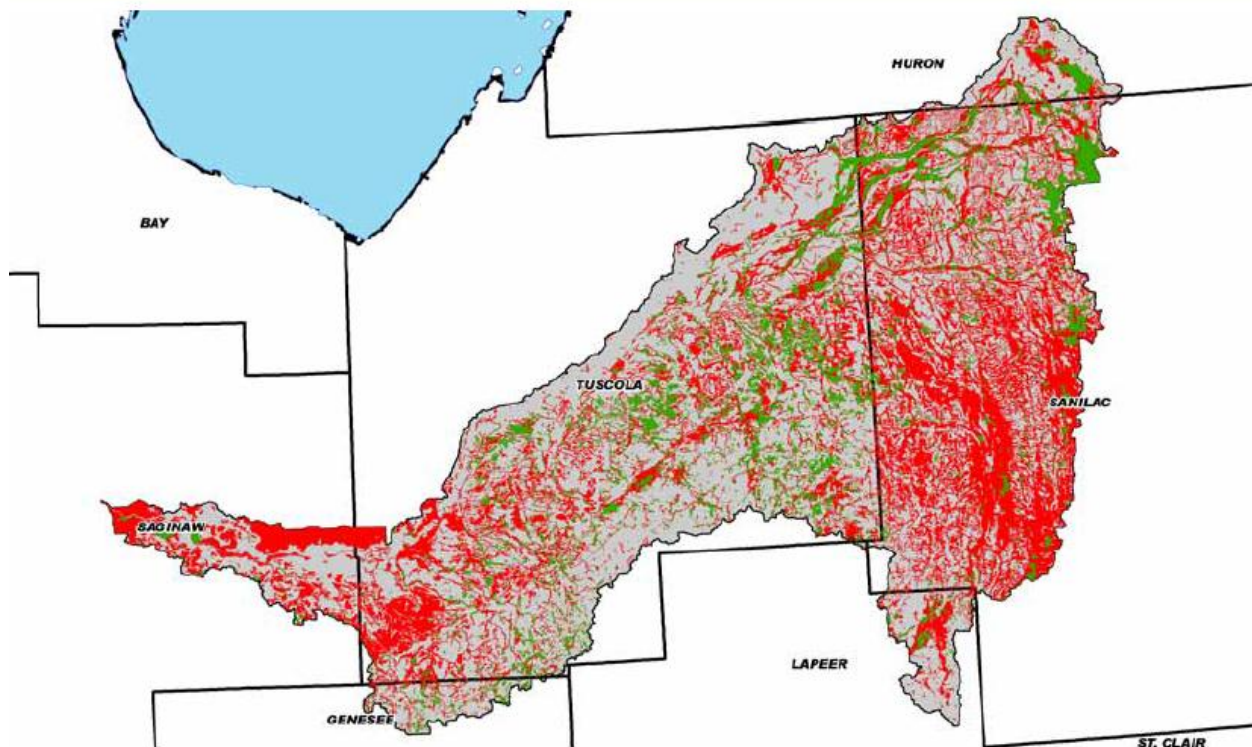
The LLWFA uses pre-European settlement data, a 2005 update of the original National Wetlands Inventory data, soils data and 2005 high resolution aerial photography to identify existing wetlands and areas with potential for wetland restoration (areas identified as pre-settlement wetland and/or hydric soils). The database associated with the mapping provides hydro-geomorphic information for each wetland area such as: landscape position, landform, water flow direction, and pond classification. This information is then interpreted to derive the specific wetland functions (i.e. flood water storage, fish habitat, nutrient transformation, ground water influence, etc.) of each wetland area. The status and trends of wetlands in the area are summarized in Table 5.4 and the current status of wetland areas is shown in Map 5.4.

Assessment completed by MDEQ for the Cass River watershed shows wetlands have decreased in the watershed by 75% or 170,000 acres from "pre-settlement" to 2005. When broken down by 10-digit HUC (hydrologic unit code) or sub-basin the lower watershed experienced 85%

wetlands loss, and the average size of a wetland decreased from 42 acres to 5.2 acres. The middle watershed experienced 62% wetlands loss with the average wetland size decreasing from 35 acres to 8 acres. The upper watershed experienced a 78% wetlands loss with the average wetland size decreasing from 36 acres to 13 acres.

Figure 5.4: Cass River Approximate Wetland Loss (DEQ)

APPROXIMATE WETLAND LOSS PRE-EUROPEAN SETTLEMENT TO 2005



Red areas show in the above map are pre-settlement wetlands that have been lost to farming and/or development and total 74% of the total wetland resource. Wetlands that are present as of 2005 are shown in green and comprise 25% of the original wetland acreage.

Table 5.4 Cass River Watershed: Wetland Resources Status and Trends

Pre-settlement conditions	Wetland	2005 conditions	Wetland
231,920 Acres of Wetlands		61,323 Acres of Wetlands	
Average Size – 33 acres		Average Size 8.8 acres	

Landscape Level Wetland Functional Assessment (LLWFA) Methodology Report

The goal of a Landscape Level Wetland Functional Assessment (LLWFA) is to add valuable information to the existing National Wetland Inventory (NWI) database. The LLWFA is used to differentiate 13 wetland functions. By doing so, it is possible to calculate the qualitative loss of wetland function. This approach was used to gather information in 2005 and to approximate wetland conditions in Michigan pre-European settlement. There are five tasks that must be completed when using the LLWFA: spatial data collection and integration, classification and enhancement of NWI data with LLWW descriptors, functional correlations and assessment, GIS tool development and status and trends report, and training and outreach. The first step involved collecting GIS spatial data for the watershed. This was done to complete some of the hydrogeomorphic (HGM) classification. The second step classified NWI polygons using the Landform, Landscape Position, Water Flow Path, and Waterbody Type (LLWW) descriptors. The third step was to relate the polygons, which are now hydrogeomorphic (LLWW) coded, to their respective functions as determined by the MDEQ. The fourth step involved taking the product of this assessment and presenting it. The final step is to have training and outreach about wetland functions and its value to the community.

The pre-European settlement wetland inventory was completed using “soil survey data from the U.S.D.A. Natural Resource Conservation Science (NRCS) and the Michigan Natural Features Inventory Pre-European Settlement vegetation maps derived from the General Land Office Survey (GLO) created between 1816 and 1856”. The 2005 enhanced National Wetland Inventory was completed using NWI mapping. After both inventories had been completed, wetland functions were assessed. These functions included: flood water storage, streamflow maintenance, nutrient transformation, sediment and other particulate retention, shoreline stabilization, fish habitat, stream shading, waterfowl and waterbird habitat, shore bird habitat, interior forest bird habitat, amphibian habitat, conservation of rare and imperiled wetlands and species, and ground water influence. The purpose of LLWFA is to approximate the size of wetland areas and its functions from pre-European settlement to present in order to restore and enhance those functional areas.

Results of Cass River Watershed: Landscape Level Wetland Functional Assessment

The Cass River Watershed LLWFA was conducted to compare wetland resources, status, and trends of pre-European settlement conditions to 2005 wetland conditions. Pre-European wetland conditions were approximated using soil survey data from the U.S.D.A. Natural Resource Conservation Service and Michigan Natural Features Inventory Pre-European Settlement vegetation maps. The latter maps were created using General Land Office Survey maps that were produced using maps dating from 1816 to 1856. The pre-European settlement wetland conditions were as follows: a total of 231,920 acres of wetlands, 7,041 polygons, and an average size of 33 acres. The wetland conditions of 2005 were as follows: a total of 61,323 acres of wetlands, 6,956 polygons, and an average size of 8.8 acres. Only 26 percent of the original wetland acreage remains, and there is a 74 percent loss of total wetland resource. There is a loss of 170,597 acres from pre-European settlement total acreage to 2005 total acreage. There were many types of wetland functions that were evaluated. The types of wetland functions that experienced the most loss were amphibian habitat (-91%), fish habitat (-84%), stream shading (-76%), shoreline stabilization (-75%), and streamflow maintenance (-74%). Statistics of wetland loss were calculated by subwatershed, the following tables compare pre-settlement wetland conditions with those of 2005.

Table 5.5 Upper Cass River Watershed, Wetland Resources Status and Trends

	Pre-Settlement Wetland Condition	2005 Wetland Condition	(Loss)
Total Acres of Wetland	111,376	24,742 (22%)	86,634 (78%)
Average Wetland Size	33 Acres	13 Acres	

Table 5.6 Middle Cass River Watershed, Wetland Resources Status and Trends

	Pre-Settlement Wetland Condition	2005 Wetland Condition	(Loss)
Total Acres of Wetland	74,421	29,031 (39%)	45,390 (61%)
Average Wetland Size	28 Acres	8 Acres	

Table 5.7 Lower Cass River Watershed, Wetland Resources Status and Trends

	Pre-Settlement Wetland Condition	2005 Wetland Condition	(Loss)
Total Acres of Wetland	46,123	7,575 (16%)	38,548 (84%)
Average Wetland Size	40 Acres	5.2 Acres	

Restoration efforts appear to be greatest in the upper Cass river watershed, where there is the highest percentage of potential wetland restoration areas identified as “high potential”, which are displayed in red in the following map series.

Potential wetland restoration areas that have a “high potential” for restoration are locations of pre-settlement wetlands and contain hydric soils. Map locations marked in yellow are those that contain hydric soils but are not known to be locations of pre-settlement wetlands and are thus classified as “medium potential” for wetland restoration. Wetlands that existed in 2005, and presumably still do, are marked as green in the map series.

The Potential Wetland Restoration Areas GIS layer was created by staff at the Michigan Department of Environmental Quality, Water Resources Division. The layer was created by merging NRCS hydric soils with Michigan Natural Features Inventory (MNFI) Presettlement Wetlands, then performing an erase command in ESRI Arc-INFO on the resulting layer to remove NWI, MIRIS Wetlands, Hydrography, and Urban polygons from the coverage area. The maps are not intended to be used to determine the specific locations and jurisdictional boundaries of wetland areas subject to regulation under Part 303, Wetlands Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended. Only an on-site evaluation performed by the MDEQ in accordance with Part 303 shall be used for jurisdictional determinations. A permit is required from the MDEQ to conduct certain activities in jurisdictional wetlands. An interactive tool for wetland and conservation professionals has also been developed for use in assessing potential restoration sites before initiating a field-visit.

Figure 5.5: Potential Wetland Restoration Areas - Upper Cass River

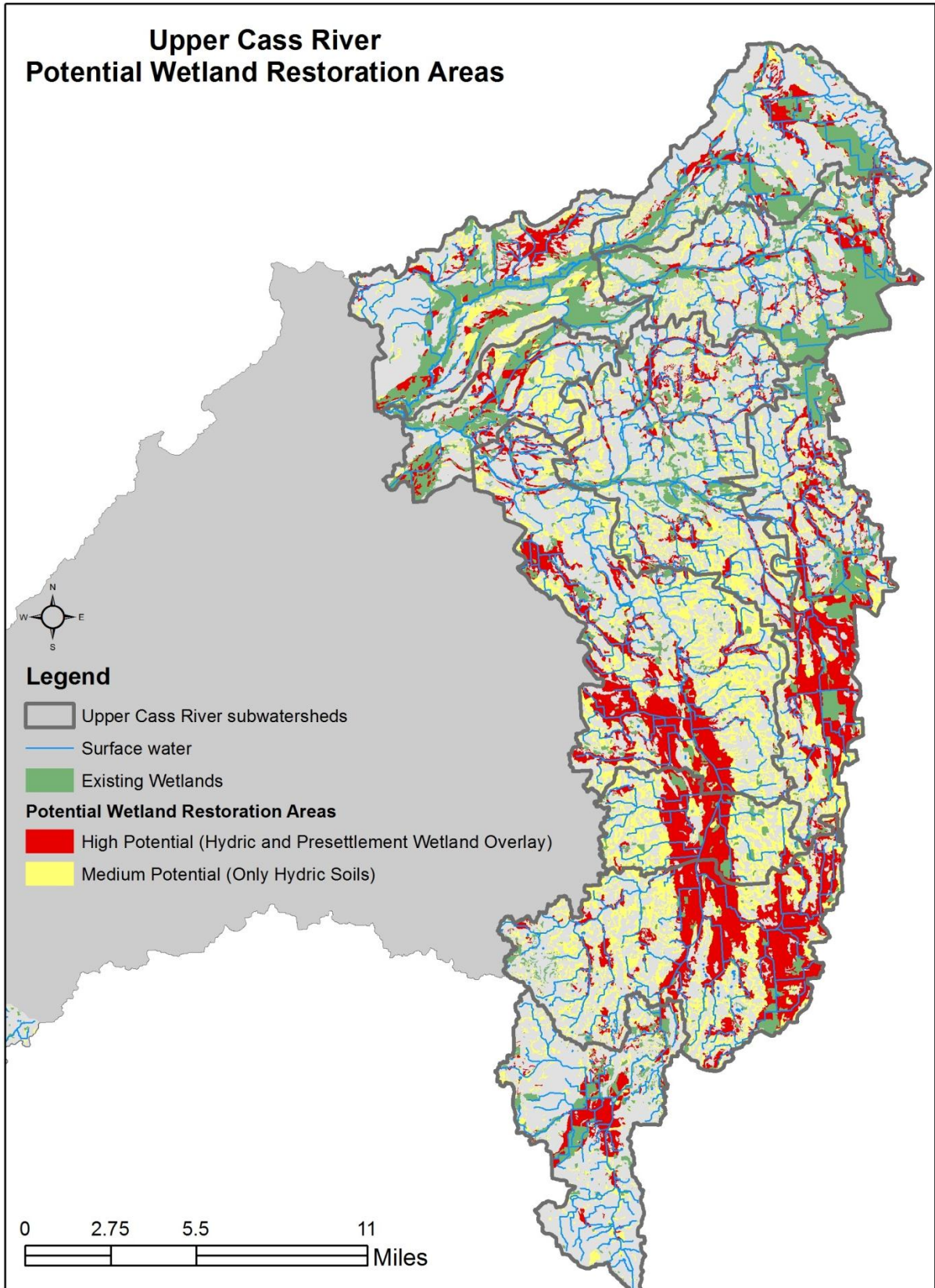


Figure 5.6: Potential Wetland Restoration Areas - Middle Cass River

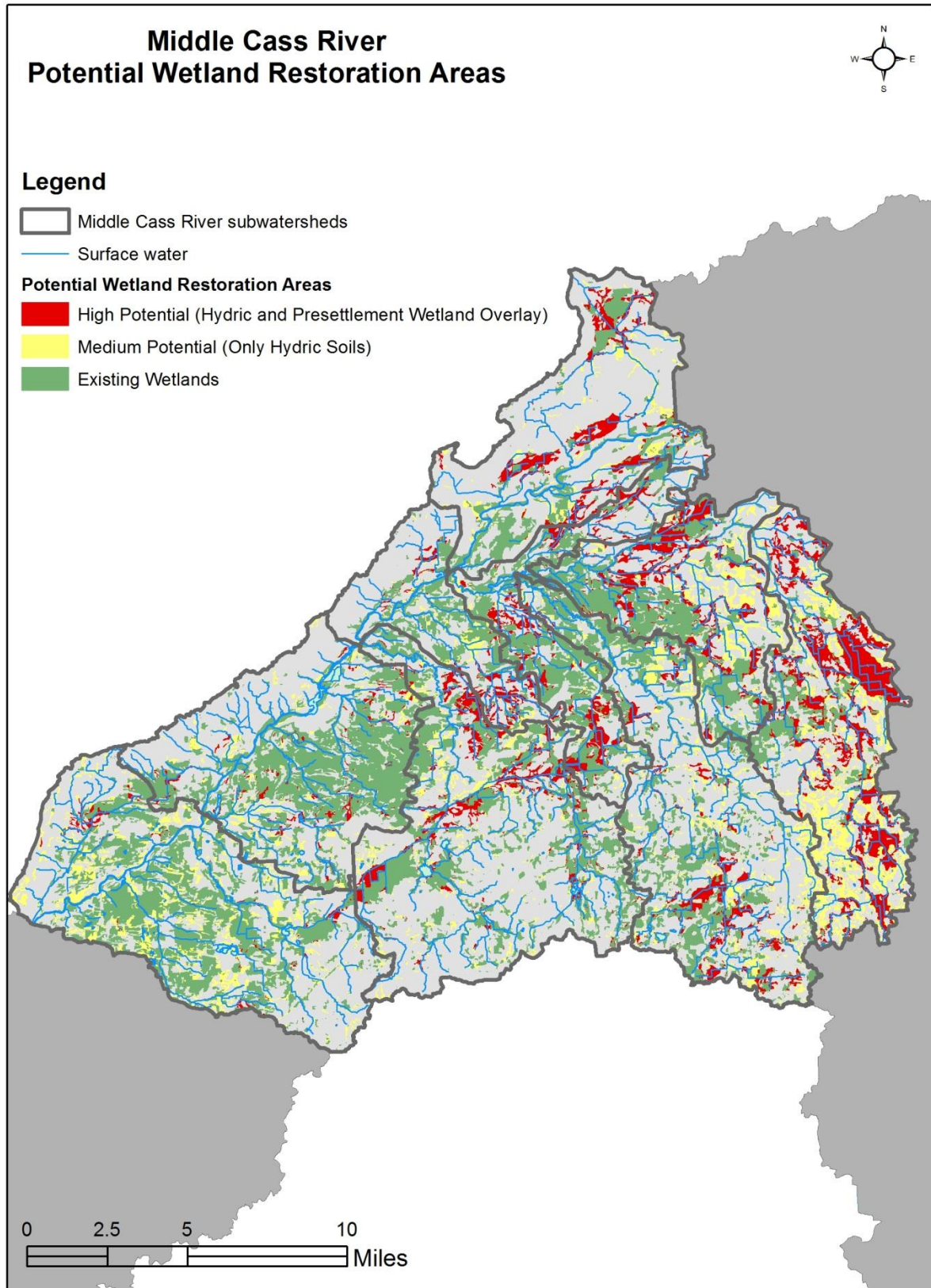
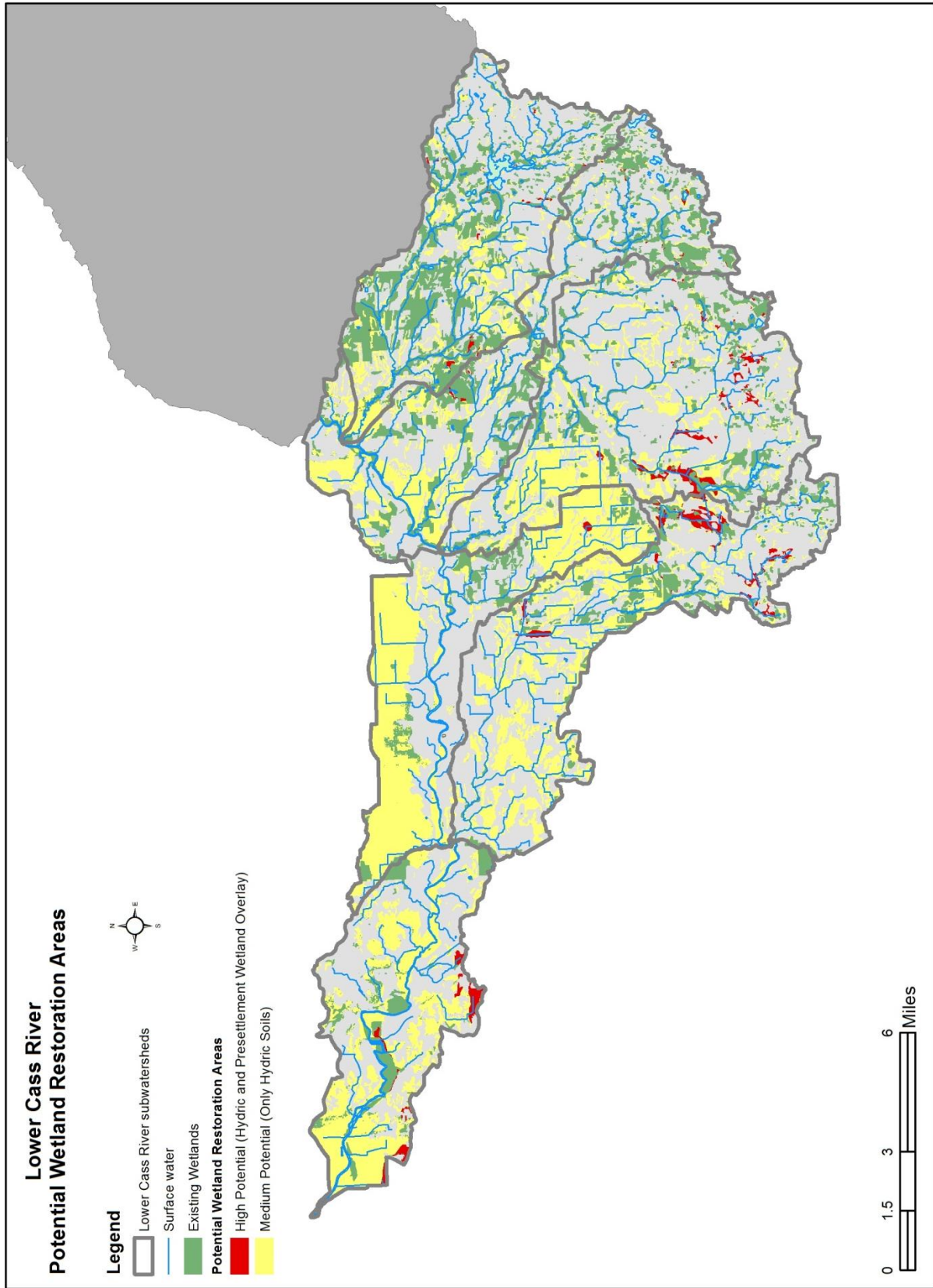


Figure 5.7: Potential Wetland Restoration Areas - Lower Cass River



Application of LLFWA

A total of twelve functions were assessed for each wetland:

Water Quality:

1. *Nutrient Transformation*
 - ability of the wetland to remove nutrients from the water column and convert them into plant material within the wetland.
2. *Sediment Retention*
 - ability of the wetland to retain the sediment that would otherwise move downstream and buildup in rivers, streams and lakes.
3. *Shoreline Stabilization*
 - ability of the wetland to protect the shoreline by minimizing bank erosion caused by wave actions and currents.

Hydrologic:

4. *Streamflow Maintenance*
 - ability of the wetland to provide a base flow of water for streams, especially critical during dry periods.
5. *Surface Water Detention*
 - ability of the wetland to store excess water during flood events.
6. *Stream Shading*
 - ability of the wetland to buffer water temperature fluctuations.

Habitat:

7. *Fish/Shellfish*
 - ability of the wetland to provide habitat for fish and shellfish.
8. *Waterfowl/Bird*
 - ability of the wetland to provide habitat for waterfowl, shorebirds and forest birds.
9. *Amphibians*
 - ability of the wetland to provide habitat for amphibians and other invertebrates.

The following steps should be followed when identifying sites to be included in funding proposals:

Define the local need and/or waterbody impairment

1. Locate all existing and potential wetlands with the Potential Wetland Restoration Areas Dataset
2. Using the LLWFA tool select only those wetland functions that address the local need and/or impairment (turn other functions off)
3. Run program and identify "High" functioning existing and potential sites first.

4. Overlay the “high” functioning sites with parcel data and determine ownership. Only move to “Medium” functioning sites if there are not any good candidate produced by the process so far.
5. Use the Prioritization tool to help select from the remaining candidate sites, ones that are of sufficient size and are connected water bodies.
6. Select the best candidate(s) for preservation and restoration to include in your proposal.

Due to the high ecological importance of wetland areas as well as the exceptionally high rate of wetland loss in the watershed all opportunities for restoration and protection of wetlands should be pursued as they arise regardless of their location in the watershed. However, the Cass River Watershed Group will selectively pursue the restoration and protection of wetlands using the following process:

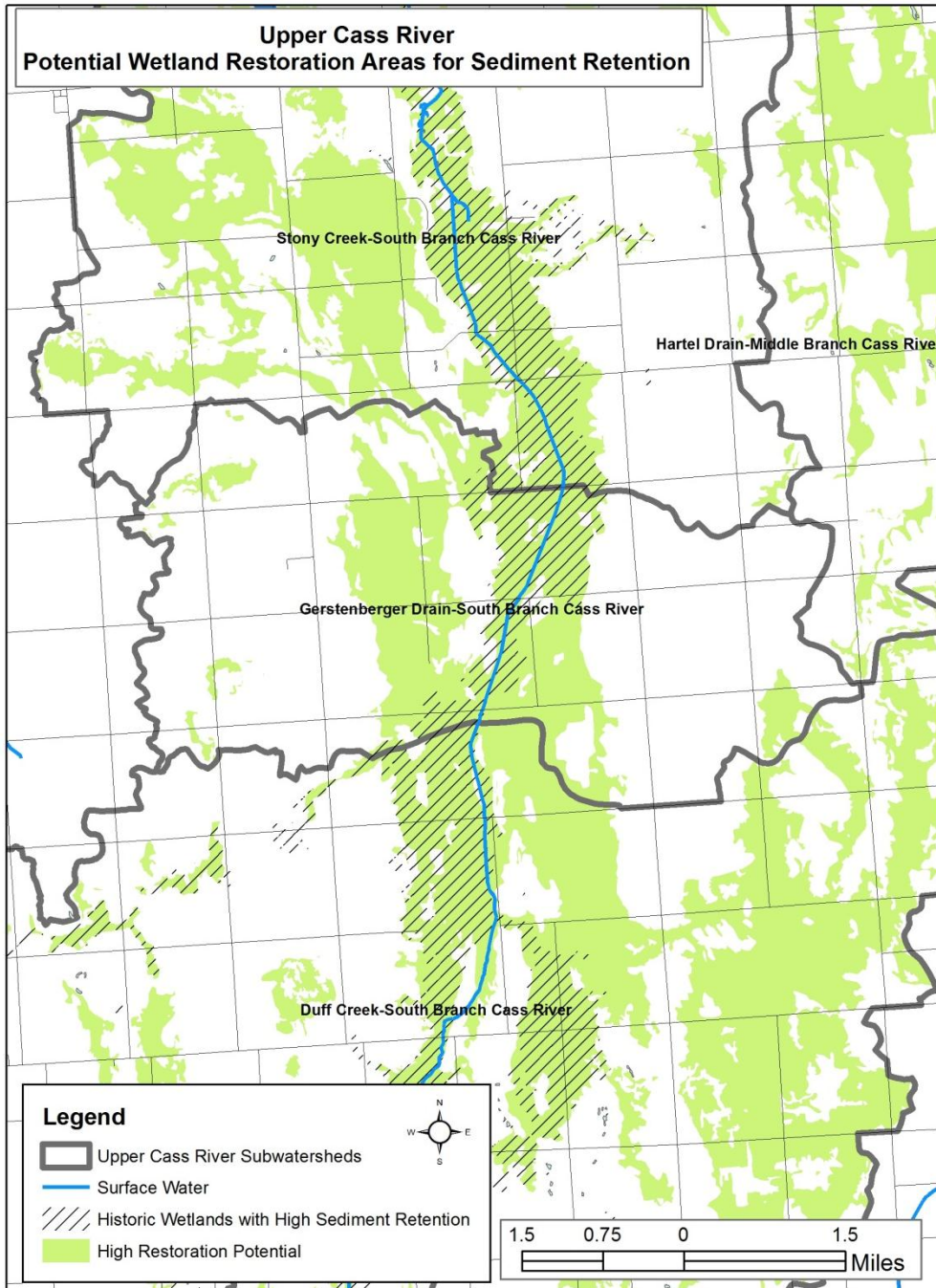
Critical areas and sites will be identified using the LLWFA and other criteria for each appropriate goal. An example might be:

For the Sediment Reduction Goals:

- In a subwatershed identified as having siltation and sedimentation impairments
- High performing for “Sediment Retention”
- Wetland area 20 acres or more in size

An example of this process is demonstrated for the Upper Cass River in northern Lapeer county and southern Sanilac county in Map 5.8 showing locations where the greatest potential lies for the restoration of wetlands for the function of sediment retention.

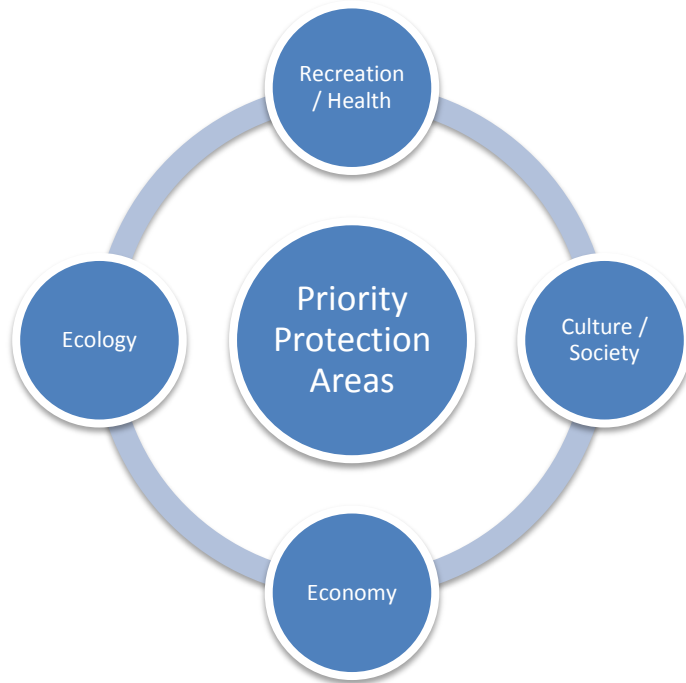
Map 5.8 Potential Restoration of Wetlands for Sediment Retention, Upper Cass River



5.6 Priority Preservation and Protection Areas

Representatives from local conservation organizations, state and federal resource managers and other local stakeholders gathered together on June 13, 2012 to prioritize areas for preservation and protection. The prioritization process was based on the priority lands inventory and the practical knowledge of the stakeholders in the room. During the meeting four

different concepts were discussed pertaining to the Cass River Watershed: Recreation and Health, Ecology, Economy, and Culture and Society. Within each of these concepts different aspects of the Cass River Watershed were discussed including what already exists, opportunities, challenges, and priorities.



There are numerous existing features in the watershed that support recreation and health. It was determined that within the Cass River Watershed. There are State Games Areas (nine) and the Shiawassee National Wildlife Refuge along with city parks including Caro and Vassar. Recreation includes fishing, hunting, and trapping. Future opportunities abound for expanding and improving public access to the Cass River. This included improved access for fishing, boating, and biking along the river. In order for new opportunities for recreation and health to manifest, work needs to be done to restore wetlands and acquire more land with the intention of linking existing areas within the Cass River Watershed.

The existing ecology along the main Cass River corridor includes five of the State Game Areas, the Shiawassee National Wildlife Refuge, forested riparian corridors, and wetlands. Opportunities include restoring wetlands near the riparian corridors and the expansion of State Game Areas and the Shiawassee National Wildlife Refuge. Another was the need to address water quality to meet total maximum daily loads (TMDLs) and make sure they are within an acceptable range. Other opportunities include the use of filter strips to help maintain water quality, work to improve the overall quality of the river, and invasive species control. It was thought that some of these goals could be met by using and promoting a public stewardship opportunity which would involve local communities in restoring the river.

The existing economy of the Cass River Watershed includes farming and recreation. Recreation includes hunting, fishing, and boat tours and rentals. Agriculture is a major contributor to the economy and over 1,500 farms exist within the Cass River corridor. Lastly, it was mentioned

that there is a sugar beet plant that also is a part of the existing economy. The expansion of State Game Areas and the Shiawassee National Wildlife Refuge would help to improve the resource-based economy by protecting wildlife and fishery habitat that sustains game species. The restoration of wetlands would cut back on pollution and likely increase the use of the river. Another opportunity exists in promoting river based recreation and tourism and expanding outdoor recreation on the river. Finally, if communities along the river were to share and coordinate different events along the river it would improve local economies.

For culture and society there are museums, Petroglyph Park, and the Octagon Barn. The value of cities such as Frankenmuth, farmers' markets and various festivals were mentioned. Several opportunities mentioned for improvement of culture and society along the Cass River could be more nature festivals to involve the community and watershed and water quality educational opportunities by way of involving more schools.

Challenges to the strategy to improve natural resources along the Cass River are:

- Need for funding to seize opportunities / poor existing economy in several small communities
- Large holdings of private-land along the river make improving recreational opportunities difficult
- General lack of awareness and concern from landowners along the River
- Dams along the River block year-round access to boating and fishing

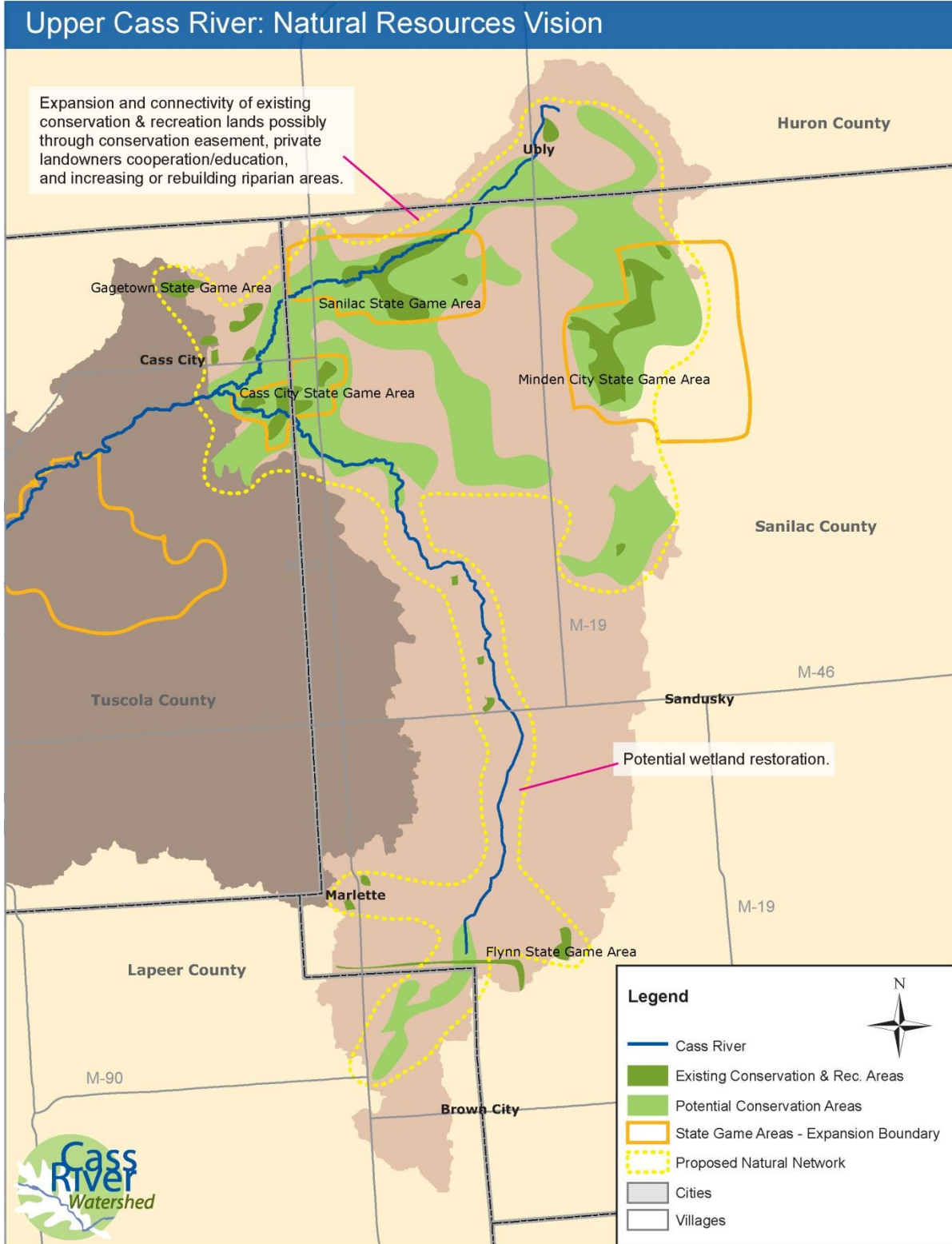
Major priorities for the Cass River corridor include:

- Increase number of recreational users and access to the river
- Raise awareness among river users and landowners about the valuable resources along the Cass (recreation, health, culture, economic, ecologic)
- Maintain rural and small town culture
- Connect State Game Areas through different private/public ownership conservation tools
- Remove failing dams
- Restore high quality wetland functions
- Expand water trail above Vassar

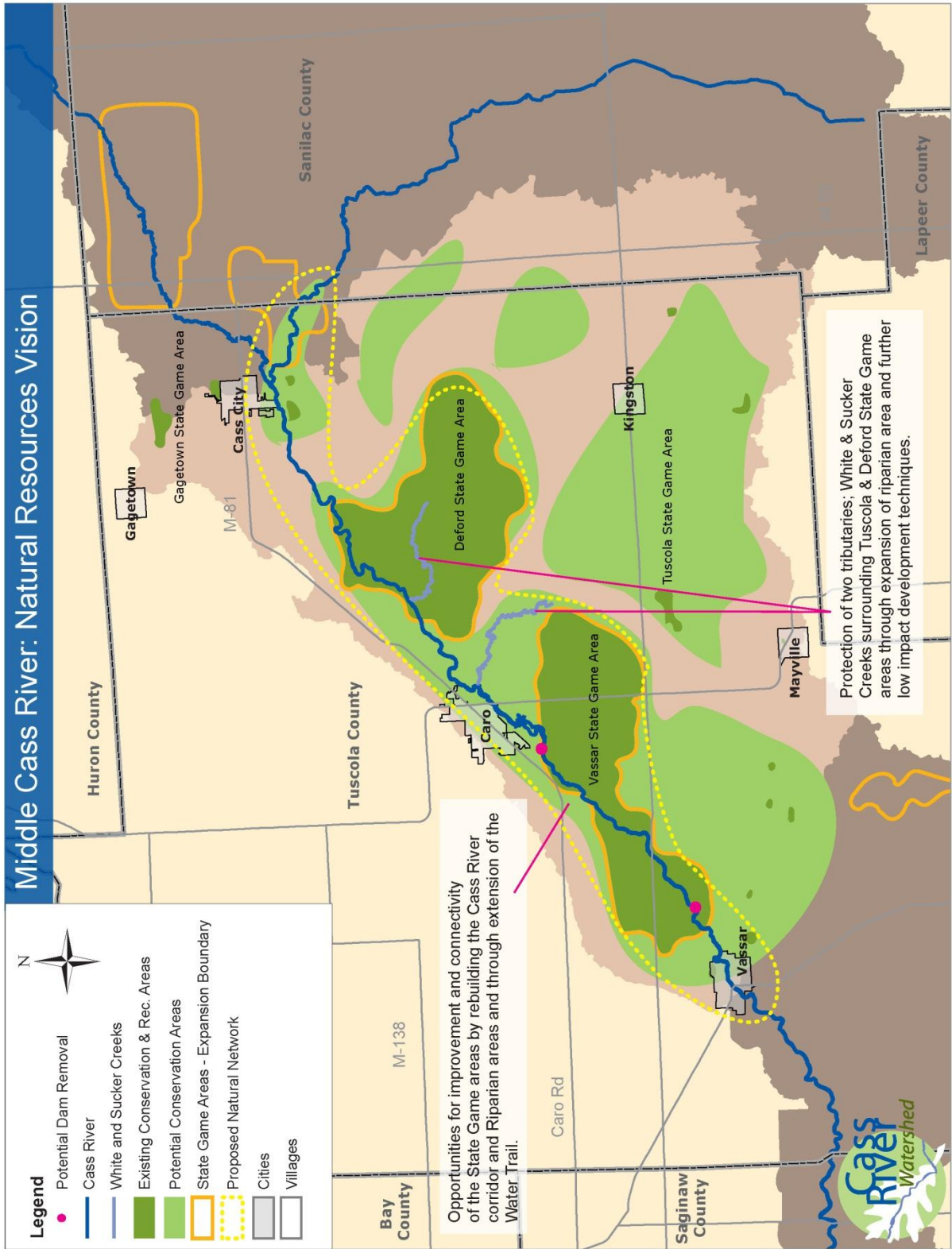
Next steps that were decided on at the meeting include identifying key stakeholders, pursuing fish passage over the dam in Frankenmuth, dam removal in Vassar and a portage around the Caro dam, and identifying key corridor opportunities to connect State Game Areas.

The natural resources convening of the Cass River watershed project culminated into a series of maps and strategies for each of the major sub-basins. These are shown in Maps 5.8-5.10.

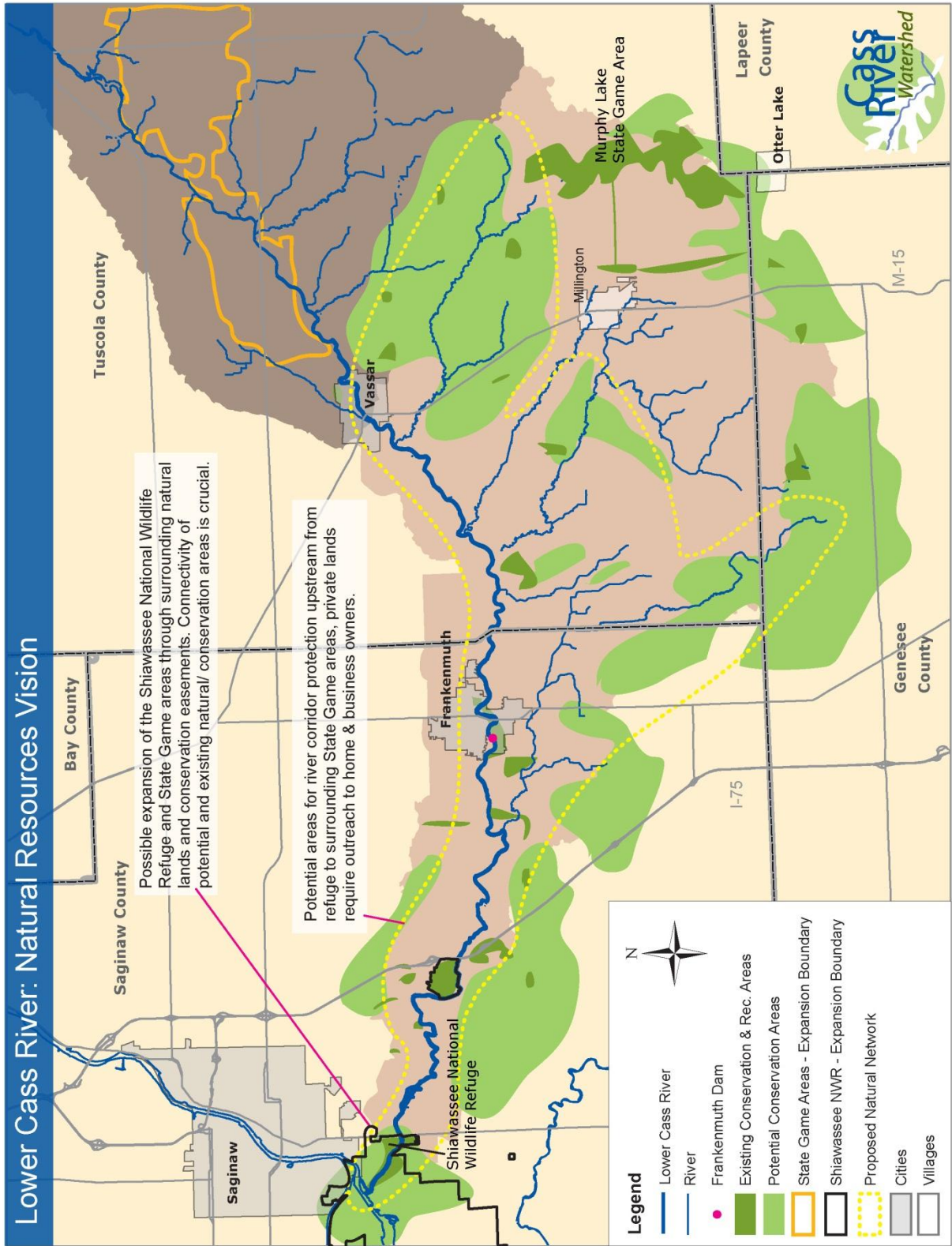
Map 5.8: Upper Cass River Priority Natural Areas



Map 5.9: Middle Cass River Priority Natural Areas



Map 5.10: Lower Cass River Priority Natural Areas



5.7 Recommended Managerial Strategies

Area planning commissions and/or management plans should have set guidelines to provide to areas residents and businesses that gives to them detailed information on where and how to find information for land preservation and conservation, in particular land protection by way of a Land Conservancy and Low Impact Development (LID) techniques; including stormwater management. Much of this information could be held at local libraries, post offices, and easily accessed through a variety of websites and documents that are available to residents and businesses. Local land conservancies are a great resource for land protection and preservation. Since much of the watershed river corridor is occupied by private property owners both methods would be in the best interest for the Cass River. According to the Saginaw Basin Land Conservancy (SBLC), “a conservation easement (or preservation agreement) is a legal agreement between a landowner and a land conservancy or other public body that permanently limits uses of the land in order to protect its conservation values.” With this option landowners still own and have full use of their land according to the agreement. Another option through SBLC is land donation and in some cases they may be able to purchase the property directly from the homeowner. All options offered by SBLC are tax deductible and can be discussed directly with the SBLC representative or furthermore with a legal advisor. LID techniques will be discussed further under Land Use Planning.

5.8 Education Outreach Strategies

Chapter 6 provides pointed recommendations for the entire watershed. There are a variety of ways that government, educational institutions, community organizations, and municipalities can reach out to area residents. It is through this outreach that individuals can be made aware of the human and ecological benefits, recreational opportunities and aesthetics the Cass River has to offer; if such a connection is made than they are more likely to participate in activities that will protect the viability of the Cass River. One method of increasing awareness for landowners in a watershed community is being implemented in the Cedar River by the Little Forks Conservancy. The Sustainable Lands partner program is voluntary and does not require a contract; it is a partnership between the Little Forks Conservancy and landowners who are dedicated to conserve the natural resources on their property (The Little Forks Conservancy Inc., 2011).

Community/volunteer based organizations would be another avenue of outreach that would be able to incorporate residents and area businesses in land and river projects surrounding the Cass. The Cass River Greenway (CRG) strives to build opportunities, growth and future sustainability for areas within the Cass River Watershed. By working directly with property owners, government agencies, area conservation districts and nonprofit agencies the CRG committee hosts annual river cleanup projects, and has worked in planning new and proposed river launch site accesses. Another large potential resource for education and outreach in the CRW would be through the SBLC. The SBLC holds approximately 20% of their conservation easements throughout the CRW (SBLC, 2012) and could further connect with easement landowners, promote membership and build volunteer groups along with other local

organizations. Local watershed organization could provide to residents support (possibly some financial/educational) and land management methods that would benefit the Cass River. Also, the conservation easements and state games areas can serve to provide educational opportunities for schools, residents, and businesses by hosting nature walks, invasive plant removal days, river paddles, and possibly a sub basin watershed tour.

5.9 Land Use Planning

LID techniques are used to aid in the storage and transport of stormwater by using native vegetation and a variety of LID practices to promote infiltration, filter sediments, and to form detention and/or holding areas that slow or stop the movement of stormwater rather than it being quickly transported by drains or runoff directly into local waterbodies. The Southeast MI Council of Governments with funding from MDEQ and U.S. Environmental Protection Agency produced an LID manual; within the manual are suggestions for homeowners and local governments on ways to incorporate LID methods at the parcel and community levels. Some suggestions for residents are to incorporate rain gardens, disconnect downspouts, and to restore areas around lakes and rivers with native plants. Some localities and state agencies suggest that a fifty to one hundred (MDEQ, 2012) foot vegetative buffer for properties surrounding rivers be implemented by homeowners and businesses, these vegetated buffer areas (riparian area) aides in river bank stabilization, filtration of sediments, and overall health of the river. Local Governments should incorporate the use of the LID manual into planning and zoning decisions/reviews and its recommendations into local parks and recreation plans. Also, many townships and counties have zoning standards that require maintenance of natural vegetation along shoreline areas (Tip of the Mitt Watershed Council, 2012). In order for the watershed to benefit from any type of land or water conservation method, plans must be set up as such to consider fundamental ecological, land cover and water management issues (Natural Lands Inventory: Lower Cass River 2010-2011). Those seeking permits to develop or re-develop a parcel of land can be provided with recommendations or restrictions well before the actual plan is submitted for review.

5.10 Sustainability Strategies

Chapter 10 provides next steps for the overall watershed management plan. One main component of sustainability for the organizations involved in the CRW is to secure future funding for future projects. Grants such as Michigan's Section 319 Nonpoint Source Pollution (NPS) grants and Clean Michigan Initiative (CMI) NPS pollution control grants have already been working to benefit the CRW and Saginaw Bay Watershed as a whole. Taking advantage of the partnerships that exist between above named organizations (and other organizations not previously named), government and educational institutions such as; the Department of Natural Resources (DNR), Department of Environmental Quality (DEQ), area Conservation Districts, Ducks Unlimited, and many more would provide for sustainability, future project funding, and most likely, continued and additional support from the community and volunteers. Another measure of sustainment would be through building connectivity of the Cass River Corridor (CRC) and available natural lands. This is currently being done by a partnership

between the CRG, MDEQ, MDNR, and local municipalities with the proposed expansion of the Cass River Water trail near the Vassar State Game area and M-46 and a portage around the dam upriver of Indianfields Township Park, both additions would be upstream of the most recent launch site addition in the City of Vassar. Also, improved access and maintenance of sites for fishing, boating, and biking along the river would ensure that residents and visitors would have those amenities in the future. Opportunities for sustainability and success occur from promoting river based recreation, tourism, and through the coordination of community sponsored watershed wide events.

5.11 Measures of Success

There are many different ways the success of the river corridor, riparian areas and state game areas enhancement and preservation could be assessed. It may be by the number of private property owners that take part in stewardship opportunities and programs. The need for funding is at all times an issue when planning environmentally so being able to secure such funding for watershed wide projects such as wetland restoration and land acquisition in order to build connectivity amongst natural lands would suffice as a measure. Increasing awareness by providing education and building membership and volunteerism within local watershed groups would aid in overcoming some of the main challenges the CRW faces. What has already been done throughout the watershed, such as the water trail expansion, and building upon those improvements by incorporating new ideas, education, and public use and awareness could be measured by the amount of users identified in and around river accesses. Improving culture and society by linking communities to local museums, parks, and historical sites in the area could be done by partnering with educational institutions and local land conservancies.

Scheduled water quality sampling has already taken place and will continue throughout 2013. “The Cass River will be sampled above and below the communities of Bridgeport, Frankenmuth, Vassar, Caro and Cass City for phosphorous, suspended solids, dissolved oxygen, biological oxygen demand, nitrates, turbidity, and fecal coliform bacteria (Cass River Greenway).” Doing so would allow total maximum daily load (TMDLs) levels to be recorded and to make certain that they are within acceptable ranges.

Chapter 6: Public education and outreach strategy

6.1 Information and Education Process

Process and role of the Cass River Information and Education (I&E) committee

The goal of the Cass River I&E Committee was create and implement a strategy that involves watershed residents and decision-makers in the watershed management planning process. This includes promoting and explaining the Cass River Watershed Management Project, pollution problems in the watershed, and best practices that improve water quality. The I&E committee will expand public participation in planning process and assist with developing the long-term outreach strategy for project implementation. The strategy was created using a three-fold process: (1) identify target audiences, (2) develop messages, (3) select methods of delivery.

Task 1: Identify Target Audiences

Target audiences are identified to narrow the scope of the I & E committee and reach out to populations in the watershed that have the greatest impact on water quality protection and pollution prevention. Target audiences in the Cass River Watershed may include:

- Agricultural Businesses/Community (Star of the West Milling Company), local farm landowners, implement dealers
- Users of the Rivers – recreational
- Outdoor clubs/conservation clubs/conservancies/conservation districts
- Riparian landowners
- Local decision-makers / municipal officials
- Septic system owners
- K-12 students
- General Residents

Task 2: Develop Messages

Concise communication messages are created for each of the target audiences concerning specific pollutants of concern and for general information sharing about the project. Examples of topics that messages will be developed for are:

- General watershed information
- Farming impacts
- Effects of sediment and nutrients
- Septic systems
- Wetlands
- Stewardship
- Land Conservation

Task 3: Select Methods of Delivery

Different methods for delivering messages will need to be created on a case-by-case basis depending on the target audience and the message we are trying to communicate. Common delivery methods include:

- direct mailings
- farm show
- county fair
- website – www.cassriver.org
- table display
- mail through township/city regular mailings
- township associations
- MSUE – digital newsletter / print
- Conservation district newsletters
- news articles/TV/radio (see Media Outlets list below)
- Farm Bureau in Lansing can put inserts into local newsletters “Michigan Farm News”
- FSA (Farm Service Agency) – sends out news to every farmer, partner with local county offices

Key Partners

- Cass River Greenway Committee
- County Soil Conservation Districts (Genesee, Lapeer, Huron, Sanilac*, Saginaw*, Tuscola*)
 - *Saginaw, Sanilac, and Tuscola counties represent the majority of the watershed area
- Saginaw Bay Resource Conservation and Development (RC&D)
- Star of the West Milling
- Michigan Milk Producers Association
- Michigan Department of Environmental Quality, Water Bureau

Media Outlets

Name of Outlet	Website	Email (or fax if no email avail.)	Phone
Frankenmuth News	http://frankenmuthnews.com/	Scott Wenzel swenzel@airadv.net	(989) 652-3246
Sanilac County News - Your Voice in Sanilac County	http://sanilacountynews.mihomepaper.com/	scneditor@mihomepaper.com	(810) 648-4000
Sandusky Tribune	http://sanduskytribune.com/	sanduskytribune@gmail.com	(810) 648-5282
The Marlette Leader	http://michigansthimb.com/marlette_leader/front/ or http://www.marletteleader.com	(989) 635-3769	(989) 635-2435
Huron Daily Tribune	http://www.michigansthumb.com/	kjerome@hearstnp.com	(989) 269-6416
Tuscola County Advertiser	http://www.tuscolatoday.com/	Judy Seifert seifert@tcadvertiser.com	(989) 673-3181
Cass River Trader Vassar	http://www.cassrivertrader.com/	(989) 823-2531	(989) 823-8651
Saginaw News	http://www.mlive.com/saginawnews/	Kathryn Lynch-Morin kmorin@thesaginawnews.com	(989) 752-7171
Bridgeport Birch Run Harold	http://www.myherald.net/	(810) 686-3840	(810) 686-9181
Vassar Pioneer Times		Megan Decker meganvpt@yahoo.com	
TV3	http://www.wvmt.com		
Delta College Television	http://www.deltabroadcasting.org/		

Name of Outlet	Website	Email (or fax if no email avail.)	Phone
ABC12 Television	http://www.abc12.com/		
NBC 25 Mid Michigan Television	http://www.minbcnews.com/		
AM790 Radio	http://tunein.com/radio/News-Radio-790-s22787/	Terry Hennie (Farm Program Director) on 5 days a week	
Tom Lounsbury, Sunday Radio Show	http://thumbnet.net/lounsbury.php	gtlouns@avci.net	

6.2 Overall Strategy and Leadership

The framework of the implementation of the education and outreach strategy is three-fold for the Cass River Watershed.

1. **Raise awareness** among regarding key pollution concerns, and the watershed overall among target audiences
2. Establish relationships with landowners and key constituents to **take action** to protect and restore the watershed
3. **Evaluate** the effectiveness of the education and outreach strategy by tracking changes in water quality and social indicators.

A Social indicators study design was created for the Cass River to aide in future evaluation and success of outreach and education programs within the watershed during and after implementation projects. A full description of these indicators is included in the Appendix.

A. Cass River Greenway Committee

Organized in 2007, the Cass River Greenway Committee (Committee) membership includes volunteer residents and municipal leaders from cities, communities and townships along the Cass River from Cass City downstream to Bridgeport. Expanding the volunteer base for work on the Cass River Greenway project is critical to achieving many of the Committee's goals. The Committee is strongly supported by federal, state and county agencies whose representatives are members of the committee. They include: MDEQ Water Bureau, US Fish & Wildlife Service, USDA/Saginaw RC&D, Saginaw Basin Land Conservancy, UM Flint-University Outreach, Saginaw Area Storm Water Authority and Saginaw County Conservation District.

The Committee has developed three goals: (1) Develop Recreation Opportunities on the Cass River and along its corridor, (2) Encourage Preservation of Wildlife Habitat and Critical Natural Lands and (3) Improve Water Quality of the Cass River (Web, 2012). The Committee is a key partner in the Cass River Watershed Management Plan, and support from its members will be critical during implementation given the committee's ability to organize stakeholders and secure funding and volunteers for projects.

B. Education of local boards and councils

The planning phase interacted routinely with local government boards and councils through presentations, news releases, phone calls, and in-person meetings. Continued interaction with this audience is needed to further implement the plan as recommendations to improve local codes for water quality protection and wastewater management are included in the plan. It is recommended that semi-annual updates be provided to local municipalities through a

combination of outreach strategies used during the planning phase. This ensures support for funding requests and projects within the communities of the watershed.

C. Management Partnerships

Implementation of all watershed activities (structural, managerial, vegetative, and educational) requires partnership or involvement between those who use the river and those who have management authority. Ongoing partnership will be required with county health departments, drain commissions, road commissions, conservation districts, local governments, landowners, and businesses to successfully secure funding, manage projects, and restore water quality. Partnerships will be maintained and developed as projects are planned and implemented. It is hoped the county Conservation Districts and the Saginaw Bay RC&D will lead these efforts. Land Conservancies are a great partner in protection of natural resources for the Cass River.

D. Data sharing via Website www.cassriver.org

The Cass River Greenway maintains a website that shares updates on their projects, and projects that benefit the Cass River. Press releases and presentations for the watershed management plan were included during the planning phase. These activities should continue to encourage membership and volunteer activity with the Cass River Greenway committee to further promote implementation projects.

E. Funding and sustained support

Ongoing support for coordination of projects and volunteers in the Cass River Watershed is a long term need for continued implementation of the watershed plan and restoration of water quality. Groups and organizations that have the ability to raise personal and monetary support are the Cass River Greenway committee and the Saginaw Bay RC&D. Continued partnership with these organizations should help sustain the network of people who regularly volunteer and support the Cass River.

F. Grant programs

Funding for many implementation projects will be through grant programs. The initial implementation grant will be sought from the Michigan Department of Environmental Quality under their Clean Michigan Initiative fund and the 319 fund (federal money from the Environmental Protection Agency). Regional funding options include the Bay Area Community Foundation, Saginaw Bay Watershed Initiative Network, Frankenmuth Rotary, and the Frankenmuth Jaycees.

6.3 Education Strategy by Target Audience

Target audiences have been developed for the Cass River Watershed based on the collective knowledge of the steering committee and inventory findings. The framework for reaching each target audience was adapted from the Information and Education Guidebook for the Lower Grand River 319 Project in Michigan. Six broad categories have been defined for target audiences addressing various known pollutants and issues of concern in the watershed:

- Local livestock producers
- Local growers
- Town Residents
- Large landowners
- Septic system owners
- Riparian landowners
- Anglers/paddlers/sportsmen

The following tables describe the rationale and approach for each target audience, and the personnel and monetary costs for engaging with each audience.

Driving Force: (Why is this important) Nutrient runoff from livestock operations, improper manure storage / management				
Goal of Education Program: (What should be done about it) Work with established agencies and networks to raise awareness about benefits of BMP's and cost-share programs available for installation				
Objective: (What outcome do you expect to achieve? Include numeric targets where possible) Greater use of manure management and feedlot runoff mitigation for approximately 138 sites and 4,617 animals				
Barriers/Concerns of Audience: Capital costs for installation of practices, rental farmland is increasing in the watershed, hobby farmers can be hard to reach if not part of larger farm organization				
Target Audience:	Message:	Format:	Distribution:	Evaluation:
Local livestock producers	Economic and water quality benefits by properly managing manure and runoff	Presentations at existing events, articles/handouts at local mills; press releases and radio spots	Quarterly Work with existing professional and social networks to distribute information	Track number of practices installed, MAEAP livestock verified farms
Hobby farmers	Several programs and technical assistance providers are available to work with you and your business to create a plan that reduces your impact on water quality			
Potential Partners: Saginaw Bay RC&D, County Soil Conservation Districts, MSUE, MAEAP, NRCS-USDA, MMPA, Drain Commission				
Timeframe: Short (1-3 years) – Mid (3-5 years)				
Implementation Request: \$2,000 annually to support existing agriculture/outreach agents at CD's for presentations in the watershed and to work with landowners on education and installation of best practices \$5,000 for crafting of press releases, articles, and brochure printing and mailing				
Ongoing Efforts: Held focus groups with farmers in late August 2012 to discuss environmental and economic messaging				

Driving Force: (Why is this important) Sedimentation from cropland erosion, increased nutrients from fertilizers				
Goal of Education Program: (What should be done about it) Work with established agencies and networks to raise awareness about benefits of BMP's and cost-share programs available for installation				
Objective: (What outcome do you expect to achieve? Include numeric targets where possible) Greater use of filter strips, cover crops, and conservation tillage, target numbers for acreage are included in chapters 7-9. Upper Cass River – 4,486 acres; Middle Cass River – 1,770 acres, Lower Cass River – 14,275 acres.				
Barriers/Concerns of Audience: Capital costs for installation of practices, potential reduction in crop yield due to less acreage in rotation, rental farmland is increasing in the watershed				
Target Audience: Local growers and producers	Message: Benefits of cover crops, conservation tillage, and filter strips; Several programs and technical assistance providers are available to work with your business to create a plan that reduces your impact on water quality	Format: Presentations at existing events, articles/handouts at local mills; press releases and radio spots	Distribution: Quarterly Work with existing professional and social networks to distribute information	Evaluation: Track number of practices installed, MAEAP livestock verified farms
Potential Partners: Saginaw Bay RC&D, County Soil Conservation Districts, MSUE, MAEAP, NRCS-USDA, MMPA, Drain Commission				
Timeframe: Short (1-3 years) – Mid (3-5 years)				
Implementation Request: \$2,000 annually to support existing agriculture/outreach agents at CD's for presentations in the watershed and to work with landowners on education and installation of best practices \$5,000 for crafting of press releases, articles, and brochure printing and mailing				
Ongoing Efforts: Held focus groups with farmers in late August 2012 to discuss environmental and economic messaging; Potential model BMP auction program in place at Huron Conservation District				

Driving Force: (Why is this important) Stormwater pollution, lack of awareness of watershed concepts, river is not viewed as an amenity to the community				
Goal of Education Program: (What should be done about it) Raise general awareness and identity of the Cass River Watershed and encourage behavior that reduces nonpoint source pollution				
Objective: (What outcome do you expect to achieve? Include numeric targets where possible) Reimagining of the Cass River Watershed by residents who have knowledge of their impact on the Cass River, and a reduction in nonpoint source pollution. Participation will be tracked during the course of implementation projects to verify an increase in awareness and positive behaviors.				
Barriers/Concerns of Audience: General lack of knowledge about the Cass River and nonpoint source pollution				
Target Audience: Residents in subdivisions and urbanized areas. Local Planning Commissions	Message: Reconnect with the Cass River. River is a community focal point and gathering place. We all live in a watershed, small actions by many residents can have a large impact on water quality. The Cass River is a productive fishery that impacts the water quality of the Saginaw River and the Great Lakes.	Format: Speakers bureau; Cass River Article Series; Map of bike/hike/paddle trails; Organized paddle and bike trips Storm drain stenciling	Distribution: Attendance at local meetings; local digital and print media; existing website; local parks departments; Middle/High School students for storm drain stenciling	Evaluation: Pre and Post-project random mail survey of watershed residents using SIPES/SIDMA framework
Potential Partners: Conservation Districts, local Parks Departments and Recreation Authorities, local government, Cass river greenway committee				
Timeframe: Short – term (1-3 years)				
Implementation Request: \$2,500 Speakers Bureau; \$6,000 Article Series; \$3,000 Printing of existing map; \$500 Per canoe/kayak trip with estimated 30 people per trip (one per year); \$1,500 for storm drain stenciling supplies				
Ongoing Efforts: Cleanups and monitoring organized by the Cass River Greenway Committee, press releases, Get to Know Your Cass River brochure, 2013 update to the bike/hike/paddle trail brochure and map, 2013 triathlon, annual swim/float on the Cass River				

Driving Force: (Why is this important) Loss of natural/wildlife areas, loss of wetlands has compromised hydrologic function; improvements forestry management				
Goal of Education Program: (What should be done about it) Establish relationships with landowners who support permanent-land protection on their property and implement conservation easements or other methods as appropriate				
Objective: (What outcome do you expect to achieve? Include numeric targets where possible) Permanent protection of high quality natural areas [see NLI and PCA], Sustainable network for the Cass River Forest Owners, Protected forested corridor along the Cass River.				
Barriers/Concerns of Audience: Many absentee landowners, majority of property may be used seasonally for hunting (North Branch), do not want to restrict future use or sale of property				
Target Audience: Landowners of high value natural lands greater than 40-acres	Message: See existing materials produced by the Saginaw Basin Land Conservancy	Format: Landowner meetings Brochures	Distribution: Meetings organized by landowners and Land Conservancy Direct Mail Prioritized by Natural Resource Committee	Evaluation: Pre and Post-project random mail survey of watershed residents using SIPES/SIDMA framework Tracking of contacts established by Land Conservancy & acres protected
Potential Partners: Little Forks Conservancy, Saginaw Basin Land Conservancy, MDOT, Michigan State Game Areas (DNR), USFWS, Michigan Forest Association				
Timeframe: Mid, 3-5 years				
Implementation Request: \$300 per landowner meeting (2 per year); \$1,000 per printing and mailing; \$600 per acre for conservation easements (1,500 acres of high priority sites)				
Ongoing Efforts: Michigan Forest Association – Cass River Forest Owners Network has held landowner meetings and workshops, Saginaw Basin Land Conservancy landowner outreach and the MSU Land Policy Institute – Local land use policy study have held landowner meetings, workbooks and brochures				

Driving Force: (Why is this important) Nutrients and bacteria pollution is being caused by failing and poorly constructed septic systems				
Goal of Education Program: (What should be done about it) Increase awareness about the maintenance needs of septic systems and the responsibility of homeowners who have a septic system				
Objective: (What outcome do you expect to achieve? Include numeric targets where possible) Septic system owners will know where the system is on their property, how often it should be pumped, and when the system is not functioning properly. Tracking of number of landowners reached and the number of permit requests to the health department for upgrades to the failing systems.				
Barriers/Concerns of Audience: Lack of funds to upgrade/replace failing systems, do not want to report on neighbors				
Target Audience: Septic system owners	Message: Septic systems do require routine maintenance and inspections to ensure they are working properly. Poorly managed septic systems can pollute groundwater, making it unsafe to drink; and can pollute surface water, making it unsafe to swim in.	Format: Incentive-based program with homeowners and commercial service providers Brochures	Distribution: One-on-one contact with homeowners Direct Mail in target areas	Evaluation: Number of homeowners engaged in the program; reduced bacteria levels in local waterways Pre and Post-project random mail survey of watershed residents using SIPES/SIDMA framework
Potential Partners: Health Departments, local commercial providers, homeowner associations/lake associations, MDARD, Septic Haulers Association, SVSU				
Timeframe: Mid to Long (3-7 years)				
Implementation Request: \$7,000 for program planning and implementation; \$8,500 for brochure design, printing and mailing, funding for Sanilac and Tuscola Counties to digitize landowner parcel records, funding for Genesee, Saginaw, Sanilac, and Tuscola County Health Departments to digitize their septic system records.				
Ongoing Efforts: SVSU working with Tuscola county for parcel mapping, Tuscola County Health Department is beginning to digitize septic system records / permits				

Driving Force: (Why is this important) Sedimentation from eroding streambanks, increased nutrients from fertilizers, loss of wildlife/natural corridor				
Goal of Education Program: (What should be done about it) Work in identified priority areas in Upper Cass River (Sanilac County and Lapeer County)				
Objective: (What outcome do you expect to achieve? Include numeric targets where possible) Stabilizing only the high priority sites will reduce annual sediment loading by 53,860 tons.				
Barriers/Concerns of Audience: loss of property and land value due to erosion, want to manage property to maximize aesthetic appeal and minimize mosquitoes				
Planning Phase: inventory completed of streambank erosion issues, well-documented				
Target Audience: Riparian landowners	Message: Your decisions on how to manage your property can have a positive or negative effect on water quality. Riparian buffers and use of low/no phosphorous fertilizers are two things that you can do to protect the Cass River and Lake Huron	Format: Brochure Postcard Door Hangers – designed and distributed by local middle/high school students	Distribution: Direct Mail Direct Mail Door-to-door outreach	Evaluation: Requests for assistance with stabilization of stream banks
Potential Partners: Saginaw Basin Land Conservancy, USDA-NRCS, CD's, Saginaw Bay RC&D, MSUE				
Timeframe: Long (5-7 years)				
Implementation Request: \$10,500 for printing and mailing; \$1,500 printing of door hangers				
Ongoing Efforts: 2008 streambank inventory, completed loading estimates in 2011				

<p>Driving Force: (Why is this important) PCB and mercury accumulation in wildlife restricts fish consumption in the Cass River watershed</p>				
<p>Goal of Education Program: (What should be done about it) Raise awareness amongst anglers and those who eat fish caught in the Cass River about fish consumption restrictions</p>				
<p>Objective: (What outcome do you expect to achieve? Include numeric targets where possible) Recreation users are aware of fish consumption guidelines; swimming and wading restrictions (if any); Increased participation in cleanup and stewardship activities by anglers, paddlers, and sportsmen</p>				
<p>Barriers/Concerns of Audience: Is the water safe to swim in? Can I eat the fish I catch?</p>				
<p>Target Audience: Anglers / Sportsmen / Paddlers</p>	<p>Message: If you eat fish caught in the Cass River watershed, or other waterways in Michigan, there are limits on how many fish you should eat per month to avoid ingestion of harmful chemicals</p>	<p>Format: Distribution of existing brochures developed by MDNR Posters</p>	<p>Distribution: Brochure placement where fishing licenses and bait are sold Posters displayed at local fishing locations</p>	<p>Evaluation: Pre and Post-project random mail survey of watershed residents using SIPES/SIDMA framework</p>
<p>Potential Partners: Sportsmen clubs, MDNR, Cass River Greenway committee, Conservation Districts</p>				
<p>Timeframe: Mid (3-5 years)</p>				
<p>Implementation Request: \$1,500 to print and distribute brochures; \$800 for poster design, printing and installation (estimated 50 posters)</p>				
<p>Ongoing Efforts: Water quality grant awarded to the Cass River Greenway committee, press releases, Get to Know Your Cass River brochure</p>				

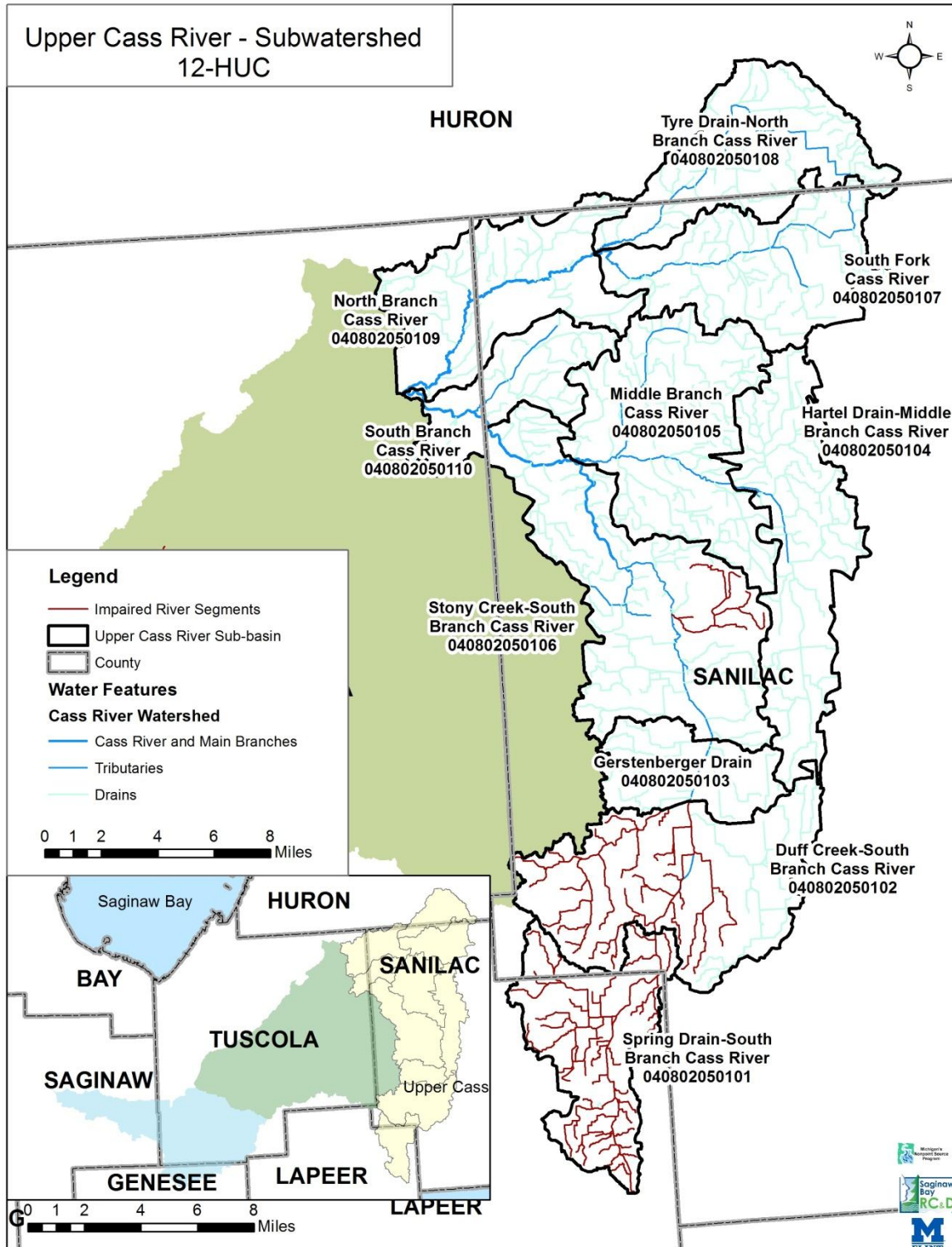
6.4 Overall I&E Budget Table

Task	Timeframe	Budget
Raise awareness about benefits of BMP's and cost-share programs to growers	Quarterly: 2014-2019	\$11,000
Promote feedlot runoff and manure management measures to livestock producers	Quarterly: 2014-2019	\$11,000
Raise awareness about watershed and behaviors that reduce NPS	2014-2017	\$14,500
Educate about permanent land protections	2017-2020	\$4,800
Educate about septic system maintenance	2016-2021	\$15,500
Parcel mapping (Tuscola, Sanilac Counties)	2016-2021	\$140,000
Digitizing Septic System Records (Genesee, Saginaw, Sanilac, Tuscola Counties)	2016-2021	\$160,000
Raise awareness for streambank stabilization	2018-2021	\$12,000
Raise awareness about fish consumption restrictions	2017-2020	\$4,800
Total Cost For All Education Programs		\$373,600

Chapter 7: UPPER CASS RIVER

Findings of inventory, critical areas and recommendations for BMP's

Figure 7.1: Upper Cass River Subwatersheds



7.1 Upper Cass River Summary

The South Branch Cass River forms out of swampland and farm fields in northern Lapeer County while the North Branch Cass River begins in southern Huron County. These two branches flow towards each other forming the Main Branch of the Cass River near Cass City. The Upper Cass River sub-basin occupies about 39.7% of the watershed totaling 231,056 acres. The Upper Cass River is further divided into ten sub-watersheds that are named and shown below in table 7.1.

Sub-watersheds	Acres	Sq. Miles	% of Watershed	Total
Upper Cass River	231,056			39.7
01-Spring Drain	19,724	30.8		3.4
02-Duff Creek	31,529	49.3		5.4
03-Gerstenberg Drain	11,150	17.4		1.9
04-Hartel Drain	25,056	39.2		4.3
05-Middle Branch Cass River	29,098	45.5		5
06-Stony Creek	36,500	57		6.3
07-South Fork	22,757	35.6		3.9
08-Tyre Drain	21,164	33.1		3.6
09-North Branch Cass River	22,405	35		3.9
10-South Branch Cass River	11,673	18.2		2

Most of the Upper Cass River is part of the Southern Michigan/Northern Indiana Drift Plains ecoregion. This ecoregion is characterized by its soils, varying landforms, and broad till plains. The soils of this region have moderate and are somewhat nutrient-rich. This region's soils and landforms make for an agricultural industry that typically produces feed grain, soybeans, and livestock (Ecoregion Details: Southern).

The Upper Cass River is predominantly made of agricultural land use, at about 71.2 percent. This sub-basin's natural land use accounts for about 26.6 percent of the watershed; it is much more agricultural than the watershed as a whole. This tells us that a large portion of the Cass River Watershed's agriculture takes place in the Upper Cass River.

Of the dominant agricultural land use, there are a few sub-watersheds that are extremely dominated by agriculture. There are a total of four sub-watersheds located in the Upper Cass River that have 80 percent or higher agricultural land use: Duff Creek, Gerstenberger Drain South Branch, Spring Drain South Branch, and Stony Creek South Branch.

7.2 Upper Cass River causes and sources of impairments and threats (EPA Element A) Water body use designations (EPA, A.1)

Designated Uses

A stream or site in the watershed is listed as impaired if it is failing to meet one or several designated uses as defined by the State of Michigan. Designated uses for the Upper Cass River and its tributaries include:

- **Agriculture** – Irrigation water for crops or water for livestock
- **Wildlife and Other Indigenous Aquatic Life** –Aquatic life and wildlife can thrive and reproduce.
- **Total and Partial Body Contact** – Recreational (swimming, fishing, boating) all waters protected for recreation shall not exceed specific levels of E.coli from May to October.
- **Warm Water Fishery** – Water supports warm water fish species including reproduction and sustainability,

Subwatersheds that have impaired designated uses as determined by MDEQ water quality testing are Spring Drain, Duff Creek, and Stony Creek. Spring Drain and Duff Creek were included in a 2004 TMDL for *E. coli* that identified pollutant source stemming from the Marlette Wastewater Treatment Plan and illicit sanitary connections in the vicinity of the creek. Stony Creek has a TMDL planned to be completed in 2018 for *E. coli* and impacts from ditching and tiling. Chapter 3 summarizes data available for the Upper Cass River prior and during the watershed planning phase in Figure 3.1 and Table 3.1. A majority of the data is from 2006 showing varying ranges of impairment. No data was available for Gerstenberger Drain, Hartel Drain or the South Fork. Duff Creek and Stony Creek have the most data available, presumably due to the known impairments there since 2004 and 2001 respectively.

Table 7.2 compiles information from the impaired waterbodies list provided by MDEQ and information gathered during the 2011 inventory. Sub-watersheds were inventoried via in-stream surveys and/or windshield surveys. Chapter 3 describes the methodology used for each of the inventory methods. South Fork, Tyre Drain, North Branch and South Branch are the four sub-watersheds listed as attaining all designated use by MDEQ and were not inventoried based on the high percentage of undeveloped land use (wetlands, forests, etc).

Impaired sub-watersheds were priority for in-stream inventory to identify sources of pollution. Three sub-watersheds in the Upper Cass River: Spring Drain, Duff Creek and Stony Creek are listed as impaired by the MDEQ and were inventoried via in-stream surveys by the Tuscola Conservation District during the 2011 field season. Headwater regions of the Gerstenberger were also waded and inventoried due to proximity and similar land use characteristics.

Two initial criteria were looked at to determine which sub-watersheds should be inventoried for agricultural NPS pollution sources and causes, a known impairment and the percentage of agricultural land use. Each sub-watershed was then assigned a priority between one and three, with priority one sub-watersheds having both impaired waterways and agricultural land use at 75% or greater. This rationale resulted in four sub-watersheds being inventoried using the windshield survey: Spring Drain, Duff Creek, Middle Branch and Stony Creek. The eastern Hartel Drain was also inventoried due to its downstream location from Spring Drain and Duff Creek.

Table 7.2 Impaired, partially impaired, and/or threatened uses (EPA A.3)
Subwatersheds that are noted with an “” are listed as impaired by the MDEQ*

Upper Cass River Sub-watersheds	Impaired Uses per MDEQ in-stream surveys	Potentially Impacted (Suspected) Uses	Notes
12-HUC: 0408020501	Fish Consumption		Mercury
Spring Drain* AUID: 0408020501-01	Total and Partial Body Contact Recreation		2004 TMDL for <i>E. coli</i>
Duff Creek* AUID: 0408020501-02	Total and Partial Body Contact Recreation		2004 TMDL for <i>E. coli</i>
Gerstenberg Drain AUID: 0408020501-03	Not assessed for Total and Partial Body Contact Recreation	Total and Partial Body Contact Recreation	Inventory Data 2011
Hartel Drain AUID: 0408020501-04	Not assessed by MDEQ		
Middle Branch Cass River AUID: 0408020501-05	Not assessed for Total and Partial Body Contact Recreation	Total and Partial Body Contact Recreation	Inventory Data 2011
Stony Creek* AUID: 0408020501-06	Total and Partial Body Contact Recreation Other Indigenous Aquatic Life and Wildlife		2018 TMDL
South Fork AUID: 0408020501-07	Not assessed for Total and Partial Body Contact Recreation		
Tyre Drain AUID: 0408020501-08	Not assessed for Total and Partial Body Contact Recreation		
North Branch Cass River AUID: 0408020501-09	Not assessed for Total and Partial Body Contact Recreation		
South Branch Cass River AUID: 0408020501-10	Not assessed for Total and Partial Body Contact Recreation		

Water quality criteria (EPA, A.2)

The water quality criteria used to evaluate the environmental health of water bodies in the Upper Cass River are defined below.

Bacteria – Partial and Total Body Contact (Taken from the 2008 TMDL for *E. coli*, developed by MDEQ for Duff Creek, Sanilac County)

For Partial Body Contact, all the waters of the State shall have not more than 1000 *E. coli* bacteria per 100 milliliters of water. For Total Body Contact, the waters of the State shall have not more than 130 *E. coli* bacteria per 100 milliliters of water, as a 30-day average and 300 *E. coli* per 100 ml water at any time. Each sampling event shall consist of three or more samples taken at representative locations within a defined sampling area. At no time shall the waters of the state protected for total body contact recreation contain more than a maximum of 300 *E. coli* per 100 ml. Compliance shall be based on the geometric mean of three or more samples taken during the same sampling event at representative locations within a defined sampling area.

In addition, sanitary wastewater discharges have an additional target: Discharges containing treated or untreated human sewage shall not contain more than 200 fecal coliform bacteria per 100 ml, based on the geometric mean of all of five or more samples taken over a 30-day period, nor more than 400 fecal coliform bacteria per 100 ml, based on the geometric mean of all of three or more samples taken during any period of discharge not to exceed seven days. Other indicators of adequate disinfection may be utilized where approved by the department.

Table 7.3 Specific causes and sources of impairments and/or threats (EPA, A.4)

The status of designated uses presented in Table 7.2 are correlated with the causes and sources of impairments for each sub-watershed in Table 7.3.

Sub-watershed name	Impaired Use Description (Suspected Use Impairment)	Cause Name	Source (s)
Spring Drain-South Branch Cass River	Total and partial body contact recreation	E. Coli	1. Agriculture, 2. Illicit Connections / Hook-ups to Storm Sewers, 3. Municipal Point Source Discharges
Duff Creek-South Branch Cass River	Total and partial body contact recreation	E. Coli	1. Agriculture 2. Illicit Connections/Hook-ups to Storm Sewers 3. Municipal Point Source Discharges
Stony Creek-South Branch Cass River	Total and partial body contact recreation	E. Coli	1. On-site Treatment Systems (Septic Systems and Similar Decentralized System) 2. Unpermitted Discharge (Domestic Wastes)
	Other Indigenous Aquatic Life and Wildlife	Organic Enrichment (Sewage) Biological Indicators Tiling and Ditching	1. Source Unknown 2. Channelization
Gerstenberger Drain	(Partial and Total Body Contact)	E. Coli	1. Agriculture
Middle Branch Cass River	(Partial and Total Body Contact)	E. Coli	1. Agriculture

Causes of impairment (or threats) quantified (EPA A.5)

The causes of threats to water quality and known impairments are quantified by *E. Coli*, organic enrichment, and tiling and ditching. Causes were quantified through data presented in the 2004 Duff Creek TMDL, and analysis of surface water hydrology in a GIS.

E. Coli

“Sampling location in Duff Creek had a 30-day geometric mean exceeding 1,000 *E. coli* per 100 ml over a six-week period while daily geometric mean concentrations exceeded 2,000 *E. coli* per 100 ml during the sampling season.” – TMDL for *Escherichia coli* for Duff Creek, Sanilac County, Michigan DEQ, July 2004.

Organic Enrichment

The amount of organic enrichment occurring in Stony Creek is unknown at this time; TMDL will be developed in 2018 for Stony Creek.

Tiling and Ditching

Stony Creek Drain totals 36,499 acres of which 80% is agricultural. The subwatershed contains over 67 miles of designated county drains in addition to an unknown amount of private field drains and tiles. It is assumed that all productive farmland in this region has some degree of tiling installed. The full impact of this cause is unknown at this time; the TMDL will be developed in 2018 for Stony Creek

Locations of Impairments (EPA, A. 6-8)

Figure 7.2 shows the known locations of impairment sources from the 2011 in-stream inventory and the windshield survey (Chapter 3).

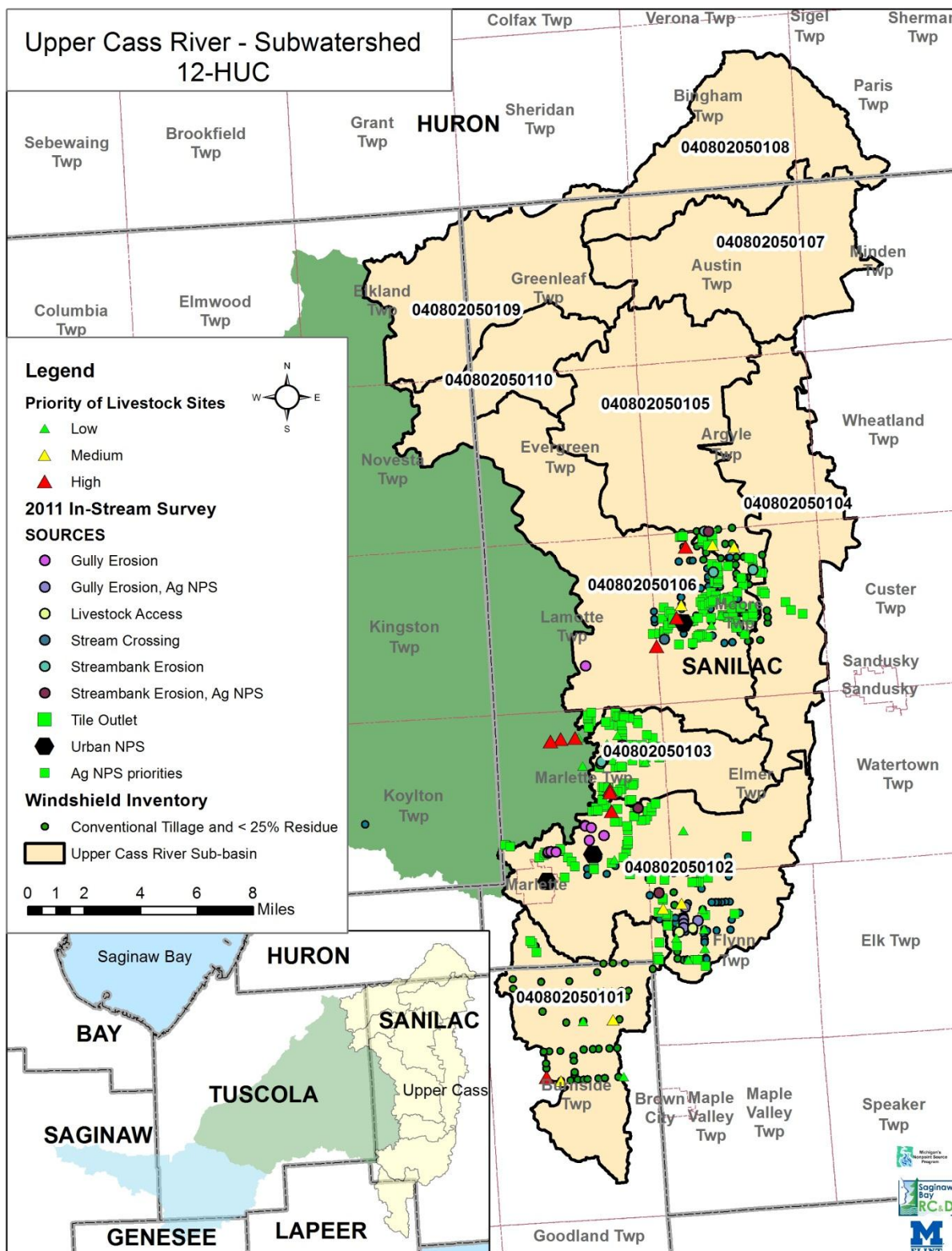
Priority livestock sites were those identified during the 2011 windshield surveys. High priority sites are those where known surface water impairment was observed and pollutant loading estimates could be calculated. Medium priority sites are those where surface water quality impairment is suspected and pollutant loading estimates can be calculated. Low priority sites are those where surface water quality impairment is suspected but pollutant loading estimates could not be calculated due to lack of adequate site details.

The 2011 In-stream survey results are those sites identified while conservation district staff were wading stretches of impaired waterways. Impairment locations were delineated by sources. Sources identified in the Upper Cass River include gully erosion, livestock access, stream crossing (eroding), streambank erosion, tile outlets, urban nps (urban nonpoint source or stormwater runoff), and ag nps (agricultural nonpoint source or field runoff).

Ag NPS priorities were those identified during the 2011 in-stream survey when conservation district staff identified priority areas to reduce field runoff. These locations are important to target for BMP's because a known impairment was observed. Ag NPS priority sites include field runoff, manure spreading, or inadequate buffer strips.

During the windshield survey, agricultural sites were classified by the practices that were installed on each site. Fields that were listed as having conventional tillage and 25% or less field residue are highlighted to aide in targeting of outreach programs for conservation tillage, grassed buffers, and cover crops. Table 7.4 further summarizes information shown in Figure 7.2 by subwatershed and recommended management measures.

Figure 7.2 All Impairment Locations, Upper Cass River



7.3 Implementation Priorities and Schedule

The inventories conducted in 2008 and 2011 were reviewed and prioritized by a technical committee for the Upper Cass River watershed including the Conservation District, MDEQ, Spicer Group, UM-Flint and the Saginaw Bay RC&D. A summary of priorities is shown below in Table 7.4.

Sources and locations were prioritized based upon the data collected during the 2011 field inventory. The highest priority sites are those where there is a known impairment and source, and pollutant loading estimates can be calculated. Lower priority sites are those where an opportunity has been identified to install practices that can reduce and/or prevent water quality impairments.

Table 7.4 Upper Cass River Implementation Priorities

Priority	Sub-shed	Management Measure	Technical Assistance Type	Quantity	Schedule	Site Specific Table and Maps
1	Spring Drain	Restrict livestock access, Manure Stacking, Livestock fencing and watering facilities	Landowner outreach and assistance with funding for practices to be installed	1 High priority site, 2 Medium priority sites	2014-2016	Table 7.4 Figure 7.3
1	Duff Creek & Middle Branch	Restrict livestock access, Livestock fencing and watering facilities	Landowner outreach and assistance	10 High priority sites	2014-2016	Table 7.5 Figure 7.3
2	Duff Creek	Gully Erosion Stabilization	Engineering and construction for grading, stabilization structures, and vegetation	19 priority sites	2015-2017	Table 7.6 Figure 7.4
3	Duff Creek & Gerstenberger Drain	Streambank Erosion Stabilization	Engineering and construction for grading, stabilization structures, and vegetation	12 priority sites totaling 2,364 linear feet	2015-2017	Table 7.7 Figure 7.5
4	Spring Drain	Conservation Tillage and Cover Crops	Landowner outreach and assistance with funding for practices to be installed	2,842 acres	2016-2018	Table 7.9 Figure 7.6
4	Duff Creek	Conservation Tillage and Cover Crops	Landowner outreach and assistance with funding for practices to be installed	4,550 acres	2016-2018	Table 7.11 Figure 7.7

Priority	Sub-shed	Management Measure	Technical Assistance Type	Quantity	Schedule	Site Specific Table and Maps
4	Stony Creek	Conservation Tillage and Cover Crops	Landowner outreach and assistance	4,730 acres	2016-2018	Table 7.13 Figure 7.8
4	Hartel Drain	Conservation Tillage and Cover Crops	Landowner outreach and assistance	480 acres	2016-2018	Table 7.15
5	Stony Creek	Tile Outlets	Engineering and construction for grading, stabilization structures, and vegetation	1 site	2016-18	Table 7.17 Figure 7.9
6	Entire upper sub-basin	Wetland Restoration	Landowner outreach and assistance	42,920 acres of high restoration potential	2016-18	Figure 7.10

7.4 Priority Source Loadings

Sources of pollutant loadings are discussed by priority: livestock access, gully erosion, streambank erosion, and cropland runoff.

Priority 1: Livestock access

Inventory

Livestock were identified as impacting water quality in the Upper Cass River during the 2011 in-stream and windshield surveys. Livestock sites were prioritized based on known impacts to water quality and distance to surface water. Spring Drain had a total of eight sites containing 654 animals that are estimated to be contributing 13,963 pounds of Phosphorous per year, and 46,904 pounds of Nitrogen per year (Table 7.5). Duff Creek inventory identified 22 sites where livestock are impacting or have the potential to be impacting water quality (Table 7.6). All livestock site information is available in an Excel table and map information is available in a GIS database.

Load Estimate Methodology

The Pollutant controlled calculation and documentation for Section 319 Watersheds Training Manual, June, 1999 section on Feedlot Pollution Reduction was utilized. The steps outlined in this document were developed into an Excel spreadsheet calculator. The calculation requires the determination of the average rainfall (R) per day by selecting the state and county in which the feedlot is located. The variable R is then calculated, in this case it is approximately R= 0.2848, as the watershed locations are within the same rainfall isopleths. The spreadsheet was set up so there were input areas for Slaughter Beef (feeder cattle); Dairy Cattle, Horses, Feeder Pigs (it was assumed that all pigs were feeders in the watershed), and sheep. So for Table 7.5 Spring Drain Impairments from Livestock Access, the pollutant loading calculator is set up to determine the Annual average mass load of pollutants in runoff using the following formula; the Mass load x Rain days per year x Correction Factor for number of rain days assuming the cows are "feeders" that yields approximately 54 lbs-P per year, and 270 lbs-N per year which could make its way to the watershed drainage system. Additionally, almost 360 lbs-BOD (biological oxygen demand) could be introduced into the surface water system annually from these feeder cattle on this site. A copy of the calculator is available for viewing in APPENDIX C, it is set up to show the above mentioned calculation.

Summary Tables

Table 7.5 Spring Drain Impairments from Livestock Access (Lapeer County)

Map Label	Lat.	Long.	# animals	acres	Type	Priority 1=High 2 = Med. 3= Low	Estimated Annual "P" Load (lbs/yr) ¹	Estimated "N" Load (lbs/yr) ¹	Estimated BOD Load (lbs/yr) ¹	Reduction Targets (Bacteria, Phosphorous, Nitrogen)
45	43.22748	-83.0781	300	5	cattle	1	810.0	4,049.0	5,399.0	100%
12	43.22533	-83.0677	21	12	20 cows, 1 horse	2	54.0	270.0	360.0	100%
51	43.25567	-83.0366	300	NR	sheep	2	49.0	567.0	405.0	100%
52	43.27052	-83.0618	13	NR	12 sheep; 1 pig	3	2.0	23.0	18.0	0%
48	43.27037	-83.0306	12	NR	sheep	3	2.0	23.0	16.0	0%
49	43.27004	-83	2	10	pigs	3	0.0	2.0	3.0	0%
45	43.25548	-83.051	4	200	3 sheep; 1 pig	3	1.0	6.0	6.0	0%
47	43.22631	-83.0248	2	10	horse	3	2.0	23.0	38.0	0%

¹See Appendix C for excel spreadsheet model

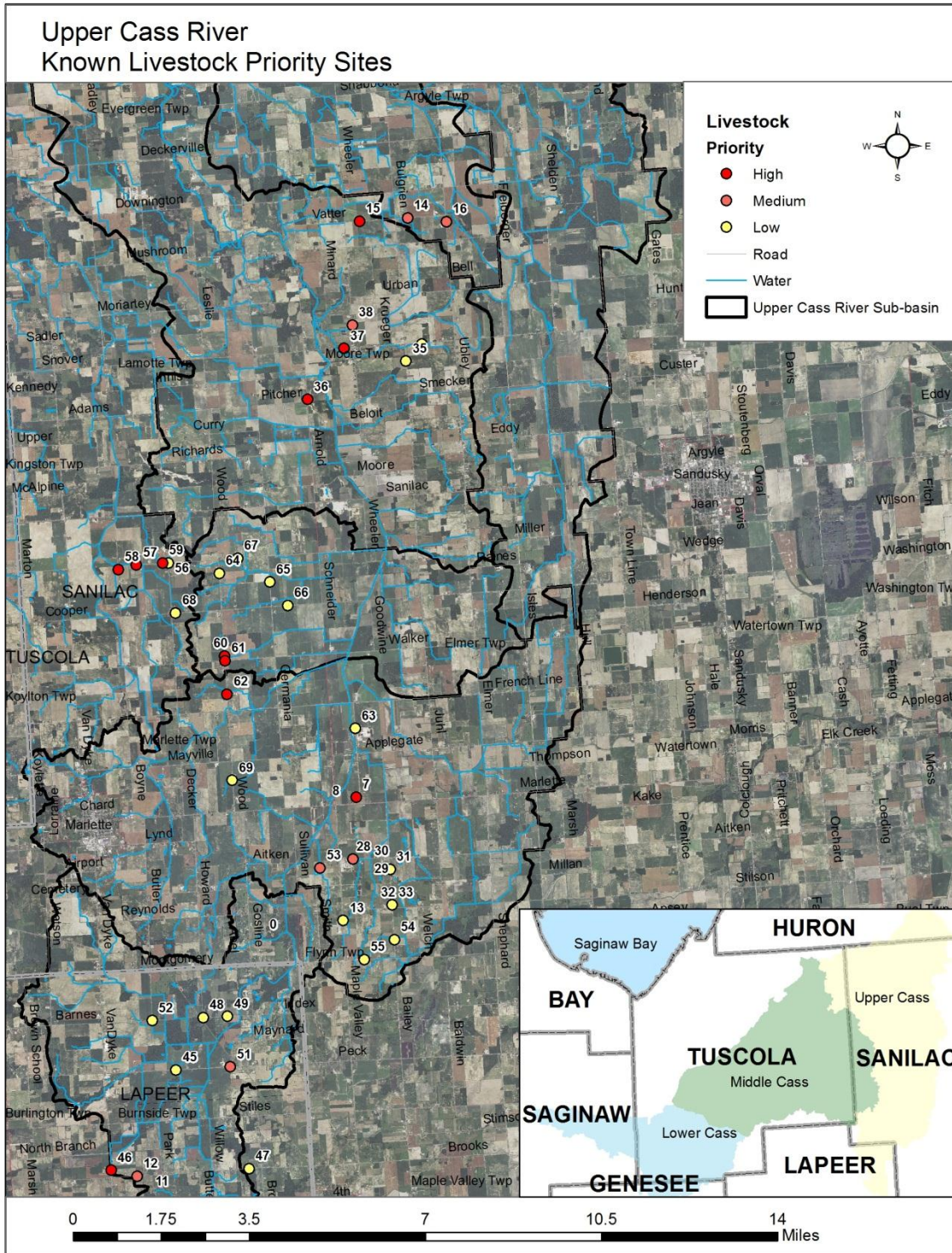
Table 7.6 Duff Creek Impairments from Livestock Access (Sanilac County)

Map Label	Lat.	Long.	# animals	acres	Type	Priority 1=High 2 = Med. 3= Low	Estimated Annual "P" Load (lbs/yr) ¹	Estimated "N" Load (lbs/yr) ¹	Estimated BOD Load (lbs/yr) ¹	Reduction Targets (Bacteria, Phosphorous, Nitrogen)
36	43.44688	-82.9897	212	15	10 cattle; 2 horses; 200 sheep	1	62.0	536.0	488.0	100%
37	43.4611	-82.9747	15	60	10 cattle; 3 horses; 2 pigs	1	31.0	171.0	241.0	100%
15	43.49752	-82.9666	70	35	cattle	1	189.0	945.0	1,260.0	100%
	UTM - Y	UTM - X								
7	4799369	339787	10	NR	sheep	1	2.0	19.0	13.0	100%
60	4804016	335862	300	NR	sheep	1	49.0	567.0	405.0	100%
61	4804016	335862	30	NR	sheep	1	5.0	57.0	40.0	100%
62	4803117	335868	50	NR	sheep	1	8.0	94.0	67.0	100%
	Lat	Long								
38	43.46774	-82.971	203	150	3 horses; 200 sheep	2	36.0	412.0	327.0	100%
16	43.49649	-82.9324	150	35	cattle	2	405.0	2,025.0	2,699.0	100%
28	43.31426	-82.9785	103	NR	3 horses; 100 sheep	2	20.0	223.0	192.0	100%
53	43.31294	-82.9008	30	40	cattle	2	75.0	773.0	756.0	100%

Map Label	Lat.	Long.	# animals	acres	Type	Priority 1=High 2 = Med. 3= Low	Estimated Annual "P" Load (lbs/yr) ¹	Estimated "N" Load (lbs/yr) ¹	Estimated BOD Load (lbs/yr) ¹	Reduction Targets (Bacteria, Phosphorous, Nitrogen)
14	43.49799	-82.9476	20	40	cattle	2	50.0	516.0	504.0	100%
13	43.29668	-82.9832	400	NR	cattle	3	248.0	2,578.0	2,519.0	0%
32/33	43.30069	-82.9636	12	40	3 cattle; 3 horses; 6 sheep	3	12.0	86.0	119.0	0%
54	43.29004	-82.9633	12	20	sheep	3	2.0	23.0	16.0	0%
55	43.28535	-82.976	5	40	pigs	3	1.0	4.0	9.0	0%
31	43.31096	-82.964	22	40	2 horses 20 sheep	3	6.0	61.0	65.0	0%
34	43.46158	-82.9439	8	NR	3 horses; 5 pigs	3	4.0	38.0	66.0	0%
35	43.45679	-82.9503	7	10	3 horses; 4 sheep	3	4.0	42.0	63.0	0%
69	480358	335879	150	NR	sheep	3	24.0	283.0	202.0	0%
73	43.30153	-82.9714	No Data	NR	NR	3	0	0	0	0%
106	43.29978 3	-82.9811	No data	NR	NR	3	0	0	0	0%

Summary Map

Figure 7.3 Livestock Priority Sites



Priority 2: Gully erosion sites

Inventory

Sites were identified during the in-stream walking survey conducted in 2011. A table and map series were created for sites to be readily identifiable when writing the follow up implementation grant to the Michigan DEQ. Gully Erosion was identified as second priority for the Upper Cass River. A total of 19 gully erosion sites were identifiable in Duff Creek during the in-stream inventory conducted in 2011 (Table 7.7).

Loading Estimate Methodology

Using the *Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual* (June, 1999), we are able to provide information on the nutrient aspect of sediment loading in a watershed in Table 7.7. Using the data gathered by field survey crews, the sediment loading could be estimated from the length, width and depth of the visible erosion. This would be developed, first into a volume, then a mass. From the mass and general type of soils, we used a ratio of 1.1 pounds of phosphorus per ton of sediment to obtain the pounds of phosphorus loading. For example, in Table 7.7 at Site #51, the erosion volume was estimated at 24 ft³ based on the field measurements of the gully erosion at that site. This estimate has to be converted to Tons, therefore, using the geotechnical reference manual *GeoTechnical Engineering-Principles and Practices, 1999 by D.P.Coduto* the soils in this area are well represented by a factor of 110 lbs/ft³, when this is divided by 2000 lbs/Ton the conversion factor of 0.055 Tons/ft³ is obtained. With the estimate of 24 ft³ x 0.055 T/ft³ ÷ 2 yrs = 1 Ton/Yr of sediment is produced with this calculation. Then applying the ratio of 1.1 lb-P / Ton of sediment we obtain the estimated load of 1.6 lbs-P/Yr for this particular gully erosion site.

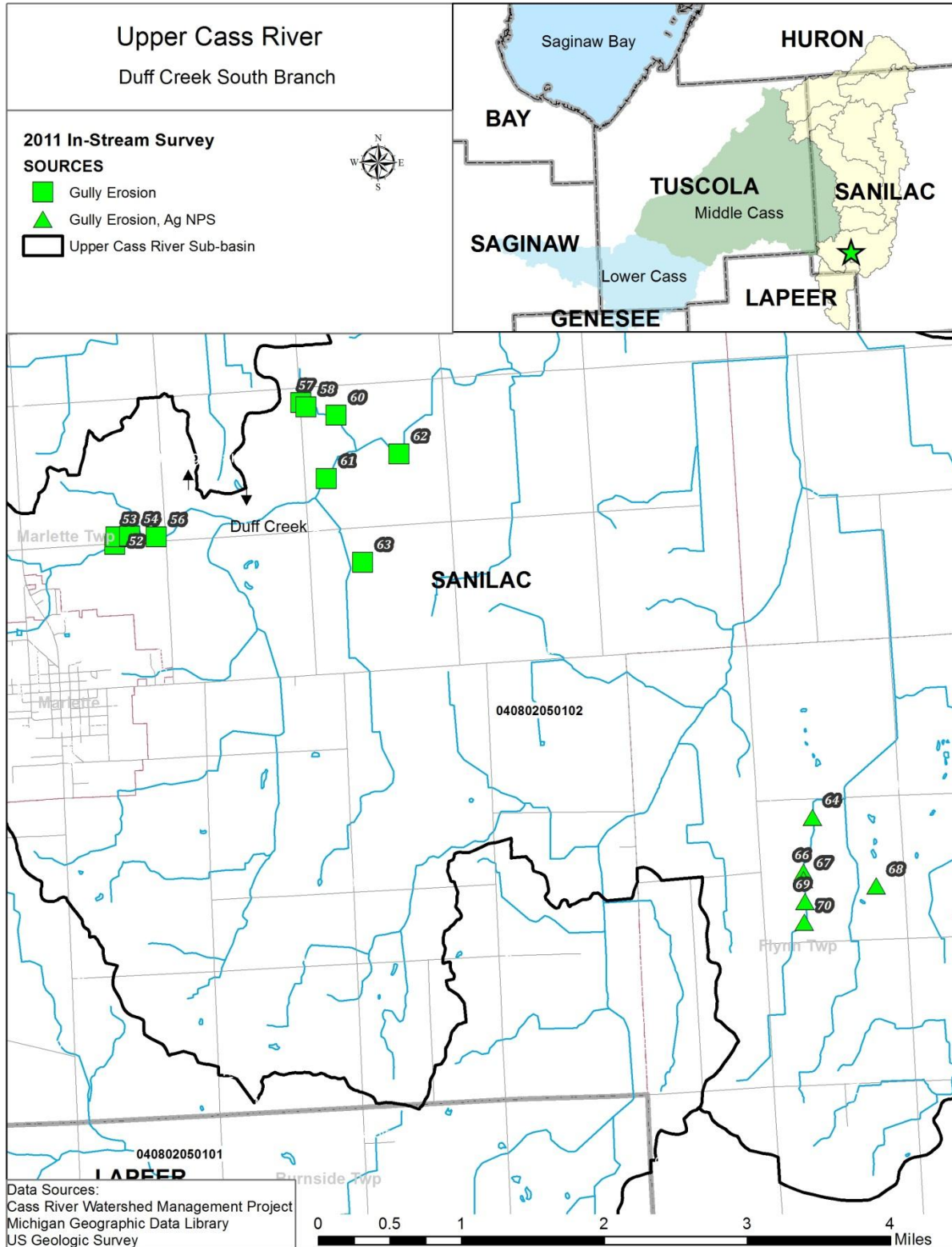
Summary Table

Table 7.7 Duff Creek Gully Erosion Sites

Site #	Latitude	Longitude	¹ Erosion volume (ft ³)	Soil weight (tons/ft ³)	No. of years	Sediment Load (tons/yr)	Est. Load - Phosphorus (lbs)	Est. Load - Nitrogen (lbs)	Reduction Targets (sediment, nutrients)
51	43.37638	-83.056117	24	0.055	2	0.7	0.7	1.5	100%
52	43.34248	-83.071517	15	0.055	5	0.2	0.2	0.4	100%
53	43.34327	-83.071367	96	0.055	5	1.1	1.2	2.3	100%
54	43.34327	-83.06945	120	0.055	5	1.3	1.5	2.9	100%
56	43.3431	-83.065733	48	0.055	5	0.5	0.6	1.2	100%
57	43.35615	-83.045033	30	0.055	5	0.3	0.4	0.7	100%
58	43.35572	-83.04435	36	0.055	5	0.4	0.4	0.9	100%
59	43.43815	-83.040517	80	0.055	5	0.9	1.0	1.9	100%
60	43.35477	-83.040183	72	0.055	5	0.8	0.9	1.7	100%
61	43.3484	-83.041883	67.5	0.055	5	0.7	0.8	1.6	100%
62	43.35063	-83.031683	2250	0.055	3	41.3	45.4	90.8	100%
63	43.3398	-83.03725	22.5	0.055	5	0.2	0.3	0.5	100%
64	43.31235	-82.976133	6	0.055	5	0.1	0.1	0.1	100%
65	43.31043	-83.976033	4	0.055	4	0.1	0.1	0.1	100%
66	43.30685	-82.977667	1800	0.055	5	19.8	21.8	43.6	100%
67	43.30608	-82.977667	12	0.055	5	0.1	0.1	0.3	100%
68	43.30517	-82.96765	64	0.055	5	0.7	0.8	1.5	100%
69	43.30387	-82.977567	9	0.055	5	0.1	0.1	0.2	100%
70	43.30175	-82.977767	240	0.055	2	2.6	0.7	1.5	100%

Summary Map

Figure 7.4 Gullies, Duff Creek



Priority 3: Streambank Stabilization

Inventory

Streambank erosion was inventoried as a part of the in-stream survey and identified as a major issue in the Upper Cass River. A total of 13 sites comprising 2,364 linear feet are in need of stabilization. Sites are presented in Table 7.8 and Figure 7.5. The inventory data collected in 2008 had some incomplete information, 'NR' is placed in the table where inventory information was not recorded.

Loading Estimate Methodology

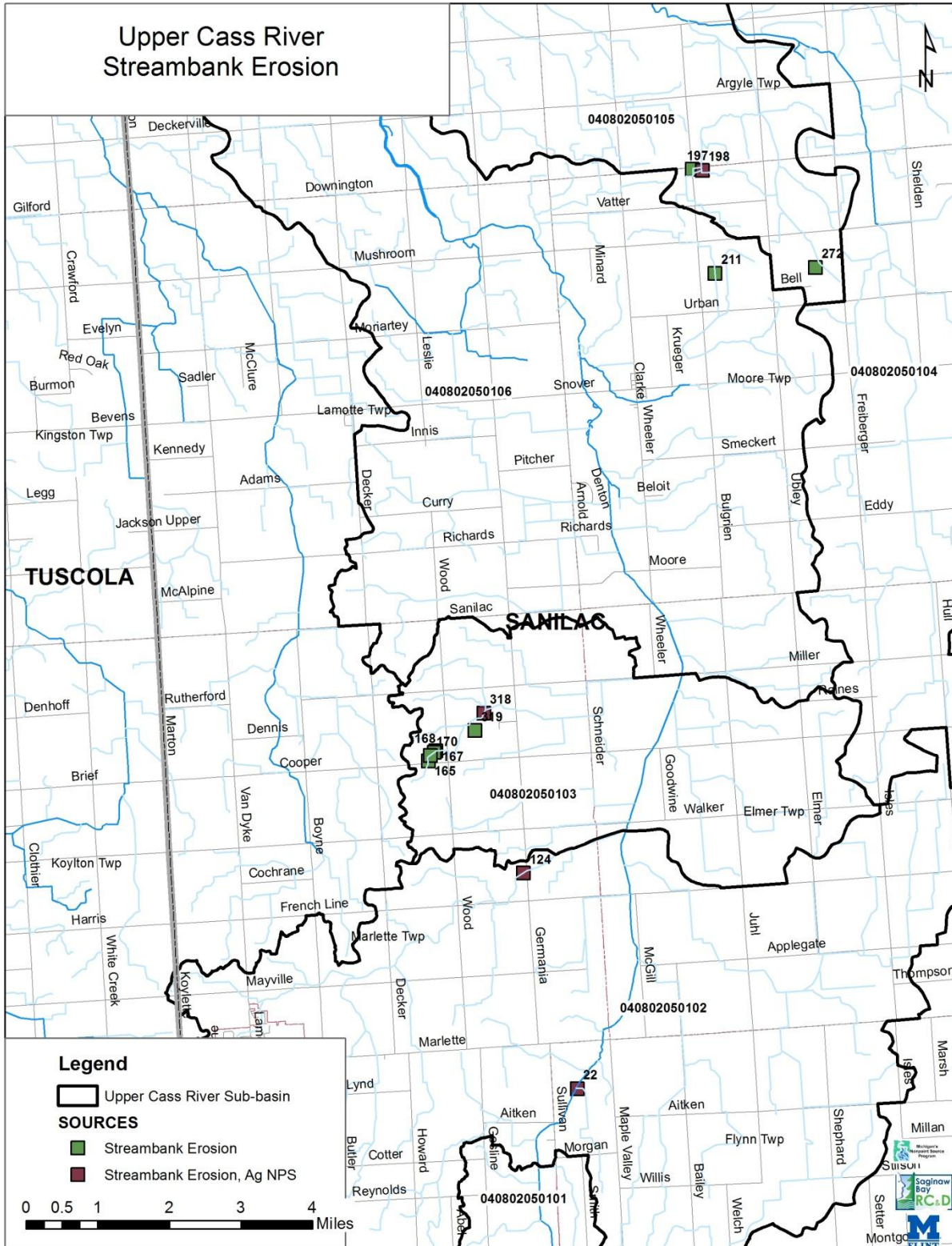
The loading reduction target for all streambank erosion sites is 100% assuming that the bank is stabilized to mitigate future erosion from occurring. For the loading calculations an identical calculation methods described for gully erosion sites; the soils in this area are well represented by a factor of 110 lbs/ft³, when this is divided by 2000 lbs/Ton the conversion factor of 0.055 Tons/ft³ is obtained.

Summary Table

Table 7.8 Streambank Stabilization, Upper Cass River

Site ID	Erosion Length (feet)	Erosion Width (feet)	Severity	Location	Apparent Cause	Sediment Load (tons/yr)	Est. Load - Phosphorus (lbs)	Est. Load - Nitrogen (lbs)
22	NR	NR	Undercut / Washout	Entire bank		7	8.2	16.3
124	50	6	Mostly bare bank	Entire bank	Storm water outfall	17	18.2	36.3
165	7	2	Mostly bare bank	Top of bank	No vegetative cover	1	0.8	1.7
167	10	2	Some bare bank	Top of bank	No vegetative cover	1	1.2	2.4
168	7	2	Some bare bank	Top of bank	No vegetative cover	1	0.8	1.7
170	10	3	Some bare bank	Top of bank	No vegetative cover	2	1.8	3.6
197	30	10	Undercut / Washout	Entire bank	No vegetative cover	17	18.2	36.3
198	20	10	Bare bank w / rills	High water mark		83	90.8	181.5
211	100	15	Mostly bare bank	Entire bank	No vegetative cover	55	60.5	121.0
272	100	10	Mostly bare bank	Entire bank	Systemic	440	484.0	968.0
318	1000	NR	NR	NR	NR	2	1.8	3.6
319	1000	8	NR	NR	NR	7	8.2	16.3
382	30	1	Bare bank w / rills	Top of bank	Storm water outfall	17	18.2	36.3

Figure 7.5: Streambank Erosion, Upper Cass River



Priority 4: Cropland Runoff

Inventory

Sites were selected that employed Conventional tilling methods and had minimal field residue, below is a summary by HUC-12 Code (Table 7.9). These sites were identified during the 2011 field inventory and are assumed to be the worst areas for agricultural runoff in each of the subwatersheds.

Table 7.9 Summary of sites identified for Agricultural Best Management Practices

HUC Name	HUC-12 CODE	Total HUC-12 Acres	Known Sites	Total Acreage of known sites	Supporting Tables and Maps
Spring Drain	402050101	19,723	46	2,842	Table 7.10 Table 7.11 Table 7.12 Figure 7.6
Duff Creek	402050102	31,528	64	3,873	Table 7.13 Table 7.14 Table 7.15 Figure 7.7
Stony Creek	402050106	36,499	64	4,730	Table 7.16 Table 7.17 Table 7.18 Figure 7.8
Hartel Drain	402050104	25,056	6	480	Table 7.19 not mapped
Middle Branch	402050105		27		Low priority, not mapped

Sites were prioritized by impairment and HIT Model Results and then cross-analyzed with sites inventoried in 2011 as having conventional tillage and 25% or less residue on the field. Duff Creek, Spring Drain, and Stony Creek were all identified as priority areas for working with landowners for the installation of cover crops and conservation tillage. Duff Creek has been listed as a priority by the MDEQ in the TMDL that was developed back in 2004. The Nature Conservancy is also working with local conservation districts to install best management practices on fields in these subwatersheds. Therefore, the Middle Branch and Hartel Drain will not be recommended for BMP implementation as they are extremely low priority in regards to impacting water quality improvement.

Loading Estimate Methodology

The STEPL model was used to calculate the total contribution of nitrogen load in pounds per year, phosphorous load in pounds per year, biological oxygen demand in pounds per year, and sediment in tons per year by subwatershed for known acreage of problem sites.

Estimated reductions for three practices were calculated at the subwatershed level using the HIT Model. Sediment and phosphorous reductions were estimated for mulch-till, no-till and 30 foot grass buffers. Spring Drain has 46 fields totaling 2,842 acres of agricultural land in production using conventional tiling and cropping practices while Duff Creek has 64 fields totaling 3,873 acres, and Stony Creek has 65 sites totaling 4,730 acres. The HIT model was used to calculate pollution reductions that would occur should the worst 5% and/or 10% total agricultural area be put into a type of conservation tillage.

Summary Tables and Maps

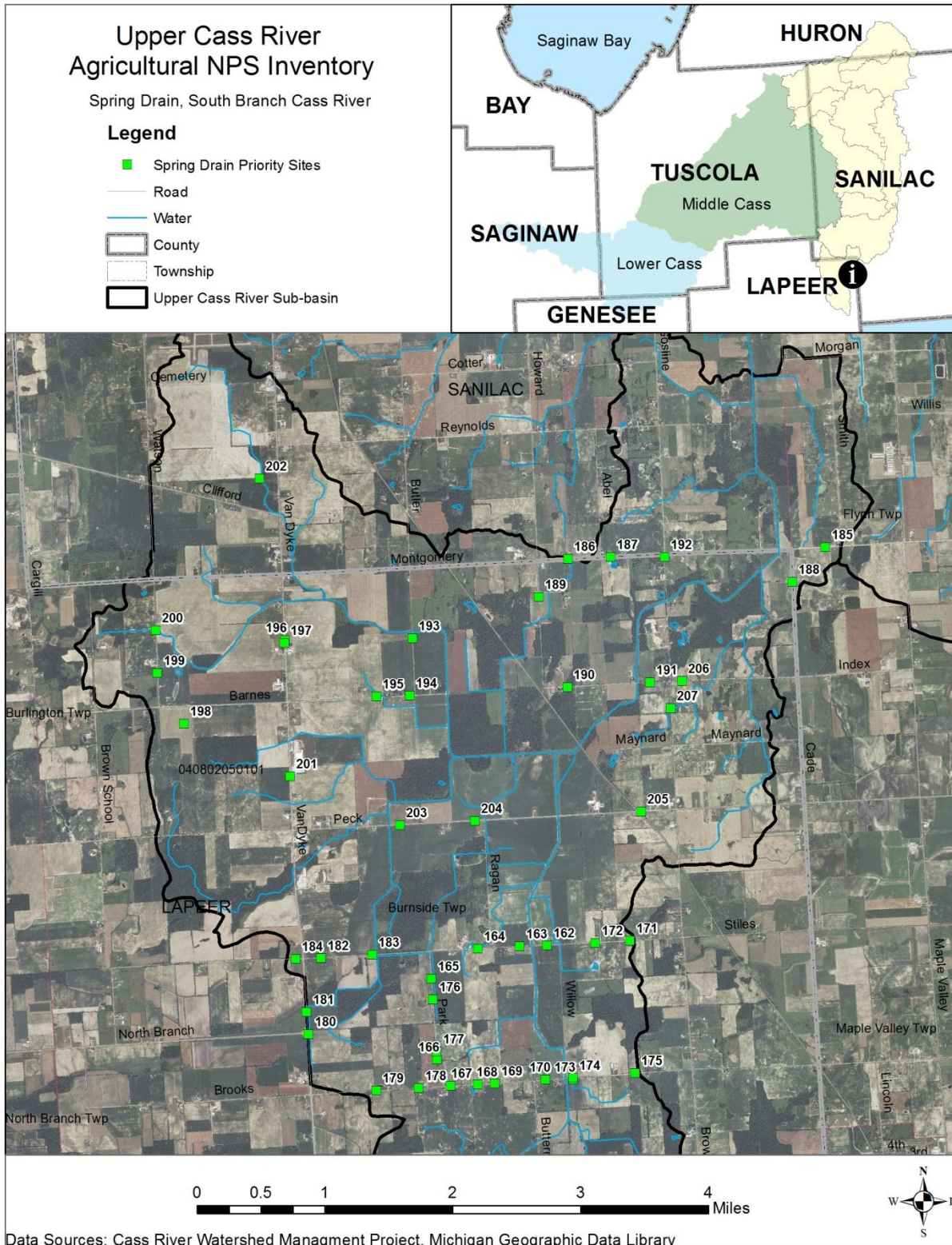
A series of tables and figures follows for each of the subwatersheds that were inventoried during the 2011 windshield survey. For the Spring Drain, Table 7.10 provides a list of field identified where practices can be installed; Table 7.11 provides pollutant loads estimates, Table 7.12 provides an estimation of pollutant reduction and a cost benefit analysis, while Figure 7.6 provides locations for the sites described in Table 7.10. For the Duff Creek, Table 7.13 lists each site for potential installation of conservation tillage and cover crops and are also shown in Figure 7.7. Stony Creek has 65 potential sites totaling 4,730 acres for implementing practices for conservation tillage and cover cropping. Table 7.16 shows locations identified in 2011 as having 25% or less residue on fields and employed conventional tillage. Locations are shown in Figure 7.8 for Stony Creek.

Table 7.10 Spring Drain, Priority Sources of Agricultural Nonpoint Source Pollution

Label	Township	Latitude	Longitude	Field Size (acres)	Field Orientation	Slope of Land	Residue Type	Percent Residue
162	Burnside	43.241110	-83.040520	40	N-S	Moderate	Corn	0 - 25%
163	Burnside	43.241070	-83.044750	6	N-S	Moderate		0 - 25%
164	Burnside	43.240990	-83.051270	80	N-S	Moderate		0 - 25%
165	Burnside	43.237780	-83.058610	80	N-S	Flat	Corn	0 - 25%
166	Burnside	43.228620	-83.058210	60	E-W	Flat		0 - 25%
167	Burnside	43.225570	-83.056180	16		Moderate		0 - 25%
168	Burnside	43.225610	-83.051980	45	N-S	Flat	Corn	0 - 25%
169	Burnside	43.225690	-83.049350	5	N-S	Flat		0 - 25%
170	Burnside	43.225880	-83.041500	50	N-S	Flat		0 - 25%
171	Burnside	43.241280	-83.027630	13	N-S	Moderate		0 - 25%
172	Burnside	43.241180	-83.033030	80	N_S	Moderate		0 - 25%
173	Burnside	43.225790	-83.037220	80	E-W	Moderate		0 - 25%
174	Burnside	43.225990	-83.037220	9	N-S	Flat		0 - 25%
175	Burnside	43.226250	-83.027580	9	N-S	Flat		0 - 25%
176	Burnside	43.235410	-83.058500	90	N-S	Moderate		0 - 25%
177	Burnside	43.229500	-83.058180	40	E-W	Moderate		0 - 25%
178	Burnside	43.225430	-83.061160	30	E-W	Moderate		0 - 25%
179	Burnside	43.225330	-83.067740	12	None (pasture)	Flat		0 - 25%
180	Burnside	43.232000	-83.077970	60	E-W	Hilly		0 - 25%
181	Burnside	43.234500	-83.078110	30	E-W	Flat		0 - 25%
182	Burnside	43.240580	-83.075570	40	E-W	Flat		0 - 25%
183	Burnside	43.240730	-83.067650	45	N-S	Flat		0 - 25%
184	Burnside	43.240550	-83.079530	12	N-S	Flat		26 - 50%
185	Flynn	43.285050	-82.995150	100	E/W	Flat		0 - 25%
186	Burnside	43.284750	-83.035140	100	N/s	Hilly	Bean	0-25%
187	Burnside	43.284810	-83.028510	80	N/s	Hilly	Wheat	0-25%
188	Burnside	43.281230	-83.000440	10	N/s	Hilly	Bean	0-25%

Label	Township	Latitude	Longitude	Field Size (acres)	Field Orientation	Slope of Land	Residue Type	Percent Residue
189	Burnside	43.280570	-83.039870	30	N/s	Flat	Corn	0-25%
190	Burnside	43.270270	-83.035900	40	N/s	Flat	Bean	0-25%
191	Burnside	43.270450	-83.023070	40	N/s	Flat	Corn	0-25%
192	Burnside	43.284600	-83.020130	60	N/s	Flat	Corn	0-25%
193	Burnside	43.276410	-83.059680	80	N/s	Flat	Bean	0-25%
194	Burnside	43.269920	-83.060410	100	N/s	Flat	Bean	0-25%
195	Burnside	43.269983	-83.065570	200	N/s	Flat	Bean	0-25%
196	Burnside	43.276690	-83.079480	80	E/w	Flat	Corn	0-25%
197	Burnside	43.276410	-83.079520	80	N/s	Flat	Bean	0-25%
198	Burnside	43.267620	-83.095570	80	N/s	Flat	Corn	0-25%
199	Burnside	43.273500	-83.099400	100	E/w	Flat	Corn	0-25%
200	Burnside	43.278310	-83.099440	200	E/w	Moderate	Corn	0-25%
201	Burnside	43.261240	-83.079380	80	N/s	Flat	Bean	0-25%
202	Burnside	43.295090	-83.082510	100	N/s	Flat	Corn	0-25%
203	Burnside	43.255310	-83.062670	40	E/w	Flat	Bean	0-25%
204	Burnside	43.255480	-83.051010	200	N/s	Flat	Bean	0-25%
205	Burnside	43.255860	-83.025160	30	N/s	Moderate	Corn	0-25%
206	Burnside	43.270480	-83.018130	40	E/w	Hilly	Corn	0-25%
207	Burnside	43.267450	-83.020000	40	E/w	Moderate	Bean	0-25%

Figure 7.6: Spring Drain, Priority Sources of Agricultural Nonpoint Source Pollution



Pollutant loading reductions were estimated for nitrogen (N), phosphorus (P), biological oxygen demand (BOD), and sediment at the subwatershed level utilizing the STEPL Model, results are shown below in Table 7.11.

Table 7.11 Spring Drain, Pollutant loads and reductions, STEPL Model

2,842 Acres of Cropland	N Load (no BMP) (lb/yr)	P Load (no BMP) (lb/yr)	BOD Load (no BMP) (lb/yr)	Sediment Load (no BMP) (lb/yr)
	9281.5	2363.9	19123.5	1236.3
	N Load (with BMP) (lb/yr)	P Load (with BMP) (lb/yr)	BOD Load (with BMP) (lb/yr)	Sediment Load (with BMP) (t/yr)
	2322.33	595.53	12500.98	201.51
	% N Reduction	% P Reduction	% BOD Reduction	% Sed Reduction
	75.0	74.8	34.6	83.7

Table 7.12 provides a comparison for the amount of sediment reduction and the associated cost per benefit for the installation cost for Best Management Practices (BMPs) per ton of sediment reduced and the pounds per year of phosphorous reduction compared to the cost per pound of sediment reduction.

The sites identified in the Spring Drain subwatershed total 2,842 acres and comprise 14% of the total land area of the subwatershed. Targets for BMP implementation are 986 acres to achieve the loading reductions outlined in Table 7.12 for the worst 5% of the subwatershed and 1,972 acres for the worst 10% of the subwatershed.

No-till provides the greatest annual reduction in sediment for the Spring Drain when applied to the worst 10% of the acreage in crop production. However, the most cost-effective practices is No-till on the worst 5% of the acreage in crop production reducing 352 tons per year of sediment at \$39 per ton reduction and 300 pounds of phosphorus per year at a cost of \$46 per pound reduced.

Table 7.12 Spring Drain Estimated Reductions in Pollutants

Practice	Sediment Reduction (tons/yr)	BMP cost benefit (\$/ton reduction)	Phosphorous Reduction (lbs/yr) / \$/lb-P
mulch till for worst 5% (986 acres)	151	\$65	128 / \$77
mulch till worst 10% (1,927 acres)	204	\$97	173 / \$114
No Till on worst 5% (986 acres)	352	\$39	300 / \$46
No Till on worst 10% (1,927 acres)	476	\$58	405 / \$68
30ft grass buffer	299	\$145	254 / \$171

Table 7.13 Duff Creek, Priority Sources of Agricultural Nonpoint Source Pollution

Label	Township	Section	Latitude	Longitude	Field Size (acres)	Field Orientation	Slope of Land	Residue Type
1	Flynn	7	43.306770	-82.989770	100	N/S	Flat	0
2	Flynn	6	43.313700	-82.983850	80	E/W	Flat	Corn
3	Flynn	6	43.320230	-82.984100	150	N/S	Moderate	0
4	Flynn	18	43.292280	-82.983060	40	E/W	Flat	0
5	Flynn	20	43.285330	-82.978920	100	N/S	Flat	0
6	Flynn	18	43.285930	-82.982880	100		Flat	0
7	Flynn	18	43.289720	-82.982990	40	E/W	Flat	Corn
8	Flynn	18	43.299030	-82.983260	100	E/W	Flat	0
9	Flynn	7	43.306590	-82.994670	40	E/W	Flat	Corn
10	Flynn	6	43.329890	-82.988580	40	E/W	Flat	Wheat
11	Flynn	6	43.327890	-83.001190	80	N/S	Flat	Corn
12	Flynn	6	43.319120	-83.000950	40	Varies	Flat	Other
13	Flynn	8	43.299780	-82.970710	40	Varies	Flat	Other
14	Flynn	17	43.299770	-82.976570	100	N/S	Flat	Corn
15	Flynn	17	43.299770	-82.976520	100	N/S	Flat	Corn
16	Flynn	17	43.299770	-82.981210	100	N/S	Flat	Corn
17	Flynn	8	43.301150	-82.983360	80	E/W	Flat	Corn
18	Flynn	8	43.304420	-82.983420	80	E/W	Flat	Corn
19	Flynn	8	43.307100	-82.983580	40	E/W	Flat	Corn
20	Flynn	8	43.314250	-82.974060	80	E/W	Moderate	Corn
21	Flynn	8	43.314250	-82.974060	80	E/W	Moderate	Corn
22	Flynn	4	43.321670	-82.964300	80	N/S	Flat	Wheat
23	Flynn	4	43.321670	-82.964300	80	N/S	Flat	Wheat
24	Flynn	4	43.329790	-82.964600	160	N/S	Flat	Corn
25	Flynn	5	43.329830	-82.964600	240	N/S	Flat	Corn
26	Flynn	5	43.330050	-82.974510	80	N/S	Hilly	Bean

Label	Township	Section	Latitude	Longitude	Field Size (acres)	Field Orientation	Slope of Land	Residue Type
27	Flynn	5	43.329920	-82.983480	80	E/W	Hilly	Corn
28	¹ Flynn	8	43.310960	-82.963960	40	E/W	Moderate	Other
29	Flynn	9	43.308380	-82.938300	200	N/S	Hilly	Corn
30	² Flynn	9	43.300690	-82.963580	40		Flat	Bean
31	³ Flynn	9	43.300690	-82.963580	40		Flat	Bean
32	⁴ Flynn	4	43.327300	-82.944620	40	E/W	Moderate	Bean
33	Flynn	9	43.314300	-82.944860	80	N/S	Flat	Corn
34	Flynn	9	43.314300	-82.947670	80	N/S	Flat	Corn
35	Flynn	9	43.314290	-82.950449	40	N/S	Moderate	Corn
36	Flynn	9	43.314300	-82.952780	80	N/S	Flat	Corn
37	Flynn	4	43.314310	-82.954400	100	N/S	Flat	Corn
38	Flynn	9	43.314330	-82.957440	100	N/S	Moderate	Bean
39	Flynn	16	43.299860	-82.945070	80	N/S	Flat	Corn
40	Flynn	9	43.304990	-82.943890	20	E/W	Moderate	Bean
41	Flynn	16	43.299830	-82.954740	80	N/S	Moderate	Corn
42	⁵ Flynn	17	43.297880	-82.963500	40		Moderate	Bean
43	Flynn	16	43.295380	-82.963420	20		Flat	Bean
44	Flynn	16	43.293940	-82.963410	80	N/S	Flat	Bean
45	Flynn	16	43.285980	-82.963150	80	N/S	Flat	Corn
46	Flynn	16	43.299800	-82.961430	40	E/W	Flat	Corn
47	Flynn	16	43.285340	-82.962660	40	N/S	Flat	Corn
48	⁶ Flynn	17	43.285350	-82.968200	40		Flat	Corn
49	⁷ Flynn	17	43.285350	-82.968200	40		Flat	Corn
50	⁸ Flynn	17	43.285350	-82.976000	40		Flat	Corn
51	Flynn	17	43.285310	-82.976000	80	N/S	Flat	Bean
			UTM-Y	UTM-X				
52	Elmer	32	4799378	341926	30		Flat	Bean
53	Elmer	32	4799376	341869	40		Flat	Wheat

Label	Township	Section	Latitude	Longitude	Field Size (acres)	Field Orientation	Slope of Land	Residue Type
54	Elmer	31	4799364	340427	20		Flat	Bean
55	Elmer	31	4799371	339226	40		Moderate	Bean
56	Elmer	31	4799617	339919	10		Moderate	Bean
57	Elmer	32	4799897	342336	80		Flat	Wheat
58	Marlette	36	4799367	338508	40		Flat	Corn
59	Marlette	34	4799347	335364	80	N/S	Flat	Corn
60	Marlette	34	4799347	335364	40		Moderate	Corn
61	Marlette	34	4799751	335879	80	N/S	Hilly	Corn
62	Marlette	33	4799724	334266	80	N/S	Moderate	Corn
63	Marlette	34	4799724	334266	80	N/S	Moderate	Corn
64	Marlette	33	4799332	334262	80	N/S	Moderate	Corn

¹Amish farm with mixed crops on 20 acres

²Amish farm: 10 acres corn, 30 acres pasture with mixed livestock

³Amish farm: 10 acres corn, 30 acres pasture with mixed livestock

⁴Clover cover crop

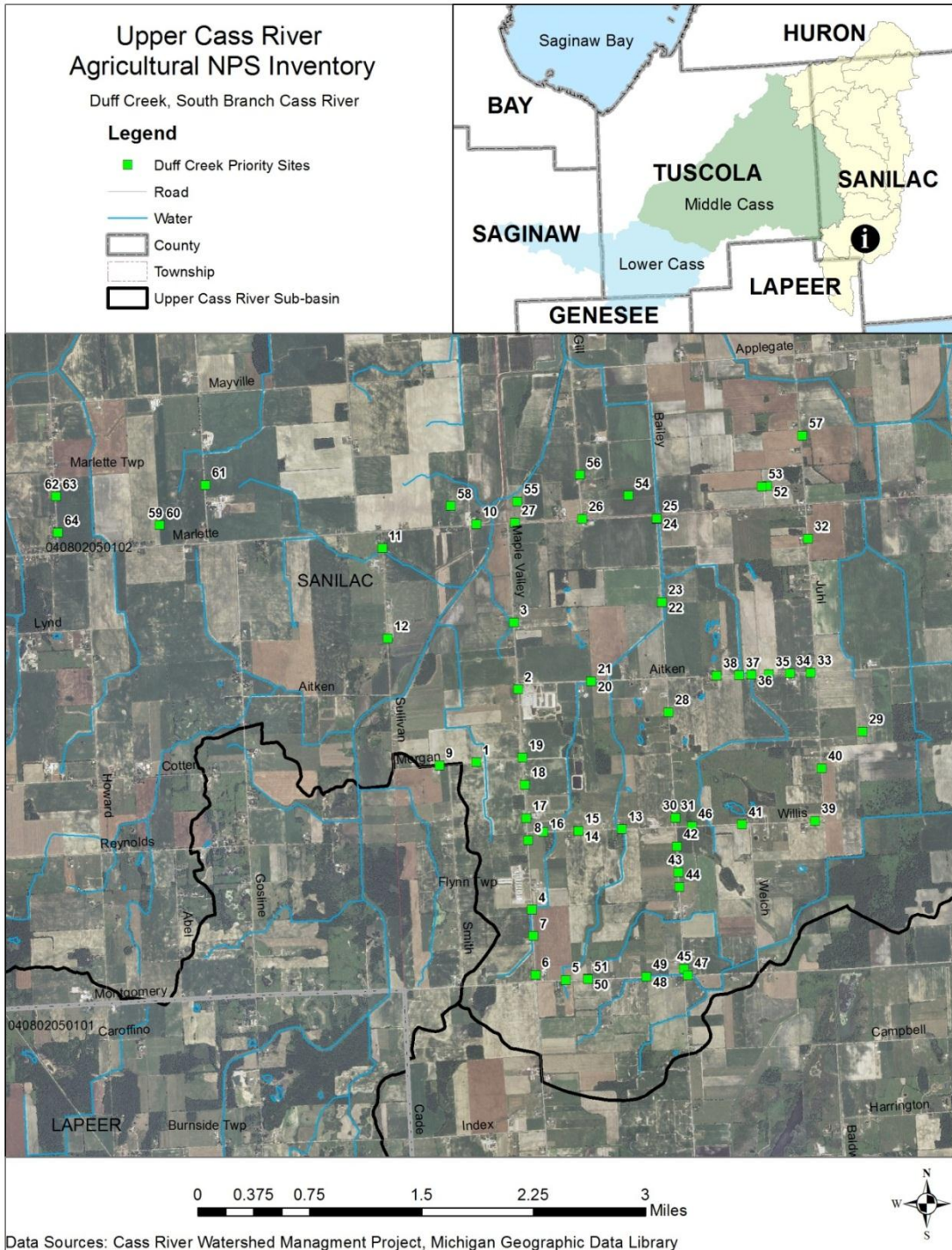
⁵Amish pasture with some oats planted

⁶Amish field of mixed crops: corn, oats, vegetables

⁷Amish field of mixed crops: corn, oats, vegetables

⁸Amish field of mixed crops: corn, oats, vegetables

Figure 7.7 Duff Creek, Priority Sources of Agricultural Nonpoint Source Pollution



Pollutant loading reductions were estimated for nitrogen (N), phosphorus (P), biological oxygen demand (BOD), and sediment at the subwatershed level utilizing the STEPL Model, results are shown below in Table 7.14.

Table 7.14 Duff Creek, Pollutant loads and reductions, STEPL Model

3,873 Acres of Cropland	N Load (no BMP) (lb/yr)	P Load (no BMP) (lb/yr)	BOD Load (no BMP) (lb/yr)	Sediment Load (no BMP) (lb/yr)
	9,720.0	2,013.7	20,241.1	659.1
	N Load (with BMP) (lb/yr)	P Load (with BMP) (lb/yr)	BOD Load (with BMP) (lb/yr)	Sediment Load (with BMP) (t/yr)
	2,741.2	628.7	16,710.3	107.4
	% N Reduction	% P Reduction	% BOD Reduction	% Sed Reduction
	71.8	68.8	17.4	83.7

Table 7.15 provides a comparison for the amount of sediment reduction and the associated cost per benefit for the installation cost for Best Management Practices (BMPs) per ton of sediment reduced and the pounds per year of phosphorous reduction compared to the cost per pound of sediment reduction.

The 2011 field inventory identified 64 sites in the Duff Creek totaling 3,873 acres comprising 14% of the total subwatershed area. Targets for BMP implementation are 1,576 acres to achieve the loading reductions outlined in Table 7.13 for the worst 5% of the subwatershed and 3,152 acres for the worst 10% of the subwatershed.

No-till provides the greatest annual reduction in sediment for the Duff Creek when applied to 10% of the acreage in crop production. However, the most cost-effective practice is No-till on 5% of the acreage in crop production reducing 641 tons of sediment annually at a cost of \$34 per ton, and 545 pounds of phosphorus annually at a cost of \$39 per pound reduced.

Table 7.15 Estimated Reductions in Pollutants for Duff Creek

Practice	Sediment Reduction (tons/yr)	BMP cost benefit (\$/ton reduction)	Phosphorous Reduction (lbs/yr) / \$/lb-P
mulch till on sediment for worst 5% (1,576 acres)	275	\$57	234 / \$67
mulch till on sediment for worst 10% (3,152 acres)	358	\$88	304 / \$104
No Till on sediment for worst 5% (1,576 acres)	641	\$34	545 / \$41
No Till on sediment for worst 10% (3,152 acres)	834	\$53	709 / \$62
sediment for 30ft grass buffer	782	\$122	665 / \$143

Table 7.16 Stony Creek, Priority Sources of Agricultural Nonpoint Source Pollution

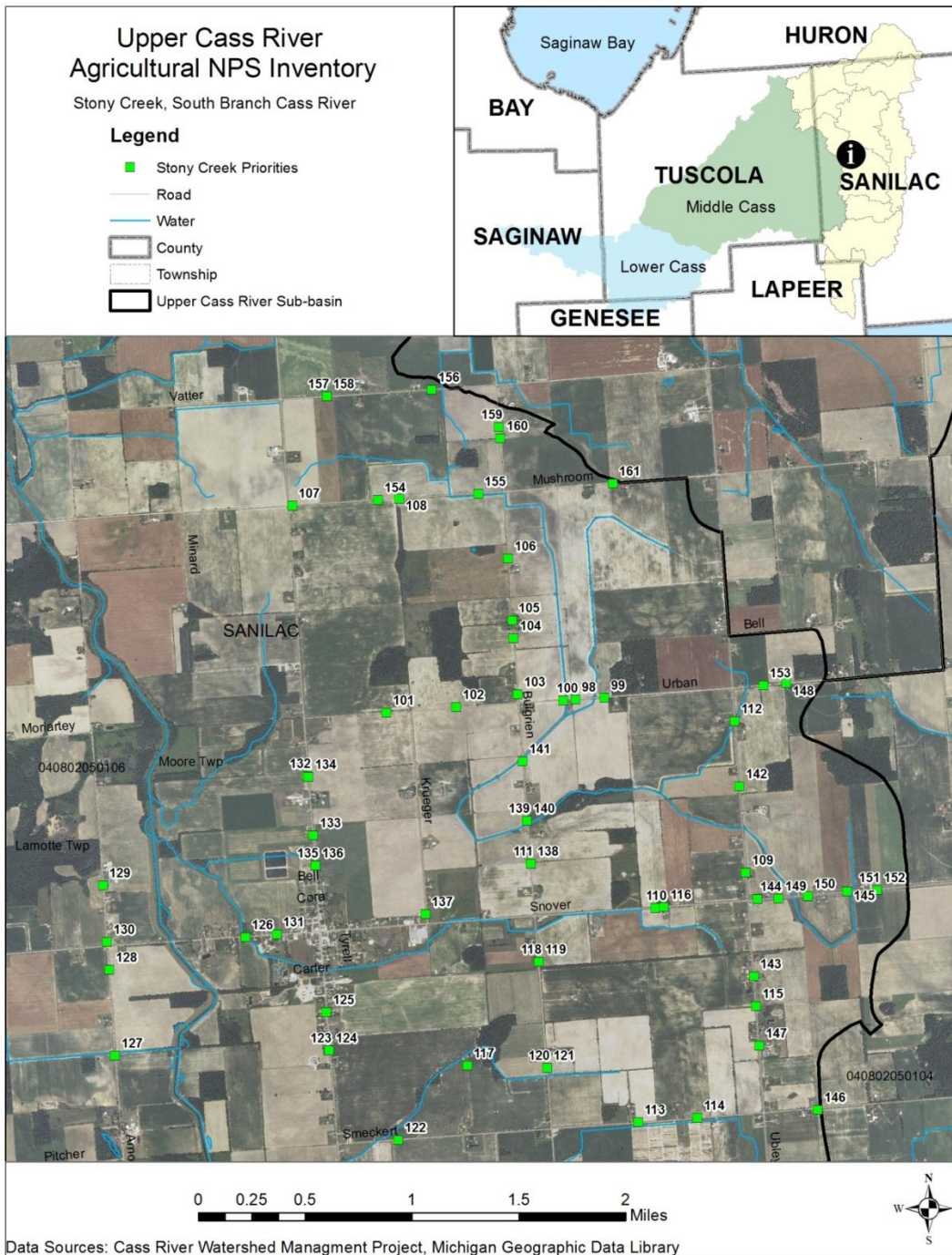
Label	Township	Section	Latitude	Longitude	Field Size (acres)	Field Orientation	Slope of Land	Residue Type
98	Moore	9	43.476290	-82.946124	200	N/S	Flat	Corn
99	Moore	9	43.476340	-82.943410	120	E/W	Flat	Sugar Beet
100	Moore	9	43.476250	-82.947230	40		Flat	Bean
101	Moore	8	43.475880	-82.963760	140	E/W	Moderate	Bean
102	Moore	8	43.476060	-82.957230	40	N/S	Moderate	Bean
103	Moore	8	43.476790	-82.951490	15	N/S	Moderate	Corn
104	Moore	8	43.480600	-82.951680	40	E/W	Moderate	Bean
105	Moore	8	43.481830	-82.951730	20	E/W	Moderate	Corn
106	¹ Moore	8	43.486030	-82.951900	60	E/W	Moderate	Wheat
107	Moore	8	43.490130	-82.971810	150	E/W	Flat	Bean
108	Moore	8	43.490360	-82.961850	80	N/S		Wheat
109	Moore	16	43.464120	-82.930890	60	N/S	Flat	Bean
110	Moore	16	43.461960	-82.939410	40	N/S	Flat	Corn
111	Moore	16	43.465260	-82.950830	80	E/W	Flat	Bean
112	Moore	16	43.474410	-82.931390	120	E/W	Flat	Corn
113	Moore	21	43.447460	-82.941730	40	E/W	Flat	
114	Moore	21	43.447620	-82.936220	80	N/S	Flat	Corn
115	Moore	21	43.455050	-82.930380	80	E/W	Flat	Corn
116	Moore	21	43.461980	-82.938610	120	N/S	Flat	Wheat
117	Moore	20	43.451740	-82.957430	60	N/S	Flat	Corn
118	Moore	20	43.458600	-82.950430	40	E/W	Flat	Corn
119	Moore	20	43.458600	-82.950430	40	E/W	Flat	Corn
120	Moore	21	43.451370	-82.950020	150	E/W	Flat	Wheat
121	Moore	21	43.451370	-82.950020	150	E/W	Flat	Wheat
122	Moore	20	43.446840	-82.964120	150	N/S	Flat	Corn

Label	Township	Section	Latitude	Longitude	Field Size (acres)	Field Orientation	Slope of Land	Residue Type
123	Moore	20	43.453100	-82.970220	100	E/W	Flat	Corn
124	Moore	20	43.453100	-82.970220	100	E/W	Flat	Corn
125	Moore	20	43.455700	-82.970340	100		Flat	Bean
126	Moore	19	43.461000	-82.977620	20	N/S	Flat	Wheat
127	Moore	17	43.453290	-82.990160	70	E/W	Moderate	Bean
128	Moore	19	43.459110	-82.990420	150	N/S	Flat	Corn
129	Moore	18	43.464870	-82.990720	60	N/S	Flat	Bean
130	Moore	18	43.461020	-82.990530	40	E/W	Moderate	Wheat
131	Moore	18	43.461100	-82.974720	60	N/S	Flat	Bean
132	Moore	18	43.471780	-82.971340	40	E/W	Flat	Bean
133	Moore	18	43.467740	-82.970990	150	E/W	Flat	Corn
134	Moore	17	43.471710	-82.971230	150	E/W	Flat	Corn
135	Moore	18	43.465670	-82.970850	5	N/S	Flat	Bean
136	Moore	17	43.465660	-82.970860	60	E/W	Flat	Bean
137	Moore	17	43.462120	-82.960810	70	N/S	Flat	Corn
138	Moore	16	43.465260	-82.950830	80	E/W	Flat	Bean
139	Moore	16	43.468200	-82.951020	100	E/W	Flat	Sugar Beet
140	Moore	16	43.468200	-82.951020	100	E/W	Flat	Sugar Beet
141	Moore	17	43.472220	-82.951220	80	E/W	Flat	Bean
142	Moore	16	43.469990	-82.931160	40	E/W	Flat	Corn
143	Moore	22	43.457070	-82.930460	40	E/W	Flat	
144	Moore	22	43.462320	-82.929890	40	E/W	Flat	Corn
145	Moore	22	43.462600	-82.921510	30	N/S	Flat	Corn
146	Moore	22	43.447860	-82.924980	20	E/W	Flat	
147	Moore	22	43.452350	-82.930210	80	E/W	Flat	Corn
148	Moore	10	43.476890	-82.926460	40	E/W	Flat	Corn
149	Moore	15	43.462280	-82.927880	20	E/W	Flat	

Label	Township	Section	Latitude	Longitude	Field Size (acres)	Field Orientation	Slope of Land	Residue Type
150	Moore	15	43.462380	-82.925180	120	N/S	Flat	Corn
151	Moore	15	43.462610	-82.918690	30	N/S	Flat	Corn
152	Moore	22	43.462600	-82.918680	30	N/S	Flat	Corn
153	Moore	15	43.476790	-82.928580	70	N/S	Flat	Corn
154	Moore	5	43.490310	-82.963830	50	E/W	Flat	
155	Moore	5	43.490480	-82.954470	20	N/S	Flat	
156	Moore	5	43.497680	-82.958440	120	E/W	Flat	Corn
157	Moore	5	43.497490	-82.968230	80	N/S	Flat	
158	Moore	5	43.497490	-82.968230	80	N/S	Flat	
159	Moore	4	43.494980	-82.952320	10	E/W	Flat	
160	Moore	4	43.494210	-82.952240	80	E/W	Flat	Corn
161	Moore	4	43.490860	-82.941910	80	N/S	Flat	

¹Surface drain caused gully erosion 43.48370N/ 082.95181W

Figure 7.8: Stony Creek, Priority Sources of Agricultural Nonpoint Source Pollution



Pollutant loading reductions were estimated for nitrogen (N), phosphorus (P), biological oxygen demand (BOD), and sediment at the subwatershed level utilizing the STEPL Model, results are shown below in Table 7.17.

Table 7.17 Stony Creek, Pollutant loads and reductions, STEPL Model

4,730 Acres of Cropland	N Load (no BMP) (lb/yr)	P Load (no BMP) (lb/yr)	BOD Load (no BMP) (lb/yr)	Sediment Load (no BMP) (lb/yr)
	11,870.8	2,459.3	24,719.9	805.0
	N Load (with BMP) (lb/yr)	P Load (with BMP) (lb/yr)	BOD Load (with BMP) (lb/yr)	Sediment Load (with BMP) (t/yr)
	3,347.8	767.8	20,407.9	131.2
	% N Reduction	% P Reduction	% BOD Reduction	% Sed Reduction
	71.8	68.8	17.4	83.7

The 2011 field inventory identified 65 sites in the Stony Creek totaling 4,730 acres comprising 13% of the total subwatershed area. Targets for BMP implementation are 1,824 acres to achieve the loading reductions outlined in Table 7.18 for the worst 5% of the subwatershed and 3,649 acres for the worst 10% of the subwatershed.

Table 7.18 shows pollutant reduction estimates from the HIT model for the Stony Creek subwatershed. No Till on 10% of acreage can provide the greatest sediment and phosphorous reductions. The most cost effective practice is to employ No Till on 5% of acreage along waterways at a cost of \$31 per ton sediment reduction, and \$37 per pound phosphorous reduction.

Table 7.18 Pollutant Reduction Estimates for Stony Creek

Practice	Reduction (tons/yr)	BMP cost benefit (\$/ton reduction)	Phosphorous Reduction (lbs/yr) / \$/lb-P
mulch till on sediment for worst 5% (1,824 acres)	351	\$52	298 / \$61
mulch till on sediment for worst 10% (3,649 acres)	441	\$83	375 / \$97
No Till on sediment for worst 5% (1,824 acres)	818	\$31	695 / \$37
No Till on sediment for worst 10% (3,649 acres)	1,029	\$50	875 / \$58
sediment for 30ft grass buffer	1,013	\$102	861 / \$120

Table 7.19 Potential locations for cover crops & conservation tillage, Hartel Drain

Label	Township	Section	Latitude	Longitude	Field Size (acres)	Field Orientation	Slope of Land	Residue Type
65	Moore	22	43.456880	-82.910670	120	N/S	Flat	0
66	Moore	22	43.459890	-82.910560	60	E/W	Flat	0
67	Moore	22	43.448210	-82.916400	40	N/S	Flat	Corn
68	Moore	22	43.447970	-82.923560	80	N/S	Flat	0
69	Moore	15	43.463340	-82.911010	120	N/S	Flat	Corn
70	Moore	15	43.473100	-82.911560	60	N/S	Flat	0

Pollutant loading reductions were estimated for nitrogen (N), phosphorus (P), biological oxygen demand (BOD), and sediment at the subwatershed level utilizing the STEPL Model, results are shown below in Table 7.20.

Table 7.20 Hartel Drain, Pollutant loads and reductions, STEPL Model

480 Acres of Cropland	N Load (no BMP) (lb/yr)	P Load (no BMP) (lb/yr)	BOD Load (no BMP) (lb/yr)	Sediment Load (no BMP) (lb/yr)
	1204.6	249.6	2508.6	81.7
	N Load (with BMP) (lb/yr)	P Load (with BMP) (lb/yr)	BOD Load (with BMP) (lb/yr)	Sediment Load (with BMP) (t/yr)
	339.7	77.9	2071.0	13.3
	% N Reduction	% P Reduction	% BOD Reduction	% Sed Reduction
	71.8	68.8	17.4	83.7

Priority 5: Tile Outlet Erosion

Inventory

One tile outlet was identified as low priority during the 2011 in-stream inventory. The site is located along the Turtle Creek in the Stony Creek subwatershed. The site information is shown in Table 7.17 and Figure 7.9.

Loading Estimate Methodology

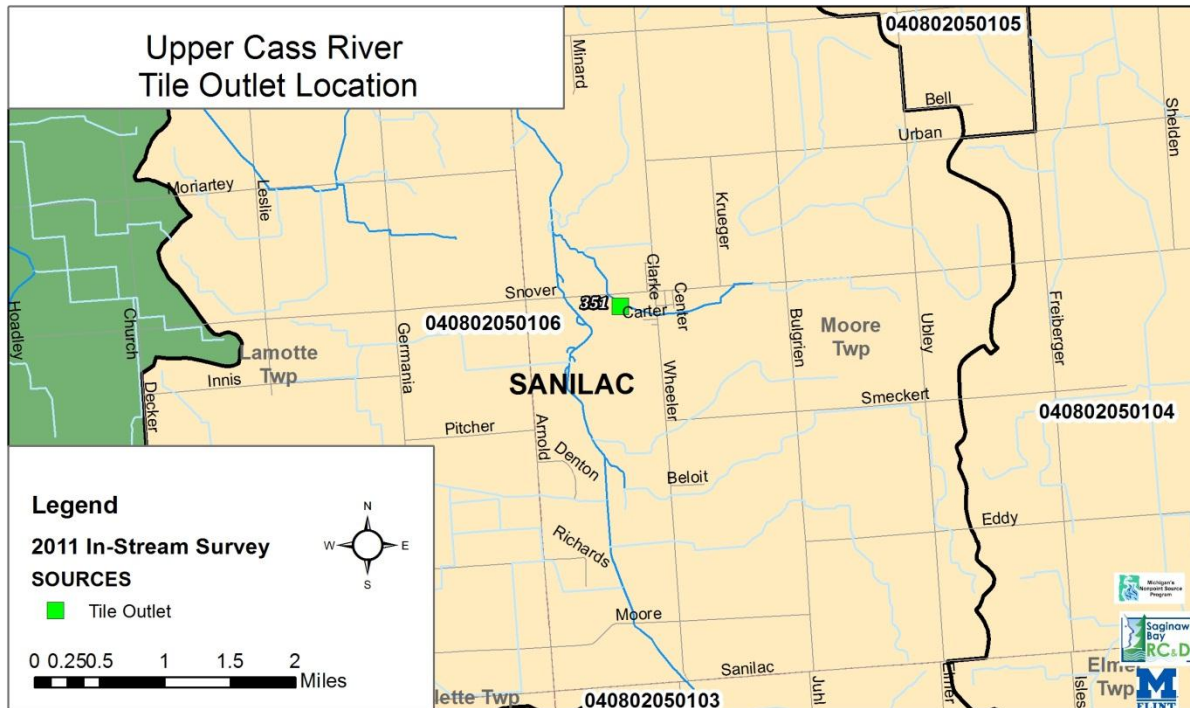
The loading reduction target for the tile outlet is 100% assuming that the outlet is stabilized to mitigate future erosion from occurring. For the loading calculations an identical calculation methods described for gully erosion sites; the soils in this area are well represented by a factor of 110 lbs/ft³, when this is divided by 2000 lbs/Ton the conversion factor of 0.055 Tons/ft³ is obtained.

Summary Table & Map

Table 7.17 Tile Outlet, Stony Creek

Site #	Pollution Source	¹ Erosion volume (ft ³)	Soil weight (tons/ft ³)	No. of years	Sediment Load (tons/yr)	Est. Load - Phosphorus (lbs/yr)	Est. Load - Nitrogen (lbs/yr)	Priority
351	Tile Outlet – 6 inch	30	0.055	1	2	1.8	3.6	Low

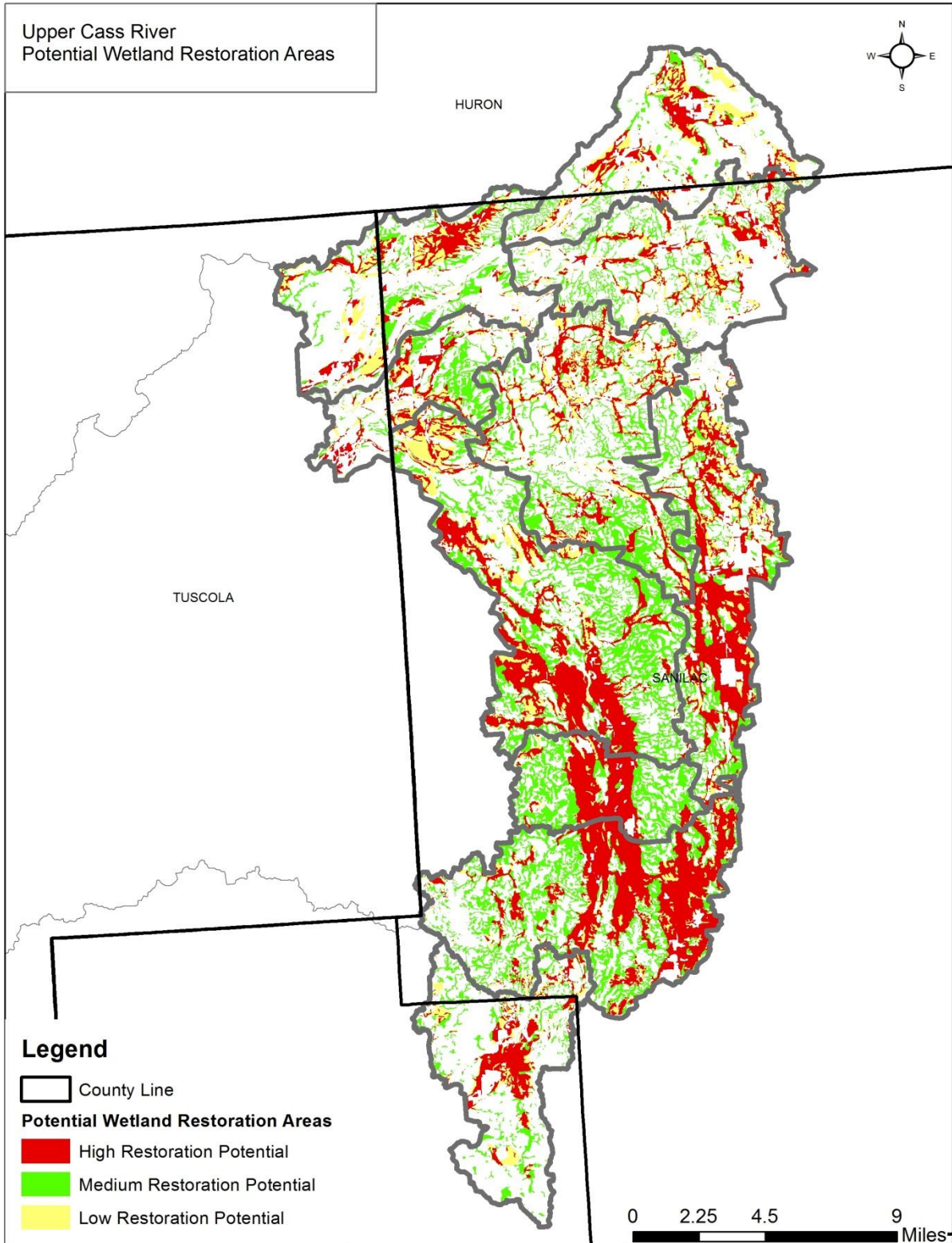
Figure 7.9 Tile Outlet, Stony Creek



Priority 6: Wetland Restoration

Wetland restoration was identified as a priority during the natural resources planning group meeting, and also by the steering committee. The Upper Cass River has experienced a 78% loss of wetlands, according to the Landscape Level Functional Wetland Assessment. There is a great potential for wetland restoration in the Upper Cass River, the LLFWA can be used to identify best potential areas to restore wetland acreage and functions. Figure 7.10 provides a general overview of where potential restoration areas are likely feasible. The LLFWA identified 42,920 acres for high potential for restoration. Greater detail is discussed in Chapter 5.6 of the watershed management plan.

Figure 7.10 Upper Cass River Potential Wetland Restoration Areas



7.5 Estimate of the load reductions expected from the proposed management measures (EPA Element B)

Load reductions needed to address each impairment and threat (EPA, B.1)

E. Coli is the only impairment that has a documented quantity needed to attain designated uses which aligns with Michigan’s Water Quality Standards (WQS). Though not calculated specifically for *E.coli*, the known sites where livestock are impacting surface waters have been estimated for sediment and nutrient reductions. Correcting these sites will address *e. coli* inputs to these waterbodies.

We will address the high and medium priority sites in the TMDL watersheds (Duff Creek and Spring Drain) to remove 100% of impairments from livestock thus removing sources for *e. coli* to enter surface water. It is also recommended that known livestock impairments are reduced upstream in the Stony Creek, and Middle Branch subwatersheds.

In water bodies that are currently meeting designated uses but where significant pollutant sources were identified, percent pollutant reductions to achieve improved water quality are based on the load reductions that would be realized by remediating high and medium priority sites identified. Exceptions where load reductions are expected to be 100% are where there is few impairment sources identified. These source impairments include tile outlets, gully erosion, and streambank erosion sites and are summarized in Table 7.18.

Table 7.18 Summary Table of Expected Load Reductions

Impairment Source	Loading Estimate for total sites	Loading Reduction	Loading Reduction %
Livestock Access	2,153.0 lbs/yr P, 14,416.0 lbs/yr N, 16,296 lbs/yr BOD	Dependent on practice – see tables 7.19-7.21	Variable depending on practice installed
Gully Erosion	81.6 tons sediment, 89 lbs P, 179 lbs N	81.6 tons sediment, 89 lbs P, 179 lbs N	100%
Streambank Erosion	875 tons sediment, 963 lbs P, 1926 lbs N	875 tons sediment, 963 lbs P, 1926 lbs N	100%
Cropland Runoff	32,076 lbs/yr N, 7,086 lbs/yr P, 66,593 lbs/yr BOD, 2,782 lbs/yr Sediment	8,751 lbs/yr N, 2,069 lbs/yr P, 51,690 lbs/yr BOD, 453 t/yr sediment	75% N, 74.8% P, 34.6% BOD, 83.7% Sediment
Tile Outlet Erosion	2.1 lbs P, 4.1 lbs N	2.1 lbs P, 4.1 lbs N	100%

Annual Nutrient Reduction Loads for Livestock in the watershed using BMPs the following BMPs:

- Filter Strips along water course
- Waste Management Systems
- Waste Storage

Method used for determination of these nutrient loadings was the *Pollutant Controlled Calculation and Documentation for Section 319 Watersheds Training Manual, June, 1999*.

Table 7.19 shows reductions in annual loadings if vegetated filter strips are used to protect waterways. Table 7.20 shows reductions in annual loadings if waste management systems are used to on high priority sites. Table 7.21 shows reductions in annual loadings if a waste storage facility is used on high priority sites.

Table 7.19 Reductions from vegetated filter strips.

Location	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)	BOD (lbs/yr)
Sanilac County (High Priority)	800	ND	ND
Lapeer County (High Priority)	690	ND	ND

ND = A reduction constant was Not Determined in the 319 method used for this table

Table 7.20 Reductions from waste management systems

Location	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)	BOD (lbs/yr)
Sanilac County (High Priority)	850	4,600	ND
Lapeer County (High Priority)	730	3,240	ND

ND = A reduction constant was Not Determined in the 319 method used for this table

Table 7.21 Reductions from waste storage facilities

Location	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)	BOD (lbs/yr)
Sanilac County (High Priority)	565	3,740	ND
Lapeer County (High Priority)	490	2,630	ND

ND = A reduction constant was Not Determined in the 319 method used for this table

7.6 Description of the management measures needed to achieve the proposed load reductions (EPA Element C)

Goals for the Upper Cass River Watershed (EPA, C1)

1. Restore designated uses of total body contact and partial body contact in Spring Drain, Duff Creek, and Stony Creek
2. Restore designated use of Other Indigenous Aquatic Life and Wildlife in Stony Creek
3. Preserve forested riparian corridor and connectivity of North Branch Cass River
4. Restore wetlands where highly feasible per LLFWA
5. Reduce impacts from stormwater where feasible

Management Measures are Applicable & Feasible (EPA, C2-3)

Livestock Access: Livestock can be restricted to accessing surface water by installation of fencing along river corridors, and installation of alternate watering facilities.

Gully Erosion can be addressed through stabilization practices including installation of vegetative buffers, swales or contour farming practices, or drop structures.

Streambank Erosion can be addressed through a variety of means. These include installation of vegetative buffers to slow overland runoff and stabilization of the bank itself using natural materials such as logs or brush mattresses to hard armoring options such as gabion baskets or rip rap in extreme erosion cases.

Agricultural NPS is a broad category that includes the following causes of impairments: cropland erosion/runoff, conventional tillage, surface ditching, and manure spreading. These can be addressed through a combination of **Agricultural BMP's**:

- Conservation tillage / Mulch-till
- Grassed Buffers
- Cover cropping

Stormwater management: A suite of management measures are available to reduce pollution and impacts to water quality in the Upper Cass River. Management measures are listed by priority. Chapter 4 details the urban stormwater analysis and appropriate management measures for Cass City. Cass City is the only urbanized area in the Upper Cass River that was inventoried as a part of the urban hydrologic assessment, detailed in Chapter 4. There are structural recommendations to keep runoff on-site and managerial recommendations for planning commissions to enact to reduce stormwater runoff.

Recommended Managerial Strategies

Point of sale septic system ordinance: Bacteria pollution is a pervasive problem in Michigan and the Cass River Watershed. Michigan is only one of two states in the union that do not have a statewide ordinance relating to the inspection of septic systems at the time of sale. Several counties have adopted or are working on developing time of sale ordinances for their

communities. A sample ordinance from the Barry-Eaton District Health Department is included in the watershed plan for local health departments to consider for adaptation and adoption.

Low impact development: A recent study performed by the Planning and Zoning Center at Michigan State University, evaluated the use of Low Impact Development in the Cass River Watershed. Full recommendations are included in appendix E. Stormwater management is also considered a component of low impact development and is detailed in Chapter 4.

Critical Locations for Management Measures (EPA C.4)

Critical locations are shown in the inventory section for Spring Drain, Duff Creek, and Stony Creek. These three subwatersheds are listed as impaired by the Michigan DEQ, inventory data from 2010-11, the HIT model, and the STEPL model all support targeted restoration in these subwatersheds. In addition, a recent study conducted by The Nature Conservancy's Great Lakes Program supports installation of agricultural BMP's in the Upper Cass River as a means to restore and protect critical fish habitat.

The Upper Cass River strategy was reviewed by stakeholders on May 2, 2013 at the Sanilac County Conservation District. Priority areas for installation of management measures included:

Priority 1:

Spring Drain (Figure 7.11), Livestock fencing, Manure stacking, and Alternative water facilities
Duff Creek (Figure 7.12), Livestock fencing, Manure stacking, Alternative water facilities

Priority 2:

Duff Creek, Gully stabilization

Priority 3:

Upper Cass River: Duff Creek, Gerstenberger Drain, Middle Branch Cass River, Stony Creek (Figure 7.13), Streambank stabilization

Priority 4:

Conservation tillage and cover crops in the Spring Drain, Duff Creek, and Stony Creek

Priority 5:

Tile outlet erosion in the Upper Cass River

Priority 6:

Wetland restoration in the Upper Cass River should be addressed based on priority areas defined in the LLWFA identified in Figure 7.10.

Figure 7.11 Spring Drain Impairments

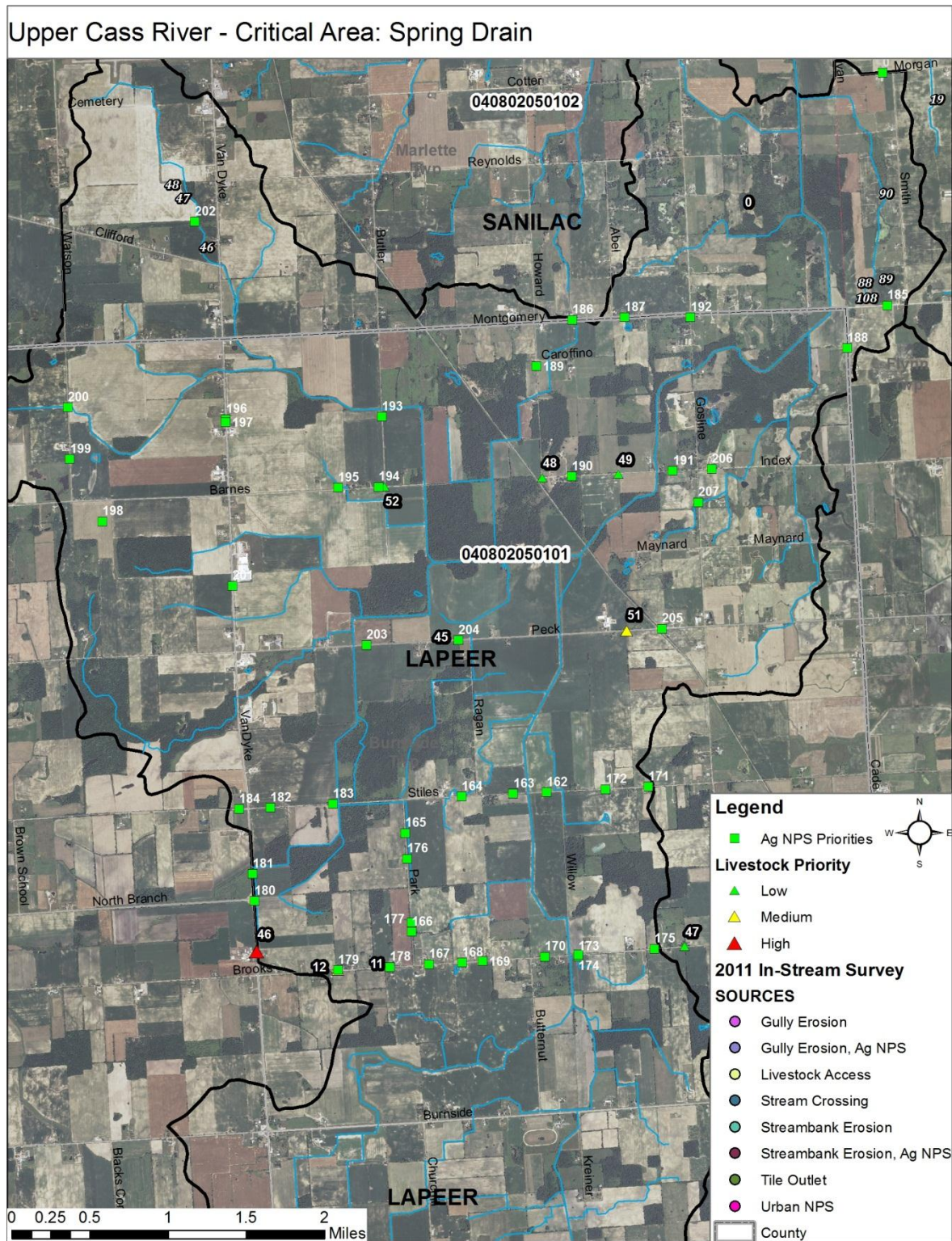


Figure 7.12 Duff Creek Impairments

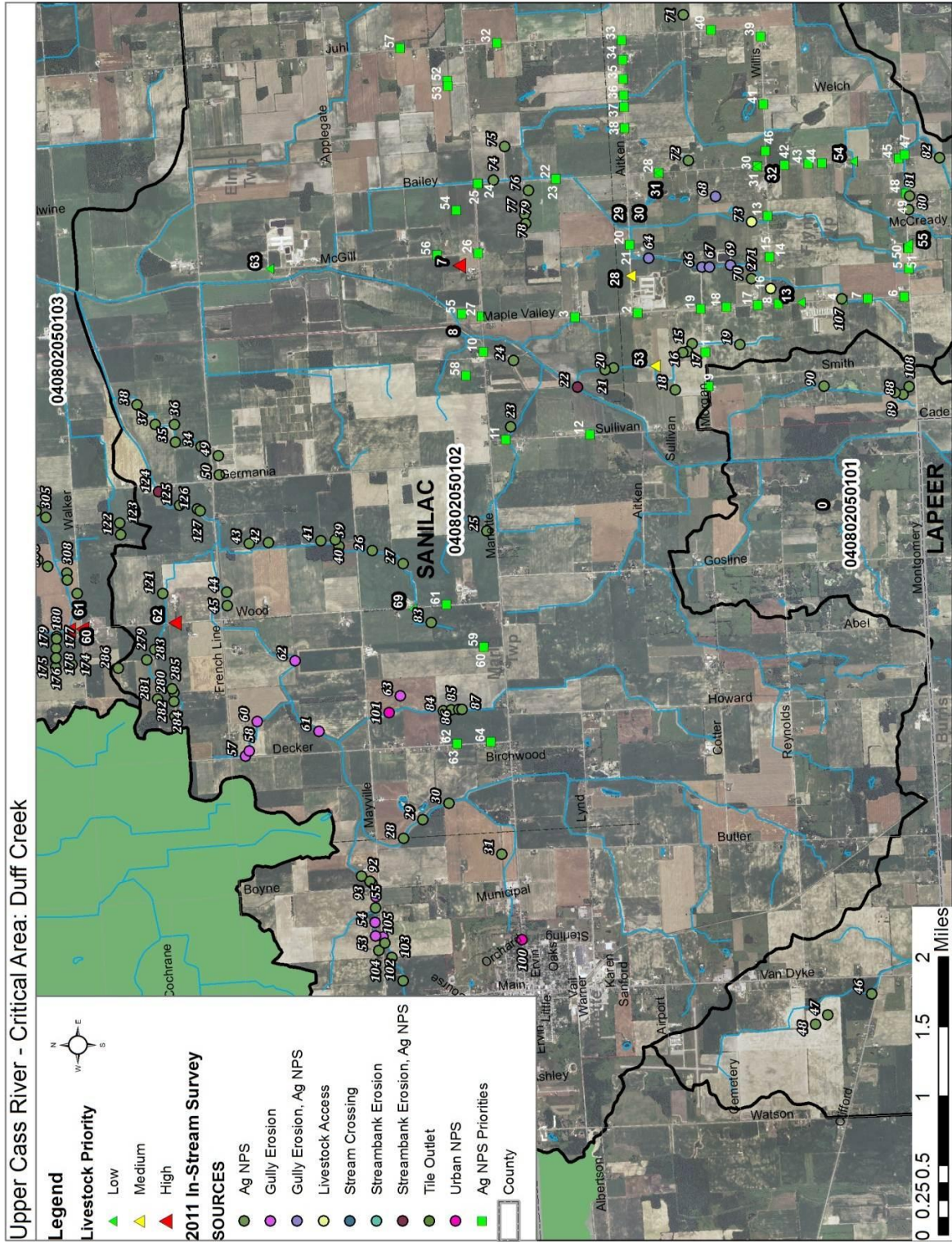
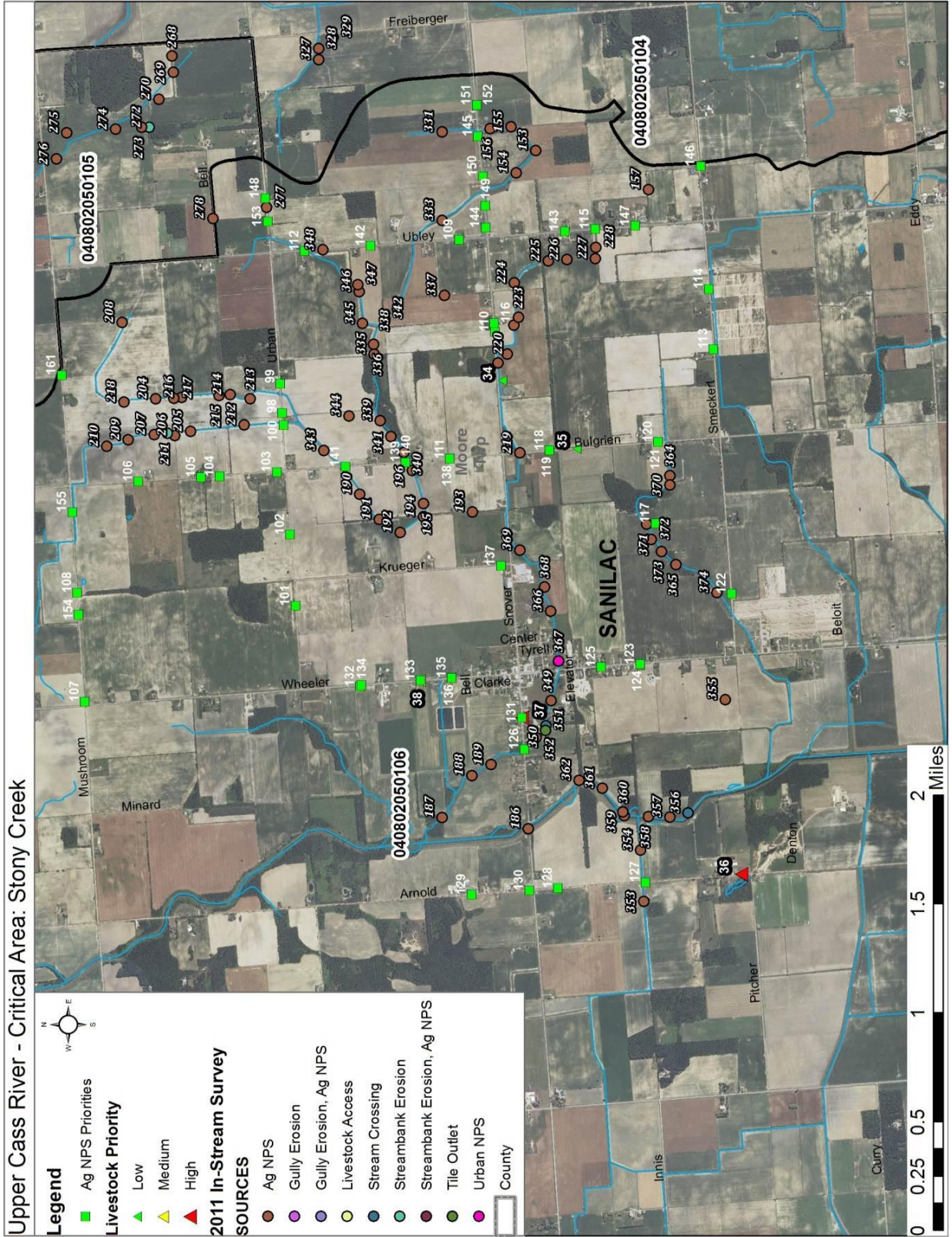


Table 7.13 Stony Creek Impairments



Load reductions linked to management measures (EPA, C5 & C6)

See STEPL Modeling results for reductions in sediment/nutrient loads through installation of agricultural BMP's. The percent reduction for agricultural BMP's are demonstrated in the HIT Model calculations for mulch-till, no-till and grass buffer strips. We assume practices installed for livestock exclusions, e. coli reduction, gully stabilization, tile outlet erosion, and streambank stabilization have the ability to reduce loading by at or near 100% (e.g. permanent sediment reduction by fencing livestock out of riparian areas and are calculated using the MDEQ 319 Manual.

7.7 Implementation Schedule and Assistance (EPA Elements D, F, G, H)

EPA elements D, F, G, and H are presented below by priority subwatershed and impairment in Table 7.22

Priority Sub-shed	MGMT Measure	Technical Assistance Type	Technical Cost	*Project Lead and Partners	Quantity	Material / Installation Cost	Total Cost and Potential Funding	Regulatory Agencies
1 Spring Drain	Restrict livestock access, Manure Stacking, Livestock fencing and watering facilities	Landowner outreach and assistance with funding for practices to be installed	County District agent at 25% FTE for 1 year	*Sanilac Conservation District, Lapeer Conservation District, MMPA, Farm Bureau	1 High priority site, 2 Medium priority sites	est \$2 per foot @ 3,500 feet = \$7,000	\$27,000 319, Farm Bill, USDA-NRCS, GLRI	MDA, Drain Office, NRCS, MDEQ
2 Duff Creek			County District agent at 25% FTE for 1 year	*Sanilac Conservation District, Saginaw Bay RC&D, MMPA, Farm Bureau	10 High priority sites (105 acres)	est \$15,000 avg per site * 10 sites = \$150,000	\$170,000 319, Farm Bill, USDA-NRCS, GLRI	MDA, Drain Office, NRCS, MDEQ
3 Duff Creek	Gully Erosion Stabilization	Engineering and construction for grading, stabilization structures, and vegetation	District engineer staff time	*Sanilac Conservation District, Sag Bay RC&D, Farm Bureau	19 priority sites	est \$5,000 avg per site * 19 sites = \$95,000	\$95,000 319, Farm Bill, USDA-NRCS	MDA, Drain Office, NRCS, MDEQ

Priority Sub-shed	MGMT Measure	Technical Assistance Type	Technical Cost	*Project Lead and Partners	Quantity	Material / Installation Cost	Total Cost and Potential Funding	Regulatory Agencies
4 Duff Creek	Streambank Erosion Stabilization	Engineering and construction for grading, stabilization structures, and vegetation	Saginaw Bay RC&D Staff time	*Saginaw Bay RC&D, Sanilac Conservation District	12 priority sites totaling 2,364 linear feet	est \$20 per linear foot = \$47,280	\$47,280 Coastal Zone Management, Great Lakes Commission	Drain Office, MDEQ
5 Spring Drain	Conservation Tillage and Cover Crops	Landowner outreach and assistance with funding for practices to be installed	county technician 100% FTE for 2 yrs, est \$90,000	*Sanilac Conservation District, Lapeer Conservation District, Farm Bureau	2,842 acres	\$28,842-\$39,788	\$62,288 319, Farm Bill, USDA-NRCS	NRCS, MDA
6 Stony Creek	Conservation Tillage and Cover Crops	Landowner outreach and assistance		*Sanilac Conservation District, Saginaw Bay RC&D, Farm Bureau	4,730 acres	\$47,300-\$66,200	\$88,700 319, Farm Bill, USDA-NRCS	MDA, NRCS

Priority Sub-shed	MGMT Measure	Technical Assistance Type	Technical Cost	*Project Lead and Partners	Quantity	Material / Installation Cost	Total Cost and Potential Funding	Regulatory Agencies
7 Duff Creek	Conservation Tillage and Cover Crops	Landowner outreach and assistance with funding for practices to be installed		*Sanilac Conservation District, Saginaw Bay RC&D, Farm Bureau	4,550 acres	\$45,500 - \$63,700	\$86,200 319, Farm Bill, USDA-NRCS	MDA, NRCS
8 Hartel Drain	Conservation Tillage and Cover Crops	Landowner outreach and assistance		*Sanilac Conservation District, Saginaw Bay RC&D, Farm Bureau	480 acres	\$4,800 - \$6,720	\$29,220 319, Farm Bill, USDA-NRCS	MDA, NRCS
9 Upper Cass River	Tile Outlet Stabilization	Engineering and construction for grading, stabilization structures, and vegetation	Existing staff time at District	*Sanilac Conservation District, Saginaw Bay RC&D, Farm Bureau	1 site	\$3,000	\$3,000 319, Farm Bill, USDA-NRCS	NRCS, MDEQ

Priority Sub-shed	MGMT Measure	Technical Assistance Type	Technical Cost	*Project Lead and Partners	Quantity	Material / Installation Cost	Total Cost and Potential Funding	Regulatory Agencies
10 Upper Cass River	Wetland Restoration	Landowner outreach and assistance	Existing staff time at District and USFWS	*Sanilac Conservation District, USFWS, MDEQ	42,920 acres of high potential wetland restoration areas – target 1,000 acres	Est \$500 per acre	\$500,000 319, Farm Bill, USDA-NRCS	NRCS, MDEQ
	1MDA, Michigan Department of Agriculture – oversees the Michigan Right to Farm Act							
	NRCS, United States Department of Agriculture Natural Resources Conservation Service – oversees BMP design specifications, approvals, and evaluations							
	MDEQ, Michigan Department of Environmental Quality – oversees Public Act 451, Part 31 to protect the water resources of Michigan							
	Drain Commissioner – oversees the Michigan Drain Code							
	319, Federal Clean Water Act Grant Dollars							
	CMI, Clean Michigan Initiative							

The public information and education plan can be found in Chapter 6 (EPA Element E). The education plan is broken to address each of the pollutant sources and causes by target audience, message, and delivery tools.

Table 7.23 schedule for implementation and milestones (EPA Element F & G)

Priority	Sub-shed	Management Measure	Implementation Schedule	Interim Measurable Milestones	Evaluation Dates
1	Spring Drain	Restrict livestock access, Manure Stacking, Livestock fencing and watering facilities	Short term (1-3 years)	3 sites - 621 animals excluded from stream	2016 confirm 3 sites identified in livestock inventory have installed BMPs
2	Duff Creek	Restrict livestock access, Livestock fencing and watering facilities	Short term (1-3 years)	10 sites - 900 animals excluded from stream	2016 confirm 10 sites identified in livestock inventory have installed BMPs
3	Duff Creek	Gully Erosion Stabilization	Mid-term (3-5 years)	10 sites	2018 confirm gullies remediated
4	Duff Creek	Streambank Erosion Stabilization	Mid-term (3-5 years)	12 sites	2018 - all 12 sites remediated
5	Spring Drain	Conservation Tillage and Cover Crops	Long term (5-10 years)	986 acres (5% total acreage); 1,972 acres (10% total acreage)	2023 confirm acreage of measures installed
6	Stony Creek	Conservation Tillage and Cover Crops	Long term (5-10 years)	1,824 acres (5% total acreage); 3,649 acres (10% total acreage)	2023 confirm acreage of measures installed
7	Duff Creek	Conservation Tillage and Cover Crops	Long term (5-10 years)	1,576 acres (5% total acreage); 3,152 acres (10% total acreage)	2023 confirm acreage of measures installed
8	Hartel Drain	Conservation Tillage and Cover Crops	Long term (5-10 years)	100 acres	2023 confirm acreage of measures installed
9	Upper Cass River	Tile Outlet Stabilization	Long term (5-10 years)		
10	Upper Cass River	Wetland Restoration	Long term (5-10 years)		

The three short-term actions required for each management measure are similar:

1. Submit funding proposal (Year One)
2. Landowner Outreach (Year Two)
3. Site Design and Implementation (Year Two - Year Three)
4. Monitoring, Re-Evaluation of WMP Status and Next Steps (Year Three - Year Four)

7.8 Load Reduction Criteria (EPA Element H)

Criteria for evaluating load reductions are strictly for *E. coli* as mentioned in section A. The planning committee should revisit the plan and TMDL's every two years to evaluate progress on achieving milestones and subsequent load reductions. All known sources of bacterial contamination will be addressed and their success measured by reductions in *e.coli* levels as dictated by state water quality standards. A monitoring request will be made in the TMDL watersheds to MDEQ after these priority impairment sources have been corrected to determine if designated uses have been restored. Numeric criteria are delineated by the state of Michigan Water Quality Standards.

There is currently no water ways listed as impaired due to sediment or phosphorous in the Upper Cass River. Criteria for determining whether load reductions have been achieved for sediment and nutrient loading will be based upon the evaluation of the amount of practices installed and associated pollutant load reduction. A monitoring request will be submitted to the MDEQ for a biological assessment pre-project and post-project implementation to determine if improvements in water quality have been achieved.

7.9 Monitoring (EPA Element I)

Chapter 3 provides an overview of previous monitoring done in the Cass River. From this evaluation data gaps have been identified that should be looked at within the context of a comprehensive monitoring strategy for this watershed. Data gap analysis for the Upper Cass River shows a lack of monitoring data for Hartel Drain and Gerstenberger Drain (Table 3.1, Chapter 3), it is a recommended a monitoring request be made to monitor these stretches of the Upper Cass River. Further testing is also recommended for stretches identified on the 303d list; Spring Drain, Duff Creek, and Stony Creek based on inventory information from 2011.

Additional inventory was conducted during the watershed planning phase in these three subwatersheds to identify projects that would help achieve water quality restoration goals. Subwatersheds that were assessed by MDEQ with high water quality scores were not inventoried due to time and budget constraints. These subwatersheds include Hartel Drain, Middle Branch Cass River, South Fork, Tyre Drain, North Branch Cass River and South Branch Cass River. Furthermore, the land use / land cover in these subwatersheds is heavily wooded as opposed to drained and tilled for agriculture as is the case in the upstream stretches in Lapeer and southern Sanilac counties. Gerstenberger Drain was inventoried in 2011 because of its downstream location of Spring Drain and Duff Creek, the two subwatershed that were identified as impaired by MDEQ, it is presumed that Gerstenberger is impaired by high *e. coli*

levels given those found upstream in Spring Drain and Duff Creek. It is recommended that further inventory work be conducted in the subwatersheds that were not inventoried in 2011, and that Gerstenberger Drain be monitored for potential E. coli exceedences.

Ongoing monitoring efforts in the watershed include: 1) MDEQ's five-year basin monitoring program and the continuation of their TMDL monitoring process, and 2) Monitoring being performed by the Cass River Greenway committee, based in Frankenmuth along the Cass River corridor.

It is assumed that major restoration projects completed during implementation will have separate monitoring plans and Quality Assurance Project Plans (QAPPs) established as a part of their funding requirements. Potential sites for restoration activities should be identified by at the beginning of any implementation effort to allow for pre-project and post-project monitoring. Monitoring should also include before and after pictures of implementation projects.

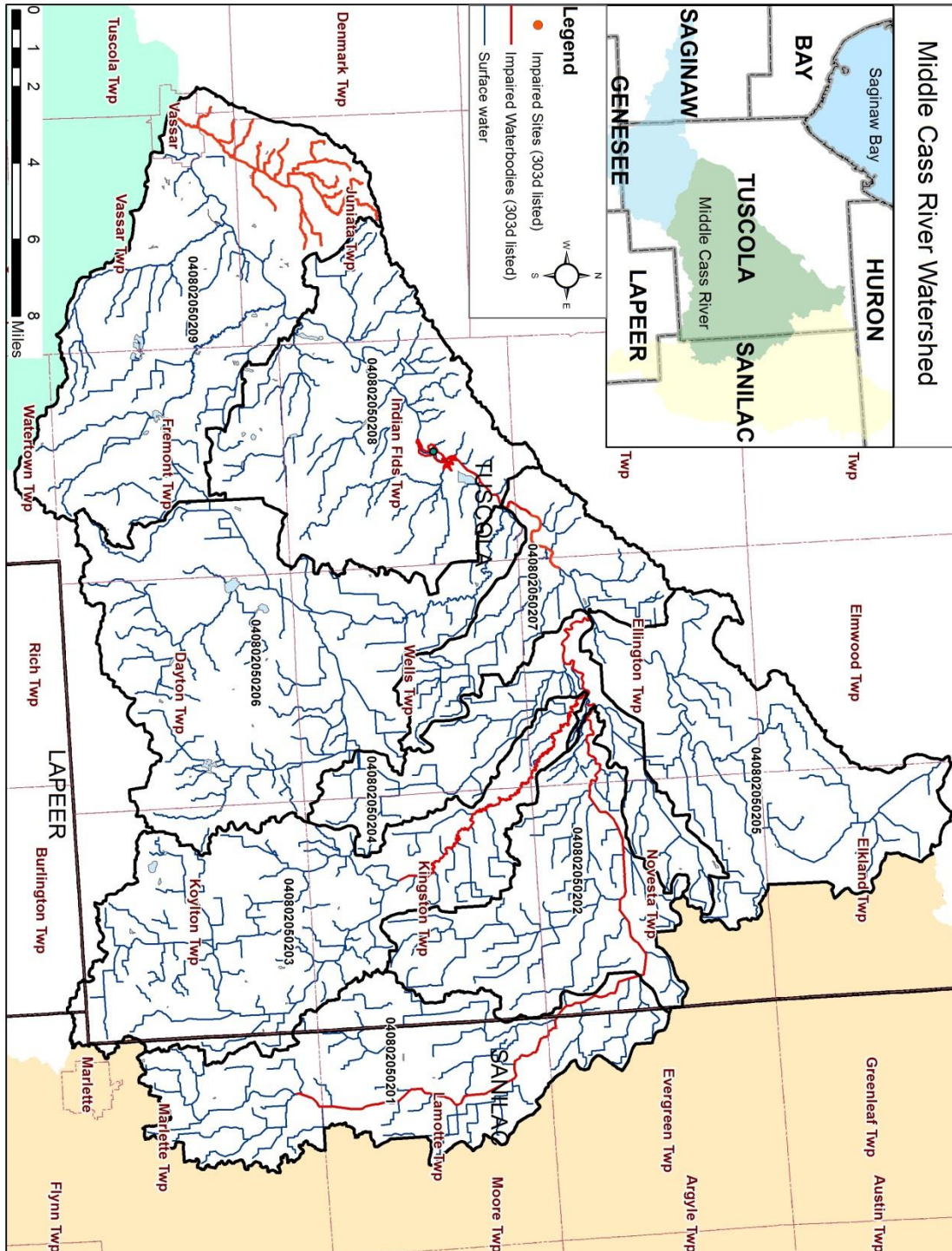
A comprehensive monitoring plan for the Upper Cass River is also recommended to fully evaluate necessary monitoring to fill data gaps, gather background information, and identify other potential water quality impairments or threats. Funding should be sought to develop and implement this Cass River Watershed monitoring plan from the MICorps program or similar funding opportunity. Building off of past monitoring efforts, the following parameters should be monitored at public access sites, and within each subwatershed to determine improvements or declines in water quality:

- E. Coli
- Total dissolved solids
- Total suspended solids
- pH
- COD
- Nitrite
- Nitrate + Nitrate
- Total Phosphorus
- Ortho Phosphorus
- Total number of macroinvertebrate taxa

Chapter 8: Middle Cass River

Findings of inventory, critical areas and recommendations for BMP's

Figure 8.1 Middle Cass River Subwatersheds



8.1 Middle Cass River Summary

The Middle Cass River includes the mainstem of the Cass River in Novesta Township, Tuscola County downstream to the city of Vassar. The Middle Branch also includes several tributaries including the White Creek, Sucker Creek and numerous county designated drains. The Middle Cass River sub-basin occupies about 40% of the watershed totaling 231,462 acres and is further divided into nine sub-basins described in Table 8.1.

Table 8.1 Watershed Sub-basins			
Sub- watersheds	Acres	Sq. Miles	% of Total Watershed
Middle Cass River	231,462		39.9
01-Clark Drain	25,804	40.3	4.5
02-North Branch White Creek	19,236	30.1	3.3
03-South Branch White Creek	32,449	50.7	5.6
04-White Creek	13,917	21.7	2.4
05-Cedar Run	24,920	38.9	4.3
06-Sucker Creek	38,179	59.7	6.6
07-Butternut Creek	11,833	18.5	2
08-Scott Drain	29,046	45.4	5
09-Moore Drain	36,078	56.4	6.2

Most of the Middle Cass River is part of the Southern Michigan/Northern Indiana Drift Plains Ecoregion. This ecoregion is characterized by its soils, varying landforms, and broad till plains. The soils of this region have more drainage than the soils of the Huron and Erie Lake Plains region and are more nutrient-rich than the soils to the north of this ecoregion. This region’s soils and landforms make for an agricultural industry that typically produces feed grain, soybeans, and livestock (Ecoregion Details: Southern).

The land use and cover in the Middle Cass River is 49.3% agricultural and 46.6% natural. Subwatersheds that are dominated by agricultural lands include the Butternut Creek, Cedar Run White Creek, South Brank White Creek, and the Clark Drain (North Branch White Creek). The Moore Drain and Scott Drain of White Creek, Sucker Creek, and the North Branch of the White Creek are dominated by natural land cover.

8.2 Middle Cass River causes and sources of impairments and threats (EPA Element A) Water body use designations (EPA, A.1)

Designated Uses

A stream or site in the watershed is listed as impaired if it is failing to meet one or several designated uses as defined by the State of Michigan. Designated uses for the Middle Cass River and its tributaries include:

- **Agriculture** – Irrigation water for crops or water for livestock
- **Wildlife and Other Indigenous Aquatic Life** –Aquatic life and wildlife can thrive and reproduce.
- **Total and Partial Body Contact** – Recreational (swimming, fishing, boating). All waters protected for recreation shall not exceed specific levels of *E. coli* from May to October
- **Warm Water Fishery** – Water supports warm water fish species including reproduction and sustainability

Subwatersheds that have impaired designated uses as determined by MDEQ water quality testing are Butternut Creek and Moore Drain. Butternut Creek was included in a 2008 TMDL for not meeting the warm water fishery use designation from low dissolved oxygen (DO) and growth of macrophytic aquatic vegetation. Moore Drain is impaired for not meeting the designated use standards for wildlife and other indigenous aquatic life from direct habitat alterations and other flow regime alterations. The 2008 TMDL for DO identified the Cass River from East Dayton Road to Deckerville Road as the impairment area shown in Figure 3.7 of Chapter 3. The cause of the impairment is abundant plant growth due to organic enrichment from agricultural NPS within the watershed.

Table 8.2 compiles information from the impaired waterbodies list provided by MDEQ and information gathered during the 2011 inventory. Sub-watersheds were inventoried via in-stream surveys and/or windshield surveys. Chapter 3 describes the methodology used for each of the inventory methods. The North Branch White Creek, South Branch White Creek, White Creek, and Sucker Creek are listed as attaining all designated use by MDEQ and were not inventoried.

Impaired sub-watersheds were priority for in-stream inventory to identify sources of pollution. Two sub-watersheds in the Middle Cass River: Butternut Creek and Moore Drain are listed as impaired by the MDEQ and were inventoried via in-stream surveys by the Tuscola Conservation District during the 2011 field season. Additional subwatersheds identified during the inventory include the Clark Drain which is suspected of not meeting water quality criteria for total and partial body contact. The Cedar Run White Creek and the Scott Drain were inventoried along the mainstem Cass River due to extensive streambank erosion and suspicion of impacts to the warm water fishery use designation.

Table 8.2 Impaired, partially impaired, and/or threatened uses (EPA, A.3)
Subwatersheds that are noted with an "" are listed as impaired by the MDEQ*

Middle Cass River Sub-basin	Impaired Uses per MDEQ in-stream surveys	Potentially Impacted	Notes
12-HUC:0408020502	Fish Consumption		PCB's
Clark Drain AUID: 0408020502-01	Not assessed for Total and Partial Body Contact Recreation	Total and partial body contact	Extensive Ag NPS problems
North Branch White Creek AUID: 0408020502-02	Not assessed for Total and Partial Body Contact Recreation		
South Branch White Creek AUID: 0408020502-03	Not assessed for Total and Partial Body Contact Recreation		
White Creek AUID: 0408020502-04	Not assessed for Total and Partial Body Contact Recreation		
Cedar Run White Creek AUID: 0408020502-05		Warmwater fishery	Extensive streambank erosion
Sucker Creek AUID: 0408020502-06	Not assessed for Total and Partial Body Contact Recreation		
Butternut Creek* AUID: 0408020502-07	Warmwater fishery		2008 TMDL for D.O.
Scott Drain AUID: 0408020502-08		Warmwater fishery	Extensive streambank erosion
Moore Drain* AUID: 0408020502-09	Other indigenous aquatic life and wildlife		Extensive agricultural runoff

Water quality criteria (EPA, A.2)

The water quality criteria used to evaluate the environmental health of water bodies in the Middle Cass River are defined below.

Sediment

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

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

Dissolved Oxygen

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

Table 8.3 summarizes the causes and sources for the designated uses in each of the Middle Cass River subwatershed. The status of each designated use presented in Table 8.2 are correlated with the causes and sources of impairments for each sub-watershed in Table 8.3.

Table 8.3 Specific causes and sources of impairments and/or threats (EPA, A.4)

Sub-watershed name	Impaired Use Description (Suspected Use Impairment)	Cause Name	Source (s)
Butternut Creek-White Creek	Warm Water Fishery	Aquatic Plants (Macrophytes) Dissolved Oxygen	1. Agriculture 2. Streambank erosion (threat)
Moore Drain-White Creek	Other Indigenous Aquatic Life and Wildlife	Direct Habitat Alterations Other flow regime alterations	1. Channelization 2. Unknown Sources
Clark Drain	THREAT: Total and partial body contact	E. Coli (suspected)	1. Agriculture (known)
Cedar Run White Creek	THREAT: Warm Water Fishery	Sediment (suspected)	1. Streambank erosion (known)
Scott Drain	THREAT: Warm Water Fishery	Sediment (suspected)	1. Streambank erosion (known)

Causes of impairment (or threats) quantified (EPA, A.5)

The causes of threats to water quality and known impairments are quantified by the percentage of agricultural land cover, ditching, water quality data for DO, and known streambank erosion sites. Causes were quantified through data presented in the 2008 TMDL for the Cass River, Tuscola County, and analysis of hydrology and land use cover in a GIS.

Agriculture

Butternut White Creek (known) subwatershed is 47% agricultural land use/land cover and contains over 19 miles of designated drain. The 2011 inventory information was not comprehensive for this stretch though a large amount of streambank erosion was identified in the 2008 streambank inventory. All known sites are shown in Figure 8.3.

Clark Drain (suspected) subwatershed is 81% agricultural land use/land cover and contains over 58 miles of designated drains. A number of agricultural nonpoint source (nps) sites were mapped during the 2011 inventory and are included in this chapter. All known sites are shown in Figure 8.7

Channelization

Moore Drain – White Creek subwatershed contains 37% agricultural land use/land cover. A number of agricultural nps sites were mapped during the 2011 inventory and are included in this chapter in Figure 8.4.

Dissolved Oxygen

Monitoring for Cass River, Butternut Creek, in the summer of 2001 showed nonattainment of the DO warmwater water quality standard during dry weather periods. “The cause of the impairment is abundant plant growth within the TMDL reach due to organic enrichment from agricultural NPS within the watershed” as was stated in the 2008 TMDL for the Cass River, Tuscola County. These sites are identified in Figure 8.3.

Streambank Erosion

Cedar Run and Scott Drain are both listed as threatened due to suspected sediment pollution from streambank erosion. 2008 streambank erosion inventory site data is presented later in this chapter in Map 8.5 and Map 8.6.

Locations of Impairments (EPA, A.6-8)

Figure 8.2 shows the known locations of impairment sources from the 2008 streambank inventory and 2011 in-stream and windshield surveys (Chapter 3).

Streambank erosion sites were identified during the 2008 field season by the U.S. Fish and Wildlife Service. Each site was scored on a set of criteria including the size of the eroding streambank, the soil type, buffer type, and if the erosion was increasing or stabilizing. High priority sites are those that ranked the highest for instability and pollution sources.

Priority livestock sites were those identified during the 2011 windshield surveys. High priority sites are those where a known surface water impairment was observed and pollutant loading estimates could be calculated. Medium priority sites are those where a surface water quality impairment is suspected and pollutant loading estimates can be calculated. Low priority sites are those where a surface water quality impairment is suspected but pollutant loading estimates could not be calculated due to lack of adequate site details.

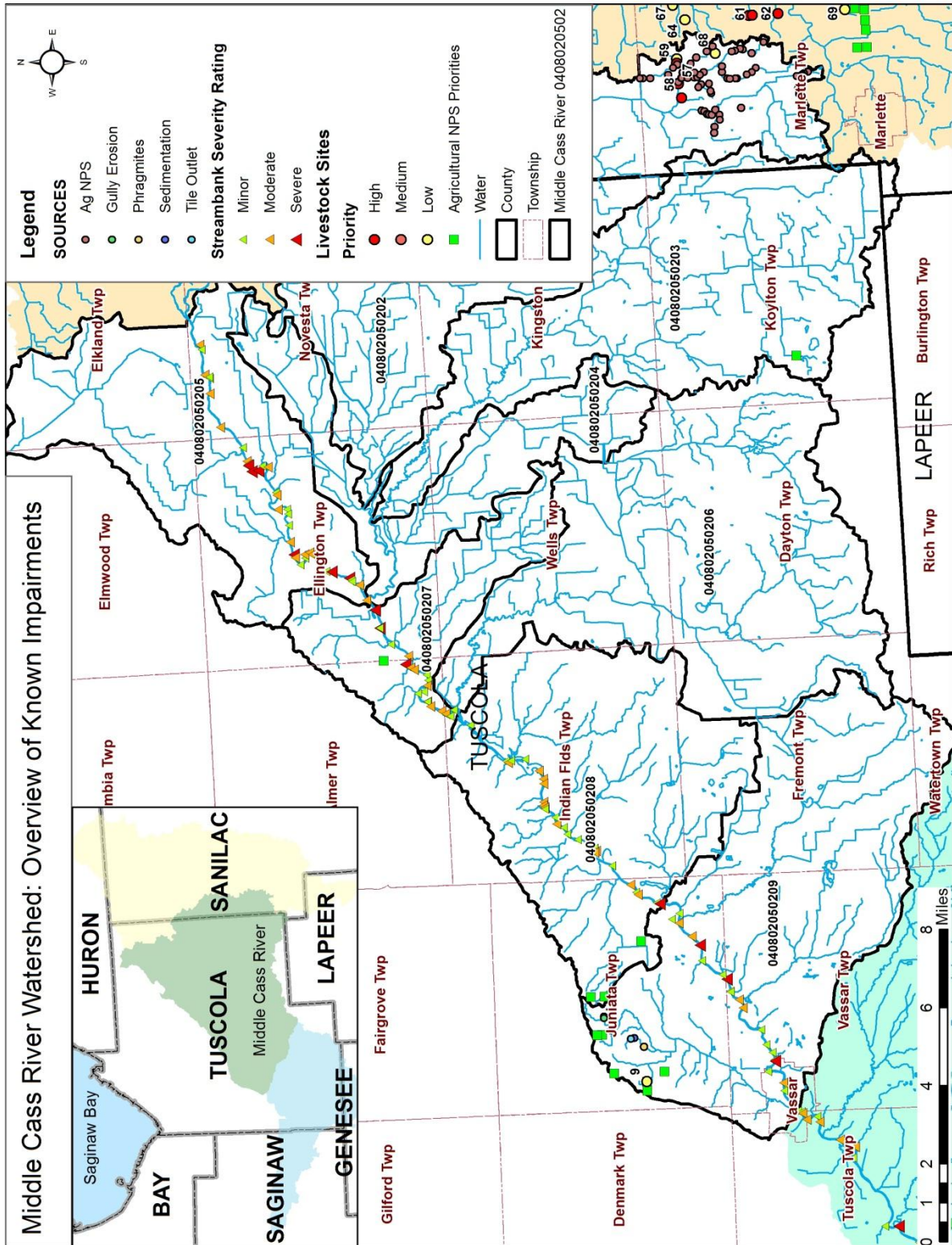
The 2011 In-stream survey results are those sites identified while conservation district staff were wading stretches of impaired waterways. Impairment locations were delineated by sources. Sources identified in the Upper Cass River include gully erosion, livestock access, stream crossing (eroding), streambank erosion, tile outlets, urban nps (urban nonpoint source or stormwater runoff), and ag nps (agricultural nonpoint source or field runoff).

Ag NPS priorities were those identified during the 2011 in-stream survey when conservation district staff identified priority areas to reduce field runoff. These locations are important to target for BMP's because a known impairment was observed. Ag NPS priority sites include field runoff, manure spreading, or inadequate buffer strips.

During the windshield survey, agricultural sites were classified by the practices that were installed on each site. Fields that were listed as having conventional tillage and 25% or less field residue are highlighted to aide in targeting of outreach programs for conservation tillage, grassed buffers, and cover crops.

Table 8.3 further summarizes information shown in Figure 8.2 by subwatershed and recommended management measures.

Figure 8.2 All Impairment Locations, Middle Cass River



8.3 Implementation Priorities and Schedule

The inventories conducted in 2008 and 2011 were reviewed and prioritized by a technical committee for the Middle Cass River watershed. Representatives present at the meeting included the Tuscola County Commission, Tuscola Conservation District, Michigan Agriculture Environmental Assurance Program, Spicer Group, MDEQ, and UM-Flint. Sources and locations were prioritized based upon the data collected during the 2008 and 2011 field inventory. The highest priority sites are those where there is a known impairment and source, and pollutant loading estimates can be calculated. Lower priority sites are those where an opportunity has been identified to install practices that can reduce and/or prevent water quality impairments. A summary of the priorities is shown in Table 8.4.

Table 8.4 Middle Cass River Implementation Priorities

Priority	Sub-shed	Management Measure	Technical Assistance Type	Quantity	Schedule
1	Butternut Creek	Streambank Erosion Stabilization	Engineering and construction for grading, stabilization structures, and vegetation	4,675 linear feet; 21 sites	2014-2016
1	Moore Drain	Streambank Erosion Stabilization	Engineering and construction for grading, stabilization structures, and vegetation	2,620 linear feet; 21 sites	2014-2016
1	Cedar Run	Streambank Erosion Stabilization	Engineering and construction for grading, stabilization structures, and vegetation	6,045 linear feet; 44 sites	2014-2016
1	Scott Drain	Streambank Erosion Stabilization	Engineering and construction for grading, stabilization structures, and vegetation	3,265 linear feet; 27 sites	2014-2016
2	Clark Drain	Manage feedlot runoff, exclusionary fencing, alternate watering facilities	landowner assistance for livestock management plans	862 Animals, 5 sites	2017
3	Moore Drain	Gully erosion stabilization	engineering and construction	3 gullies	2017
4	Moore Drain	Conservation tillage and cover cropping	landowner outreach and assistance with funding for practices to be installed	430 Acres; 7 sites	2018-2020
4	Clark Drain	Conservation tillage and cover cropping	landowner outreach and assistance with funding for practices to be installed	1340 Acres; 105 sites	2018-2020

8.4 Priority Source Loadings

Sources of pollutant loadings are discussed by priority: streambank erosion, livestock access, gully erosion, and agricultural nonpoint source pollution.

Priority 1: Streambank erosion

Inventory

Streambank erosion was identified as a priority for the Middle Cass River to support the further development of the Cass River water trail and to reduce sedimentation occurring in the river. Streambank stabilization can also improve habitat for benthic macroinvertebrates, particularly in the Moore Drain and Butternut Creek where there are known impairments.

Butternut Creek has a total of 21 sites identified for Streambank stabilization as shown in Table 8.5, totaling 4,675 linear feet. Pollutant loading calculations estimate these sites are contributing a total of 11,247 tons of sediment. It is assumed that streambank stabilization of moderate and severe sites will reduce pollutant loading by 100%. Sites that are rated as minor are not included in the pollutant reduction estimates.

Moore Drain has a total of 21 sites identified for Streambank stabilization, shown in Table 8.6, totaling 2,620 linear feet. Pollutant loading calculations estimate these sites are contributing a total of 2,466 tons of sediment annually. Loading reduction estimates for moderate and severe sites are estimated to be 100% when streambanks are properly stabilized. Sites rated as minor are not included in the pollutant reduction estimates.

Cedar Run has a total of 44 sites identified for Streambank stabilization, shown in Table 8.7, totaling 6,045 linear feet. Pollutant loading calculations estimate these sites are contributing a total of 19,481 tons of sediment annually. Moderate and severe rates sites are slated for remediation and included in the pollutant loading reduction estimates.

Scott Drain has a total of 27 sites identified for Streambank stabilization, shown in Table 8.8, totaling 3,265 linear feet. Pollutant loading calculations estimate these sites are contributing a total of 4,353 tons of sediment annually. Loading reduction estimates for sites rated as moderate or severe are presumed to be 100%. Sites rated as minor are not included in the pollutant loading reduction estimates.

Loading Estimate Methodology

The loading reduction target for all streambank erosion sites is 100% assuming that the bank is stabilized to mitigate future erosion from occurring. For the loading calculations an identical calculation methods described for gully erosion sites; the soils in this area are well represented by a factor of 110 lbs/ft³, when this is divided by 2000 lbs/Ton the conversion factor of 0.055 Tons/ft³ is obtained.

Summary Tables & Maps

Table 8.5: Butternut Creek impairments from Streambank erosion

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes &Comments	Rating Chart	Sediment Load (Tons)	Est Load – Phosphorous (lbs)	Est Load – Nitrogen (lbs)
57	2	25	450	2:1	Bank Eroding, Toe Unstable, Roots exposed, runoff in areas or animal path	Minor	1750	1925	3850
716	2	10	120	1:1	Undercutting, Homes above. Sediment slumping in areas. Roots exposed.	Minor	150	165	330
63	3	40	600	1:1	Bank Eroding, Toe Stable, Seepage, trees slanting in, trees down, some areas more stable than others	Minor	4500	4950	9900
64	2	25	120	1:1	Bank Eroding, Toe Stable, Illicit discharge, Tiles, Seepage, human activity homes above on bank	Minor	375	412.5	825
66	2.5	125	45	1:1	Bank Eroding, Toe Unstable, Undercutting, high water, roots exposed, some trees leaning in	Minor	878	966	1933
67	3	15	100	2:1	Bank Eroding, Toe Stable, Undercutting, slight bend in river. Possible seepage-no visual sediment slumped, starting to restabilize w/veg	Minor	281	309	618

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes & Comments	Rating Chart	Sediment Load (Tons)	Est Load – Phosphorous (lbs)	Est Load – Nitrogen (lbs)
68	1	8	40	1:1	Bank Eroding, Toe Unstable, Undercutting, deflection, high water, roots exposed	Minor	20	22	44
72	3	8	55	1:1	Toe Stable, River Bend, human refuse (bricks) roots exposed	Minor	82.5	90.8	181.5
73	1.5	10	1000	1:1	Bank Eroding, Toe Stable, River Bend, Seepage, Possible deflection. Road above, Sediment slumped. Toe re-vegetating in some areas	Minor	937	1031	2062
59	2	6	500	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, Sediment slumped in areas, trees leaning in	Moderate	375	412	825
61	2	5	130	1:1	Bank Eroding, Toe Unstable, Undercutting, high water, Roots exposed, some veg re-growing on toe	Moderate	81.25	89.4	178.8
62	2	3	300	1:1	Bank Eroding, Toe Unstable, Undercutting, high water, roots exposed, beg to veg and stabilize in some areas only	Moderate	112.5	123.8	247.5
65	1	12	35	1:1	Toe Stable, River Bend, Seepage, sediment slump w/veg	Moderate	26.25	28.9	57.8

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes & Comments	Rating Chart	Sediment Load (Tons)	Est Load – Phosphorous (lbs)	Est Load – Nitrogen (lbs)
719	2.5	NR	NR	NR	Undercutting has potential to increase	Moderate	No data	No data	No data
69	1-1.5	6	90	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, high water, roots exposed	Moderate	59.06	65	129.9
720	NR	NR	NR	NR	Undercutting, potential 3-DOT	Moderate	No data	No data	No data
70	1.5	8	250	1:1	Undercutting, high water, roots exposed	Moderate	187.5	206.3	412.5
71	2	5	40	1:1	Bank Eroding, Toe Unstable, Undercutting, high water?, roots exposed	Moderate	25	27.5	55
56		35	800	2:1	Toe Unstable, Undercutting, Roots exposed, some stable areas, slumping in some areas	Severe	1750	1925	3850
715	NR	NR	NR	NR	Agricultural Runoff, Illicit discharge, Tiles, Big dredged site. Field behind. 2 drainage tiles and a water pump	Severe	No data	No data	No data
60	NR	NR	NR	NR	Illicit discharge, Drainage	Severe	No data	No data	No data

Table 8.6 Moore Drain impairments from Streambank erosion

Site ID	Average Depth	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
100	NR	NR	NR	NR	just past bridge; potential access site; 1-2 parking; Caine Rd; (ID 100 used to enter database); (decreasing trend and minor used to enter database)	Minor	No data	No data	No data
101	NR	NR	NR	NR	Erosion during storm waters; beginning to re-stabilize	Minor	No data	No data	No data
756	1.5	25	120	2:1	Bank Eroding, Toe Stable, River Bend, Sediment Dropped	Minor	281.25	309.4	618.8
757	3.5	7	150	2:1	Bank Eroding, Toe Unstable, Undercutting, Sediment Dropped, high water, illicit water pump at this location	Minor	229.69	252.7	505.3
841	2	6-7	40	1:1	Bank Eroding, River Bend, toe stabilizing; natural run-off; beginning of	Minor	32.50	35.8	71.5

Site ID	Average Depth	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
					riverbend				
842	2	5-10	200	1:1	Bank Eroding, Sediment Dropped, high water toe stabilizing; slope increases	Minor	187.5	206.3	412.5
844	1.5	12	35	2:1	Bank Eroding, Toe Unstable, Trampled, Undercutting, Foot Traffic, Residence, rope swing; observation water up higher; aquatic vegetation submerged due to high water	Minor	39.38	43.3	86.6
847	2	4-5	60	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, high water	Minor	33.75	37.1	74.3
848	1.5	5	40	1:1	Bank Eroding, Toe Unstable, Sediment Dropped, high water, left bank 65ft	Minor	18.75	20.6	41.3

Site ID	Average Depth	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
849	1.5	10	90	1:1	Bank Eroding, Toe Unstable, Trampled, Foot Traffic, Sediment Dropped, high water	Minor	84.38	92.8	185.6
850	2	5	30	2:1	Bank Eroding, River Bend, Sediment Dropped, high water; big river bend, toe stabilizing	Minor	18.75	20.6	41.3
852	1.5	4	80	2:1	Bank Eroding, River Bend, Sediment Dropped, high water, toe stabilizing	Minor	30	33	66
854	NR	3	35	3:1	Bank Eroding, Toe Unstable, Agricultural Runoff, 2 Drains; Partially Rocked	Minor	6.56	7.2	14.4
758	1.5	10	65	1:1	Bank Eroding, Toe Stable, Undercutting, Sediment Dropped, high water	Moderate	60.94	67.0	134.1

Site ID	Average Depth	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
839	2	5-7	140	1:1	Bank Eroding, Toe Unstable, Undercutting, Sediment Dropped, Seepage, high water, toe stabilizing in some areas	Moderate	105.0	115.5	231.0
845	2	7	200	1:1	Obstruction, high water; water diverted around vegetation bed in front, natural run-off; roots exposed	Moderate	175.0	192.5	385.0
846	1.5	5	275	1:1	Bank Eroding, Toe Unstable, River Bend, high water foot path above bank	Moderate	128.91	141.8	283.6
853	2	4	300	1:1	Bank Eroding, Toe Unstable, Undercutting, Sediment Dropped, high water, toe stabilizing in some areas	Moderate	150	165	330

Site ID					Average Depth	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
840					1	5-25	400	1:1	Bank Eroding, Toe Unstable, Undercutting River Bend, Sediment Dropped, Seepage, high water, toe stabilizing in some areas; slope increases	Severe	425	467	935
843	1	12	300	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, Sediment Dropped, Seepage, high water; river bend is slight, roots exposed; trees leaning in; toe stabilizing in some areas	Severe	225	247	495				
851	2.5	25	60	2:1	Bank Eroding, Toe Unstable, Trampled, Foot Traffic, natural runoff; private access site;	Severe	234	257	515				

Site ID					Average Depth	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
						residence/camp above bank; wood stains put into bank							

Figure 8.4 Moore Drain Impairments

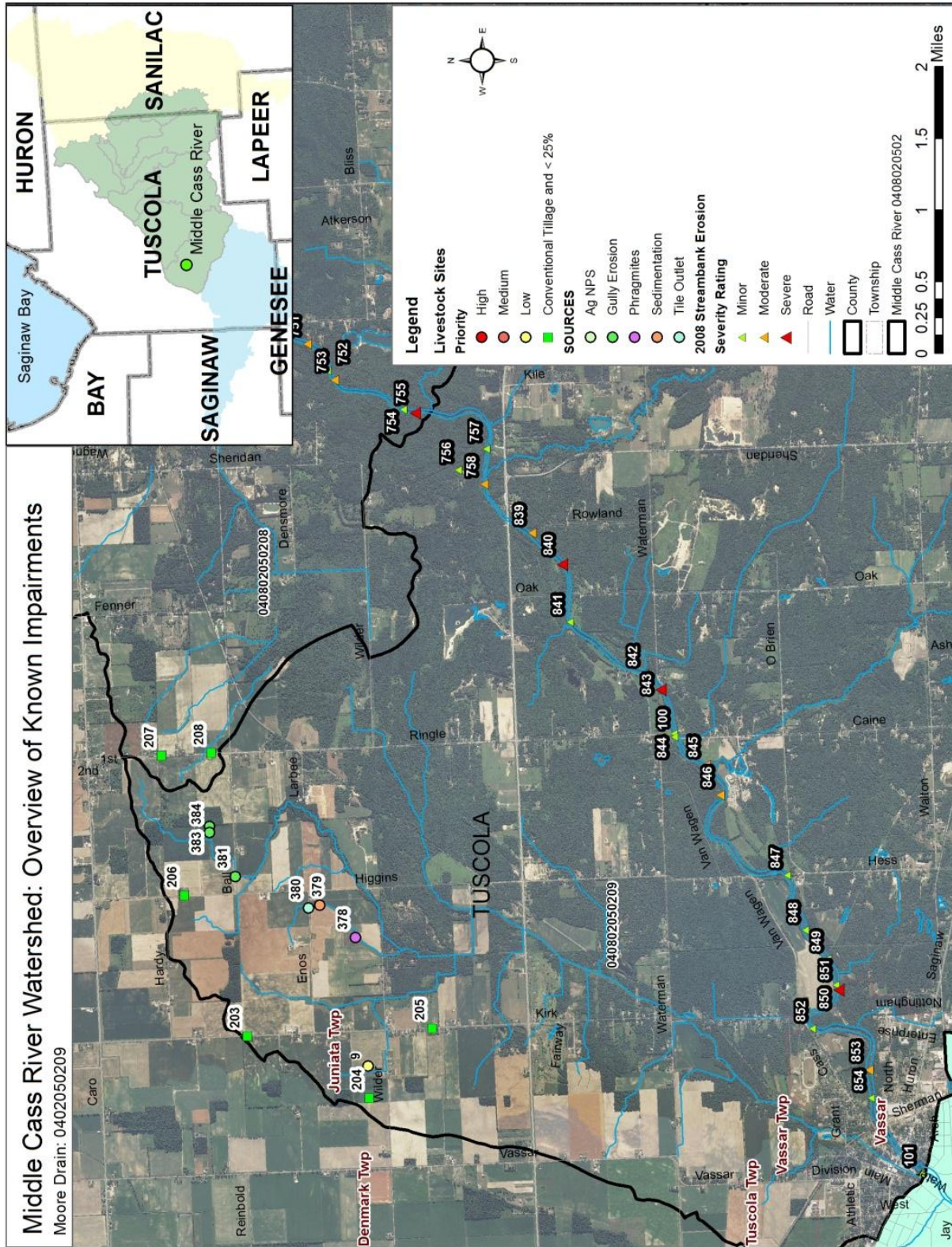


Table 8.7 Cedar Run impairments from Streambank erosion

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
714	1	8	120	1:1	Bank Eroding, deflection upstream, vegetated bed sticking out, Potential to increase (3-DOT)	Minor	60	66	132
17	1	15	120	2:1	Trampled, Undercutting, toe not stable due to foot traffic	Minor	112.50	123.8	247.5
20	1.5	20	50	2:1	Bank Eroding, Toe Stable, Seepage	Minor	93.75	103.1	206.3
21	1	25	40	1:1	road nearby above? River Rd.	Minor	62.5	68.8	137.5
25	2.5	8	40	1:1	Toe Unstable, Deflection/sediment/bank slump, Change in river width redirects water flow against bank	Minor	50	55	110
31	1.5	15	40	1:1	Bank Eroding, Undercutting, River Bend, sediment slump, vegetated bank above	Minor	56.25	61.9	123.8
33	2	25	120	1:1	Bank Eroding, Toe Stable, sediment slumping	Minor	375	412.5	825
36	2	50	60	2:1	Bank Eroding, Toe Stable, grass on bank now. Possible storm damage.	Minor	375	412.5	825
37	3	40	120	2:1	Bank Eroding, Toe Stable, River Bend	Minor	900	990	1980

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
38	1.5	40	60	1:1	Bank Eroding, Toe Stable, Seepage, lots of small trees and grass on toe	Minor	225	247.5	495
42	3	40	800	2:1	Bank Eroding, Seepage, Trees beginning to fall forward into river	Minor	6000	6600	13200
43	2.5	10	200	1:1	Bank Eroding, Toe Unstable, Foot Traffic, Seepage	Minor	312.5	343.8	687.5
47	2.5	5	40	1:1	Undercutting, some minor sediment slump tree leaning, old trees fell in, roots exposed	Minor	31.25	34.4	68.8
49	2	20	150	1:1	Bank Eroding, Toe Stable, River Bend, Seepage, sediment fell in	Minor	375	412.5	825.0
709	1.5	8	10	2:1	Bank Eroding, Toe Stable, Seepage	Minor	7.5	8.3	16.5
711	1.5	8	10	2:1	Bank Eroding, Agricultural Runoff, drainage	Minor	7.5	8.3	16.5
712	1.5	8	35	1:1	Undercutting, Sediment Dropped, Potential to increase (3dot)	Minor	26.25	28.9	57.8
52	1.5	8	60	2:1	Toe Unstable, water flow faster from rapids just upstream, Roots exposed. Eroding on both banks	Minor	45	49.5	99.0

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
53	2.5	10	75	1:1	Bank Eroding, Toe Stable, Sediment slump, Deflection, exposed roots, veg re-growing	Minor	117.19	128.9	257.8
54	3	12	40	2:1	Bank Eroding, River Bend, Deflection, pooling water, Sediment slumped, beginning to re-vegetate	Minor	90	99	198
16	2	NR	NR	NR	Agricultural Runoff, nutrient loading	Moderate	No data	No data	No data
18	2	NR	NR	NR	Agricultural Runoff, veg cover	Moderate	No data	No data	No data
19	3	10	55	1:1	Bank Eroding, Undercutting, Seepage, because water diverted due to 80% veg cover island water flow up causing undercutting on opposite bank, Logjam	Moderate	103.13	113.4	226.9
22	1	35	400	2:1	Bank Eroding, Undercutting, Human impact	Moderate	875	962.5	1925
23	1	40	100	1:1	Toe Unstable, Undercutting, Foot Traffic, River Bend, Seepage, some kind of pump sticking straight out into the middle of the river, large rocks	Moderate	250	275	550

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
26	1.5	35	40' and continues to 300' w/ some veg stabilized bank	1:1	sediment slump, Toe beginning to stabilize. Not much sunlight for vegetative growth.	Moderate	131.25	144.4	288.8
27	2	15-20	60	1:1	Undercutting, high water	Moderate	131.25	144.4	288.8
32	1	40-50	450-500	1:1	Bank Eroding, Toe Stable, River Bend, Seepage, large sediment slump, Toe stabilized with natural cobble an veg, some bank stabilization by veg patchy	Moderate	1335.9	1469.5	2939.1
34	1.5-2	20	110	1:1	Bank Eroding, winter damage not much vegetation on bank due to shade cover	Moderate	240.63	264.7	529.4
35	1.5	45-50	120	1:1	Bank Eroding, River Bend, sediment fell in large area several trees down. Possible human activity (trash site) above bank	Moderate	534.38	587.8	1175.6
39	1.5	7	75	1:1	Undercutting, Seepage	Moderate	49.22	54.1	108.3
41	3	20	20	2:1	Bank Stable, Undercutting, site of old water pump litter that eroded small area in bank drainage	Moderate	75	82.5	165

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
44	1.5	8	200	1:1	Bank Eroding, Toe Unstable, Undercutting, Trees falling in, sediment slumping	Moderate	150	165	330
45	2	20	335	2:1	Bank Eroding, Toe Unstable, River Bend River Bend, Road above, Trees & sediment falling in road above on top of bank. Cut-bank	Moderate	837.50	921.3	1842.5
46	1	8	110	1:1	Bank Eroding, Toe Unstable, Undercutting, 300 ft downstream from rapid/riffle, past river bend old trees fell in	Moderate	55	60.5	121.0
48	1	5	340	1:1	Bank Eroding, Toe Unstable, Undercutting, Seepage, high water, trees slanting in	Moderate	106.25	116.9	233.8
55	1	8	120	1:1	Bank Eroding, Toe Unstable, Deflection upstream, vegetated bed sticking out, Roots exposed	Moderate	60	66	132
713	3	12	40	2:1	Bank Eroding, River Bend, Obstruction, Deflection, pooling water, Sediment island (pt. bar?) 80% covering/island	Moderate	90	99	198

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
28	2	30	110	1:1	Bank Eroding, Undercutting, River Bend, Seepage, Some veg cover to stabilize bank patchy	Severe	412.5	453.8	907.5
29	1	8	800		Bank Eroding, Toe Unstable, Undercutting River Bend, Seepage, Sediment fell in Bank undercutting and eroding . 3-5 ft of stabilized toe w/vegetation.	Severe	400	440	880
30	<1	45	300	1:1	Bank Eroding, Undercutting, high water	Severe	843.75	928.1	1856.3
40	2	30	140-400	1:1	Bank Eroding, Toe Unstable, Undercutting, People living above on bank, Sediment slumped. Cedar tree recently fell in water	Severe	1012.5	1113.8	2227.5
50	2	30	500	1:1	Bank Eroding, Toe Stable, Undercutting, high water, Sediment slump, roots exposed	Severe	1875	2062.5	4125
51	1.5	35	180	2:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, water flow	Severe	590.63	649.7	1299.4

Figure 8.5 Cedar Run Impairments

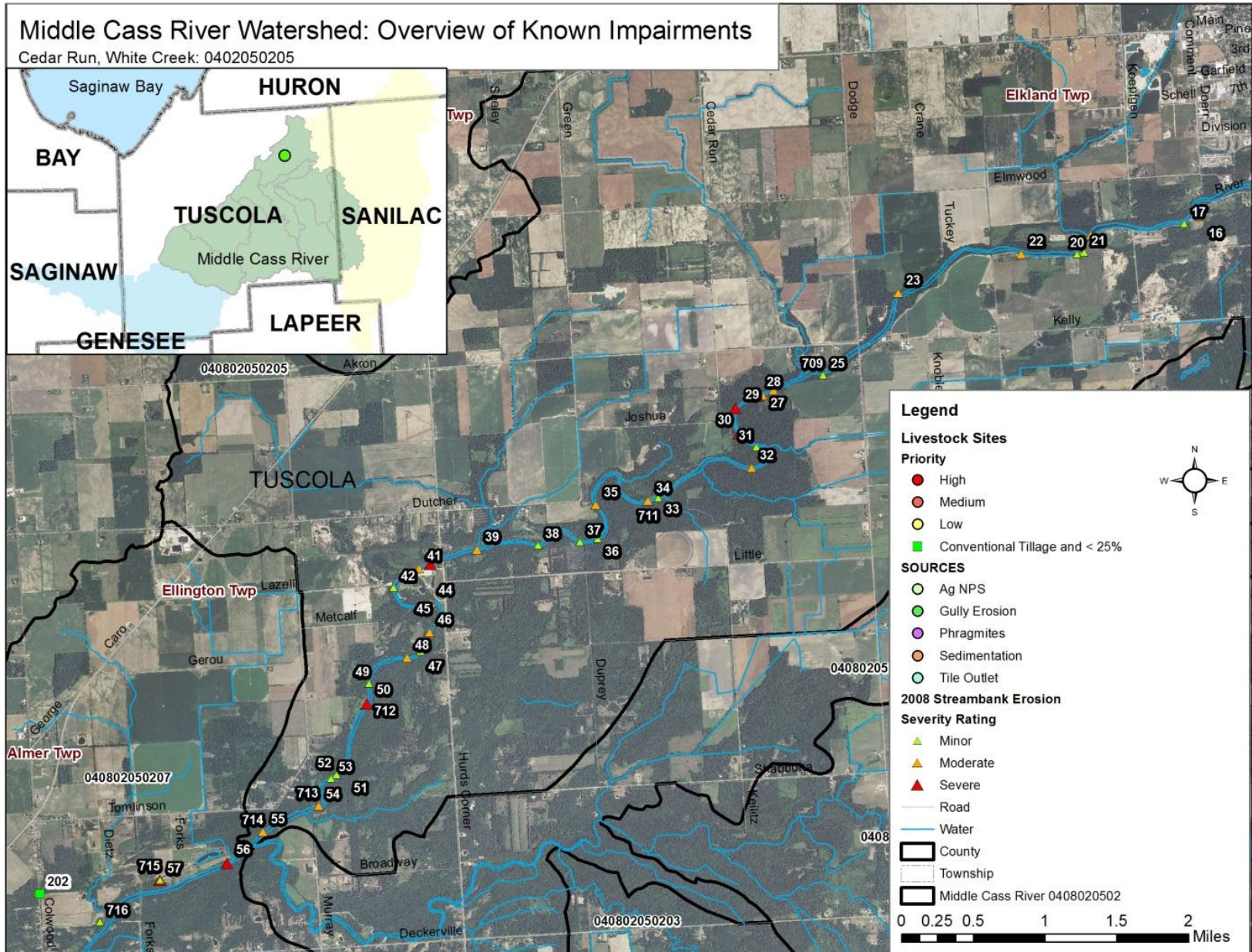


Table 8.8 Scott Drain impacts from Streambank erosion

Site ID	Average Height (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
74	2- 2.5	NR	NR	NR	Bank Eroding, Toe Stable, River Bend, seepage possible but not visible, part of bank re vegetating	Minor	No Data	No Data	No Data
737	2	8	30	1:1	Bank Eroding, Toe Unstable, Undercutting, Foot Traffic, Sediment Dropped, Left bank 25 ft. Right Bank 150 ft, logs, dead trees in water; roots exposed	Minor	30	33	66
738	1.5	5	85	2:1	Bank Eroding, Toe Stable, River Bend, high water	Minor	39.84	43.8	87.7
740	1	5	125	1:1	Bank Eroding, Toe Unstable, River Bend, Sediment Dropped, high water	Minor	39.06	43	85.9

Site ID	Average	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
741	1.5	6	50	1:1	Bank Eroding, Toe Unstable, Undercutting, high water-residence above bank	Minor	28.13	30.9	61.9
742	1	8-10	60	1:1	Bank Eroding, Toe Stable, Sediment Dropped, high water, animal traffic	Minor	33.75	37.1	74.3
746	1	20	85	1:1	Bank Eroding, Toe Stable, river bend just before residence/prison areas above bank. Human dumping of vegetation removal on top bank	Minor	106.25	116.9	233.8
750	2	8	50	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, deflection/pool; high water, roots	Minor	50	55	110

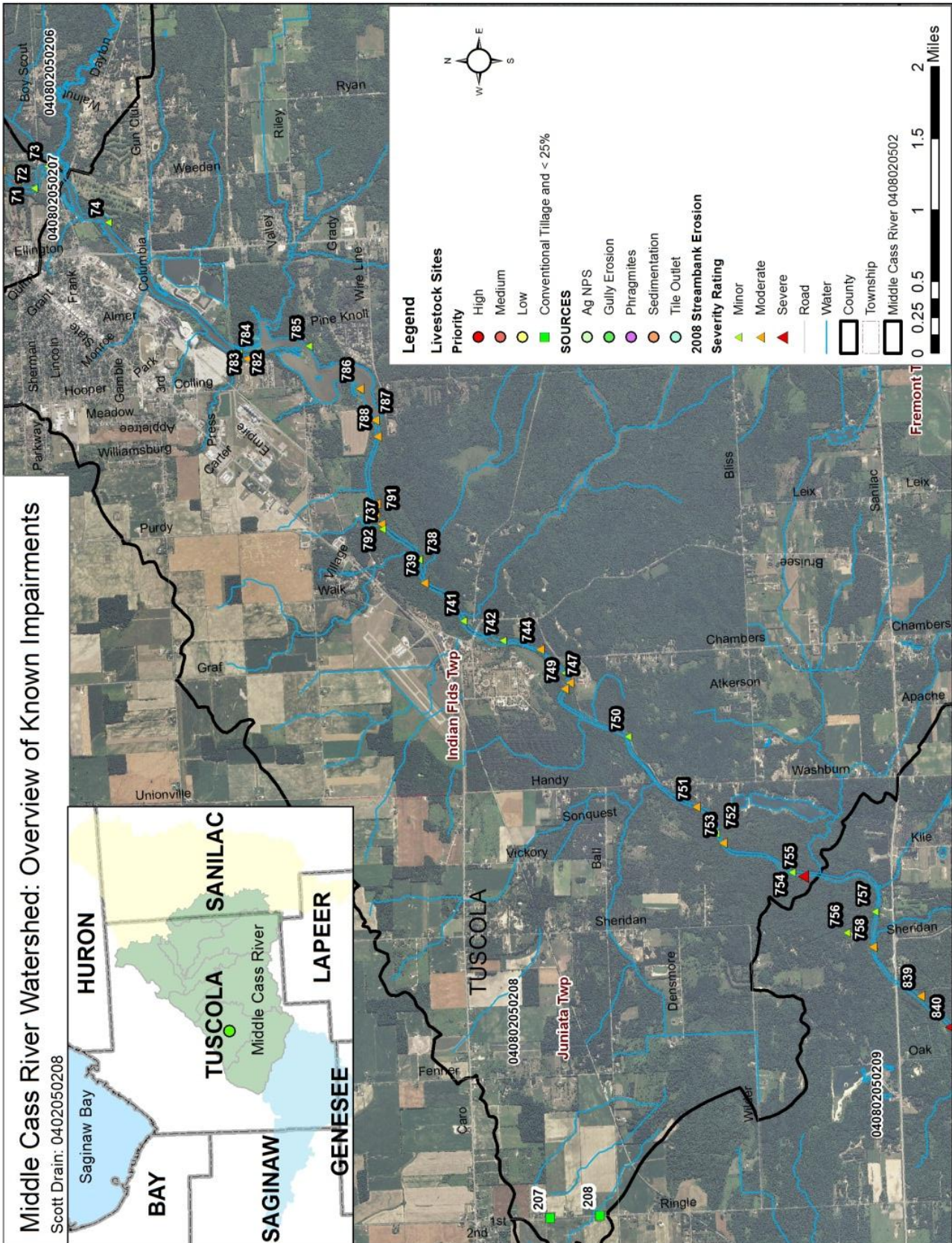
Site ID	Average	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
					exposed				
752	2	20	70	1:1	Bank Eroding, Toe Unstable, Obstruction, Sediment Dropped, vegetation deflecting water around/high water, some patchy areas of toe are more stable w/vegetation	Minor	175	192.5	385
754	1	8	40	1:1	Bank Eroding, Toe Unstable, Sediment Dropped, high water	Minor	20	22	44
782	1	3	60	1:1	Bank Eroding, Toe Stable, Undercutting, high water, roots exposed	Minor	11.25	12.4	24.8
784	1	3	80	1:1	Undercutting, roots exposed	Minor	15	16.5	33

Site ID	Average	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
785	1	5	60	2:1	Bank Eroding, Toe Unstable, Trampled, Illicit discharge, Tiles, Foot Traffic, high water residence; private property; mowed to edge; trees falling in; dead tree debris on bank	Minor	18.75	20.6	41.3
739	1	12	30	NR	Bank Eroding, Toe Unstable, River Bend, roots exposed	Moderate	22.5	24.8	49.5
744	1.5	8	140	1:1	Bank Eroding, Toe Unstable, Sediment Dropped, deflection, drainage (cemented)	Moderate	105	115.5	231
747	3	12	40	1:1	Bank Eroding, Toe Unstable, Undercutting River Bend, Sediment	Moderate	90	99	198

Site ID	Average	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
					Dropped, old cement structure.				
749	2	15-20	75	1:1	Bank Eroding, Toe Unstable, Undercutting River Bend, Sediment Dropped, deflection, roots exposed	Moderate	164.06	180.5	360.9
751	1	20	300	2:1	Bank Eroding, Toe Unstable, Undercutting, Sediment Dropped, Seepage, high water cutting down trees on bank, attempting to put in stairs, etc.	Moderate	375	412.5	825
753	1.5	5	110	1:1	Bank Eroding, Toe Unstable, Undercutting, Sediment Dropped, high water	Moderate	51.56	56.7	113.4

Site ID	Average	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
783	1	40	10	1:1	Bank Eroding, Toe Unstable, Trampled, foot traffic, mowed, cut down for path, residence, private property	Moderate	25	27.5	55.0
786	1	5	30	1:1	Bank Eroding, Toe Unstable, Undercutting, high water	Moderate	9.38	10.3	20.6
787	1.5	7	800-1000	1:1	Bank Eroding, Toe Unstable, Undercutting, Sediment Dropped, high water, This portion cannot be traveled from the upstream portion due to dangerous dam portage and no access at dam.	Moderate	590.63	649.7	1299.4
788	1.5	10	1000	1:1	Bank Eroding, Toe Unstable, Undercutting, Seepage, high water	Moderate	937.5	1031.3	2062.5

Site ID					Average Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes & Comments	Rating Chart	Sediment Load (tons)	Est Load Phosphorous (Lbs)	Est Load Nitrogen (lbs)
					(dam)							
789	1	10	450	1:1	Bank Eroding, Undercutting, Sediment Dropped, high water, roots exposed	Moderate	281.25		309.4	618.8		
791	1	8	60	2:1	Bank Eroding, Toe Unstable, Undercutting, Sediment Dropped, Seepage, high water	Moderate	30		33	66		
792	1	10	80	1:1	Undercutting, high water, Access site, Roots exposed	Moderate	50		55	110		
755	2.5	30	225	1:1	Bank Eroding, Toe Unstable, Sediment Dropped, high water	Severe	1054.69		1160.2	2320.3		



Priority 2: Livestock Access

Inventory

A total of five sites were identified during the watershed inventory that are impacting water quality in the Clark Drain (Table 8.9). These five sites contain 862 animals and are contributing and estimated 120 pounds of phosphorus per event and 8,470 pounds per event of COD. Loading reduction estimates for individual sites are presumed to be 100% when sites are properly remediated.

Loading Estimate Methodology

The Pollutant controlled calculation and documentation for Section 319 Watersheds Training Manual, June, 1999 section on Feedlot Pollution Reduction was utilized. The steps outlined in this document were developed into an Excel spreadsheet calculator. The calculation requires the determination of the average rainfall (R) per day by selecting the state and county in which the feedlot is located. The variable R is then calculated, in this case it is approximately $R = 0.2848$, as the watershed locations are within the same rainfall isopleths. The spreadsheet was set up so there were input areas for Slaughter Beef (feeder cattle); Dairy Cattle, Horses, Feeder Pigs (it was assumed that all pigs were feeders in the watershed), and sheep. So for Table 8.9 Clark Drain Impairments from Livestock Access, the pollutant loading calculator is set up to determine the Annual average mass load of pollutants in runoff using the following formula; the Mass load x Rain days per year x Correction Factor for number of rain days assuming the cows are "feeders" that yields approximately 548 lbs-P per year, and 2,794 lbs-N per year which could make its way to the watershed drainage system. Additionally, almost 3,667 lbs-BOD (biological oxygen demand) could be introduced into the surface water system annually from these feeder cattle on this site. A copy of the calculator is available for viewing in APPENDIX C.

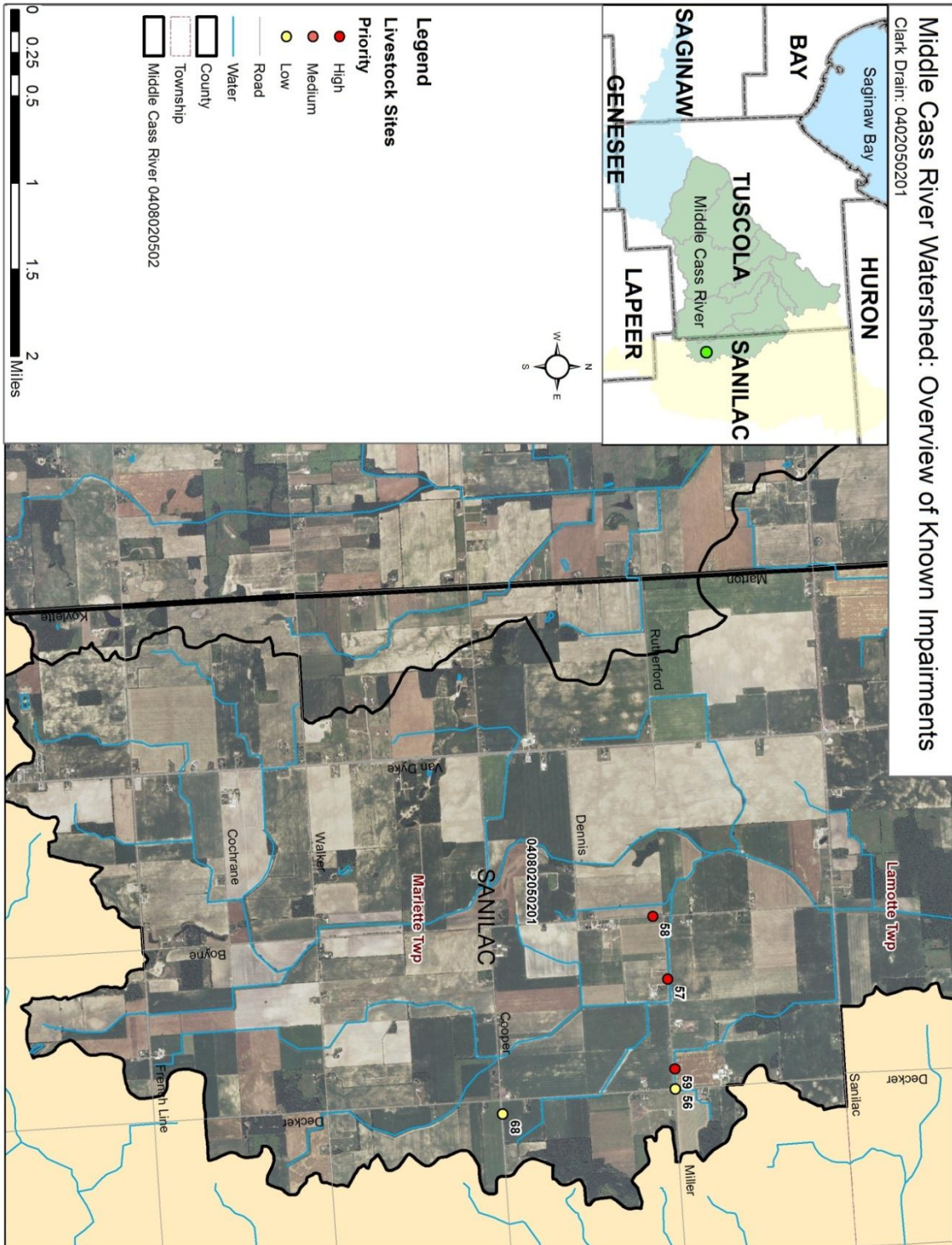
Summary Table & Map

Table 8.9 Clark Drain impairments from livestock access

Map Label	UTM-X	UTM-Y	# animals	Type	Priority 1=High 2 = Med. 3= Low	Estimated Annual "P" Load (lbs/yr) ¹	Estimated "N" Load (lbs/yr) ¹	Estimated BOD Load (lbs/yr) ¹	Reduction Targets (Bacteria, Phosphorous, Nitrogen)
57	4807411	333225	250	200 cattle 50 sheep	1	548.0	2,794.0	3,667.0	100%
58	4807342	332631	100	sheep	1	16.0	189.0	135.0	100%
59	4807409	33438	200	sheep	1	32.0	378.0	270.0	100%
68	480579	334379	12	sheep	3	2.0	23.0	16.0	100%
56	4807435	334246	300	sheep	3	49.0	567.0	405.0	100%

¹See Appendix C for excel spreadsheet model

Figure 8.7 Clark Drain, Livestock Impairments



Priority 3: Gully Erosion

Inventory

Three sites were identified in the Moore Drain (Table 8.10) as impacting water quality due to gully erosion. Pollutant loading calculations indicate these three gullies are contributing 35 tons per year of sediment, 38.5 pounds per year of phosphorus, and 77 pounds per year of Nitrogen. Loading reduction estimates for individual sites are presumed to be 100% when sites are properly remediated.

Loading Estimate Methodology

Using the *Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual* (June, 1999), we are able to provide information on the nutrient aspect of sediment loading in a watershed in Table 7.7. Using the data gathered by field survey crews, the sediment loading could be estimated from the length, width and depth of the visible erosion. This would be developed, first into a volume, then a mass. From the mass and general type of soils, we used a ratio of 1.1 pounds of phosphorus per ton of sediment to obtain the pounds of phosphorus loading. For example, in Table 7.7 at Site #51, the erosion volume was estimated at 24 ft³ based on the field measurements of the gully erosion at that site. This estimate has to be converted to Tons, therefore, using the geotechnical reference manual *GeoTechnical Engineering-Principles and Practices, 1999 by D.P.Coduto* the soils in this area are well represented by a factor of 110 lbs/ft³, when this is divided by 2000 lbs/Ton the conversion factor of 0.055 Tons/ft³ is obtained. With the estimate of 24 ft³ x 0.055 T/ft³ ÷ 2 yrs = 1 Ton/Yr of sediment is produced with this calculation. Then applying the ratio of 1.1 lb-P / Ton of sediment we obtain the estimated load of 1.6 lbs-P/Yr for this particular gully erosion site.

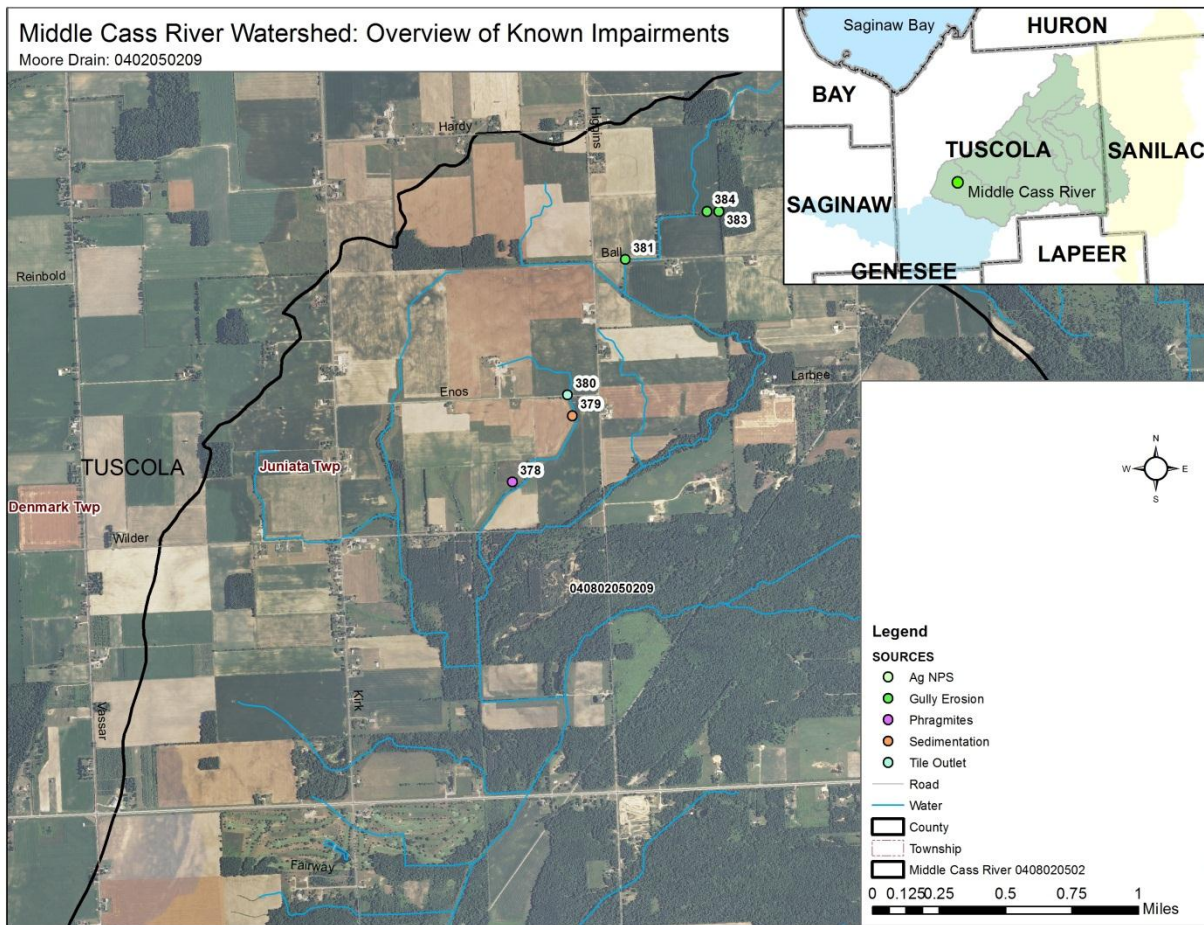
If the site was a nonpoint source of sediment, for example a field draining towards a drain or watercourse, the spreadsheet to determine nutrient and sediment loading would be correlated with the regions of the HIT model and data columns would be added for annual erosion rates and Delivery Ratios. From this data an annual sediment load in tons could be obtained, from that mass again a simple ratio of 1.1 lbs of P per ton of sediment or 2.2 lbs of N per ton of sediment could provide the nutrient loading for that area or district. USE of the HIT model could also show how a BMP could have an effect on nutrient and sediment loading.

Summary Table & Map

Table 8.10 Moore Drain impairments from gully erosion

Site #	¹ Erosion volume (ft ³)	Soil weight (tons/ft ³)	No. of years	Sediment Load (tons/yr)	Est. Load - Phosphorus (lbs/yr)	Est. Load - Nitrogen (lbs/yr)	Notes
381	80	0.0625	1	5	5.5	11.0	4'Wx1'Hx20'L
383	390	0.0625	1	24	26.8	53.6	3'Wx1'Hx130'L
384	90	0.0625	1	6	6.2	12.4	3'Wx1'Hx30'L

Figure 8.8 Moore Drain, Impairments from Gullies



Priority 4: Cropland Runoff

Inventory

Sites were selected that employed Conventional tilling methods and had minimal field residue, below is a summary by HUC-12 Code (Table 8.11). These sites were identified during the 2011 field inventory and are assumed to be the worst areas for agricultural runoff in each of the subwatersheds.

Table 8.11 Summary of sites identified for Agricultural Best Management Practices

HUC Name	HUC-12 CODE	Total HUC-12 Acres	Known Sites	Total Acreage of known sites	Supporting Tables and Maps
Moore Drain-White Creek	40802050209	36,077	7	430	Figure 8.9 Table 8.12 Table 8.13 Table 8.14
Clark Drain-North Branch White Creek	40802050201	25,803	107	1,340	Figure 8.10 Table 8.15 Table 8.16 Table 8.17

Inventory information verified a total of 430 acres in Moore Drain subwatershed and 1,340 acres in the Clark Drain subwatershed as contributing sediment and nutrients to surface water via field runoff. Sites were prioritized by impairment and HIT Model Results and then cross-analyzed with sites inventoried in 2011 as having conventional tillage and 25% or less residue on the field. Moore Drain (Table 8.12) and Clark Drain (Table 8.14) were identified as priority areas for working with landowners for the installation of agricultural BMPs that reduce nonpoint source runoff.

Loading Estimate Methodology

The STEPL model was used to calculate the total contribution of nitrogen load in pounds per year, phosphorous load in pounds per year, biological oxygen demand in pounds per year, and sediment in tons per year by subwatershed for known acreage of problem sites.

Estimated reductions for three practices were calculated at the subwatershed level using the HIT Model. Sediment and phosphorous reductions were estimated for mulch-till, no-till and 30 feet grass buffers. Clark Drain has 107 fields totaling 1,340 acres of agricultural land in production using conventional tiling and cropping practices while Moore Drain has 7 fields totaling 430 acres. The HIT model was used to calculate pollution reductions that would occur should the worst 5% and/or 10% total agricultural area be put into a type of conservation tillage.

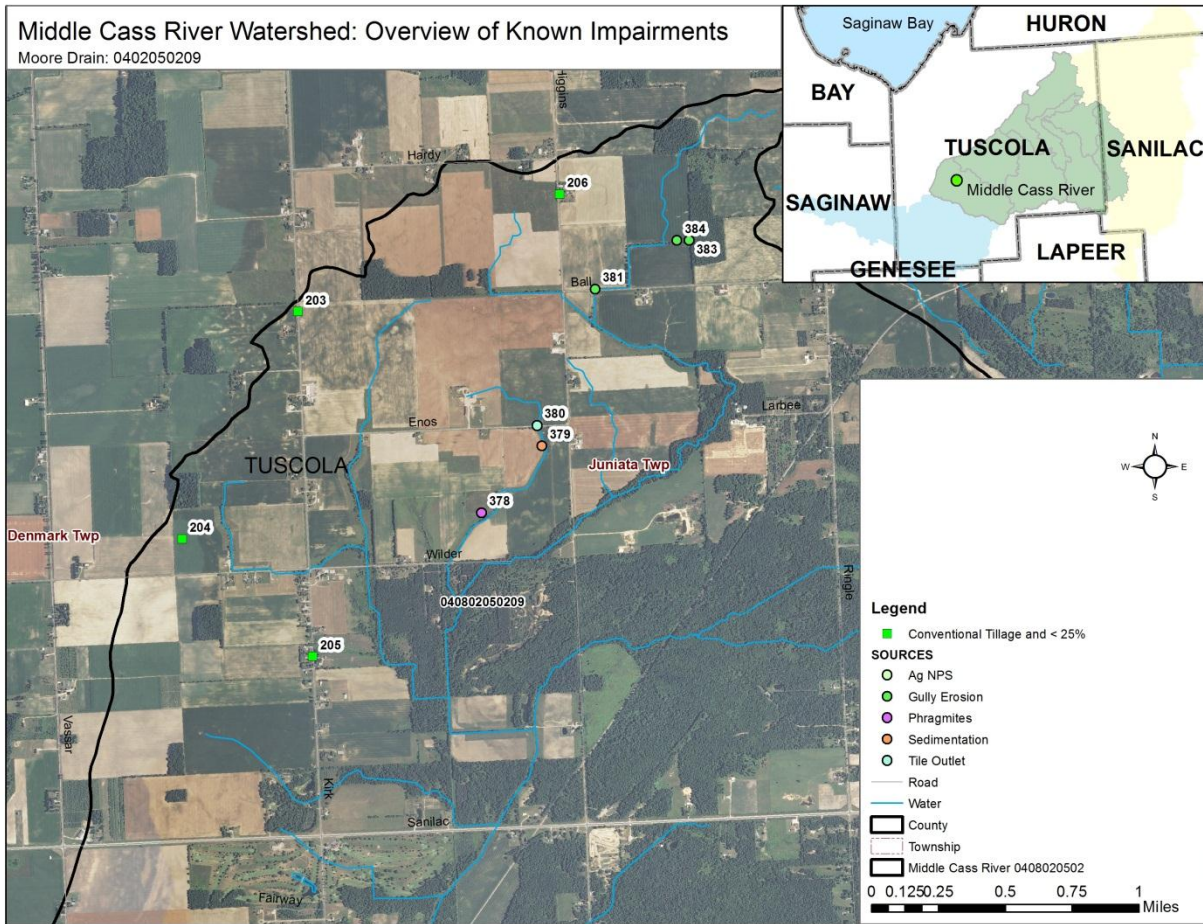
Summary Tables and Maps

A series of tables and figures follows for each of the subwatersheds that were inventoried during the 2011 windshield survey. For the Moore Drain, Table 8.12 provides a list of field identified where practices can be installed; Table 8.13 provides pollutant loads estimates, Table 8.14 provides an estimation of pollutant reduction and a cost benefit analysis, while Figure 8.9 provides locations for the sites described in Table 8.12. For the Clark Drain, Table 8.15 lists each site for potential installation of conservation tillage and cover crops and are also shown in Figure 8.10.

Table 8.12 Moore Drain Priority Sources of Agricultural Nonpoint Source Pollution

Label	UTM-Y	UTM-X	SLOPE	ACRES	TILLAGE	RESIDUE	% RESIDUE
202	4820753	310203	Flat	40	Minimum tillage	Bean	0 - 25%
203	4812272	292649	Flat	80	Conventional tillage	Corn	0 - 25%
204	4810948	291871	Moderate	30	Conventional tillage	Corn	0 - 25%
205	4810195	292613	Flat	80	Conventional tillage	Bean	0 - 25%
206	4812883	294266	Moderate	40	Conventional tillage	Bean	0 - 25%
207	4813045	295852	Hilly	80	Conventional tillage	Wheat	0 - 25%
208	4812485	295847	Flat	80	Conventional tillage	Bean	0 - 25%

Figure 8.9: Moore Drain, Priority Sources of Agricultural Nonpoint Source Pollution



Pollutant loading reductions were estimated for nitrogen (N), phosphorus (P), biological oxygen demand (BOD), and sediment at the subwatershed level utilizing the STEPL Model, results are shown below in Table 8.13.

Table 8.13 Moore Drain, Pollutant loads and reductions, STEPL Model

430 Acres of Cropland	N Load (no BMP) (lb/yr)	P Load (no BMP) (lb/yr)	BOD Load (no BMP) (lb/yr)	Sediment Load (no BMP) (t/yr)
	1177.9	283.2	2434.8	133.7
	N Load (with BMP) (lb/yr)	P Load (with BMP) (lb/yr)	BOD Load (with BMP) (lb/yr)	Sediment Load (with BMP) (t/yr)
	306.0	75.8	1718.3	21.8
	% N Reduction	% P Reduction	% BOD Reduction	% Sed Reduction
	74.0	73.2	29.4	83.7

Table 8.14 provides a comparison on the amount of sediment and nutrient reduction cost per unit for mulch till, no till, and 30 feet grass buffers. No Till on the worst 10% of acreage in crop production can reduce sediment by 552 tons per year. The greatest cost-benefit is estimated to occur when no-till is employed on the worst 5% of the watershed area costing \$53 per ton of sediment reduced and \$63 per pound of phosphorous reduced.

Table 8.14 Pollutant Reduction Estimates for Moore Drain

Practice	Sediment Reduction (tons/yr)	BMP cost benefit (\$/ton reduction)	Phosphorous Reduction (lbs/yr) / \$/lb-P
mulch till on sediment for worst 5% (1,804 acres)	203	\$89	173 / \$105
mulch till on sediment for worst 10% (3,607 acres)	237	\$152	201 / \$179
No Till on sediment for worst 5% (1,804 acres)	475	\$53	404 / \$63
No Till on sediment for worst 10% (3,607 acres)	552	\$91	469 / \$108
sediment for 30ft grass buffer	310	\$80	264 / \$94

Table 8.15 Clark Drain Priority Sources of Agricultural Nonpoint Source Pollution

Site #	Latitude	Longitude	Twp	Section #	⁵ Contributing area (CA) (acres)
111	43.39265	-83.0736	Marlette	8	
112	43.39165	-83.0741	Marlette	8	
113	43.39068	-83.07551667	Marlette	8	
114	43.39005	-83.07573333	Marlette	8	
115	43.389	-83.07608333	Marlette	8	
116	43.38757	-83.07343333	Marlette	8	
117	43.38613	-83.0761	Marlette	8	
118	43.38607	-83.07846667	Marlette	8	
119	43.38805	-83.08211667	Marlette	8	
120	43.3884	-83.08511667	Marlette	8	
121	43.36415	-83.02143333	Marlette	23	
122	43.3683	-83.01285	Marlette	23	
123	43.36835	-83.01116667	Marlette	23	
125	43.36207	-83.00895	Marlette	23	
126	43.3602	-83.00958333	Marlette	23	
127	43.35992	-83.00981667	Marlette	23	
128	43.40935	-83.00521667	Marlette	1	40
129	43.40777	-83.00475	Marlette	1	40
130	43.40127	-83.0497	Marlette	4	40
131	43.40265	-83.05126667	Marlette	4	
132	43.40468	-83.05478333	Marlette	4	
133	43.41138	-83.05628333	Marlette	4	60
134	43.41412	-83.05611667	Marlette	4	60
135	43.4151	-83.05605	Marlette	4	
136	43.4122	-83.02026667	Marlette	2	30
137	43.41337	-83.0204	Marlette	2	20
138	43.41155	-83.01901667	Marlette	2	
139	43.41153	-83.01765	Marlette	2	20
140	43.41163	-83.01543333	Marlette	2	
141	43.4117	-83.0146	Marlette	2	
142	43.41142	-83.014	Marlette	2	40
143	43.4106	-83.01108333	Marlette	2	145
144	43.41063	-83.01088333	Marlette	2	25
145	43.41068	-83.0143	Marlette	2	20
146	43.40722	-83.025	Marlette	2	60
147	43.40662	-83.0182	Marlette	2	40

Site #	Latitude	Longitude	Twp	Section #	⁵ Contributing area (CA) (acres)
148	43.407	-83.01638333	Marlette	2	40
149	42.40493	-83.01581667	Marlette	2	80
150	43.40382	-83.01598333	Marlette	2	40
151	43.40242	-83.01618333	Marlette	2	40
152	43.48183	-83.058665	Lamotte	8	
175	43.37552	-83.03143333	Marlette	15	30
176	43.37548	-83.03015	Marlette	15	same
177	43.3754	-83.02871667	Marlette	15	same
178	43.37547	-83.03011667	Marlette	15	10
179	43.37533	-83.02701667	Marlette	15	15
180	43.37535	-83.02738333	Marlette	15	same
181	43.3734	-83.04546667	Marlette	15	10
182	43.37668	-83.04331667	Marlette	15	15
183	43.37772	-83.04275	Marlette	15	15
184	43.37948	-83.04363333	Marlette	15	10
185	43.3807	-83.04396667	Marlette	15	10
239	43.39425	-83.05526667	Marlette	9	same
240	43.395	-83.05663333	Marlette	9	40
241	43.40102	-83.05875	Marlette	9	
242	43.39395	-83.04655	Marlette	9	same
243	43.3977	-83.05173333	Marlette	9	same
244	43.39607	-83.0496	Marlette	9	same
245	43.39928	-83.05381667	Marlette	9	same
246	43.3978	-83.05175	Marlette	9	same
247	43.39925	-83.05596667	Marlette	9	same
248	43.39983	-83.05665	Marlette	9	120
249	43.39957	-83.05656667	Marlette	9	same
250	43.3974	-83.05663333	Marlette	9	same
251	43.39383	-83.05646667	Marlette	9	40
252	43.3915	-83.05403333	Marlette	9	
253	43.39197	-83.03805	Marlette	9	
254	43.39273	-83.0554	Marlette	9	
255	43.38883	-83.06483333	Marlette	9	
256	43.3891	-83.06383333	Marlette	9	
257	43.38953	-83.06018333	Marlette	9	
258	43.39247	-83.0603	Marlette	9	
259	43.39357	-83.06176667	Marlette	9	
260	43.40937	-83.03793333	Marlette	3	

Site #	Latitude	Longitude	Twp	Section #	⁵ Contributing area (CA) (acres)
261	43.40977	-83.03965	Marlette	3	
262	43.40645	-83.03971667	Marlette	3	15
263	43.4108	-83.03996667	Marlette	3	
264	43.41148	-83.04006667	Marlette	3	
265	43.41263	-83.04006667	Marlette	3	30
266	43.4141	-83.0375	Marlette	3	40
267	43.40893	-83.02743333	Marlette	3	
279	43.36518	-83.02938333	Marlette	22	
280	43.36333	-83.03563333	Marlette	22	
281	43.36507	-83.0365	Marlette	22	
282	43.36332	-83.039	Marlette	22	
283	43.36602	-83.03081667	Marlette	22	
284	43.36338	-83.0369	Marlette	22	
285	43.36352	-83.03506667	Marlette	22	
286	43.369	-83.03185	Marlette	22	
287	43.36872	-83.03978333	Marlette	22	
294	43.37203	-83.05281667	Lamotte	16	
295	43.3791	-83.05776667	Lamotte	16	20
296	43.38272	-83.05766667	Lamotte	16	20
297	43.37343	-83.05481667	Lamotte	16	20
298	43.37547	-83.05595	Lamotte	16	
299	43.37973	-83.05783333	Lamotte	16	
300	43.38458	-83.05438333	Lamotte	16	
301	43.38187	-83.0578	Lamotte	16	
302	43.38457	-83.05133333	Lamotte	16	
313	43.39445	-83.02648333	Lamotte	11	40
314	43.39445	-83.02253333	Lamotte	11	
315	43.4002	-83.01611667	Lamotte	11	
316	43.39902	-83.01621667	Lamotte	11	
317	43.39902	-83.01621667	Lamotte	11	
320	43.39492	-83.05405	Lamotte	11	

Pollutant loading reductions were estimated for nitrogen (N), phosphorus (P), biological oxygen demand (BOD), and sediment at the subwatershed level utilizing the STEPL Model, results are shown below in Table 8.15.

Table 8.15 Clark Drain, Pollutant loads and reductions, STEPL Model

1,340 Acres of Cropland	N Load (no BMP) (lb/yr)	P Load (no BMP) (lb/yr)	BOD Load (no BMP) (lb/yr)	Sediment Load (no BMP) (t/yr)
	5212.0	1156.5	10818.1	458.9
	N Load (with BMP) (lb/yr)	P Load (with BMP) (lb/yr)	BOD Load (with BMP) (lb/yr)	Sediment Load (with BMP) (t/yr)
	1418.6	336.3	8359.8	74.8
	% N Reduction	% P Reduction	% BOD Reduction	% Sed Reduction
	72.8	70.9	22.7	83.7

Table 8.16 provides a comparison on the amount of sediment and nutrient reduction cost per unit for mulch till, no till, and 30 feet grass buffers for the Clark Drain. No Till on the worst 10% of acreage in crop production can reduce sediment by 674 tons per year. The greatest cost-benefit is estimated to occur when no-till is employed on the worst 5% of the watershed area costing \$34 per ton of sediment reduced and \$40 per pound of phosphorous reduced.

Table 8.16 Pollutant Reduction Estimates for Clark Drain

Practice	Sediment Reduction (tons/yr)	BMP cost benefit (\$/ton reduction)	Phosphorous Reduction (lbs/yr) / \$/lb-P
mulch till on sediment for worst 5% (1,290 acres)	226	\$57	192 / \$67
mulch till on sediment for worst 10% (2,580 acres)	289	\$89	246 / \$105
No Till on sediment for worst 5% (1,290 acres)	527	\$34	448 / \$40
No Till on sediment for worst 10% (2,580 acres)	674	\$54	573 / \$63
sediment for 30ft grass buffer	665	\$98	565 / \$116

8.5 Estimate of the load reductions expected from the proposed management measures (EPA Element B)

A discussion on the methods used to calculate pollutant loading estimates is covered in Chapter 6 Upper Cass River, and follows the same methods used for the Middle Cass River.

Load reductions needed to address each impairment and threat (EPA, B.1)

Priority sites are identified in waterways listed as impaired by the MDEQ (Butternut Creek and Moore Drain). Load reductions will be achieved by remediating streambank erosion sites, livestock access sites, gully erosion sites, and agricultural runoff. Loading reductions for streambank erosion and livestock access are only estimated for high and medium priority sites. Loading reductions are calculated at 100% for gully erosion and for 5% acreage targets for cropland runoff (Table 8.17).

Table 8.17 Summary Table of Expected Load Reductions

Impairment Source	Loading Estimate for total sites	Loading Reduction	Loading Reduction %
Streambank Erosion	Sediment (tons/yr) = 11,590 + 2,466 + 19,481 + 4,353 = 37,890	Sediment (tons/yr) = 2,616 + 1,503 + 10,248 + 3,786 = 18,153	47.9%
Livestock Access	647 lbs/yr P, 3,951 lbs/yr N, 4,493 t/yr BOD	Dependent on practice – see tables 8.18-8.20	Variable depending on practice installed
Gully Erosion	Sediment (tons/yr) = 35; 38.5 lbs P; 77 lbs N	Sediment (tons/yr) = 35; 38.5 lbs P; 77 lbs N	100%
Cropland Runoff	6,389 lb/yr N, 1,439 lbs/yr P, 13,252 lbs/yr BOD, 592 t/yr Sediment	4,665 lb/yr N, 1,027 lb/yr P, 3,174 lb/yr BOD, 496 t/yr Sediment	73% N, 72% P, 26% BOD, 83% Sediment

Annual Nutrient Reduction Loads for Livestock in the watershed using BMPs the following BMPs:

- Filter Strips along water course
- Waste Management Systems
- Waste Storage

Method used for determination of these nutrient loadings was the *Pollutant Controlled Calculation and Documentation for Section 319 Watersheds Training Manual, June, 1999*.

Table 8.18 shows reductions in annual loadings if vegetated filter strips are used to protect waterways. Table 8.19 shows reductions in annual loadings if waste management systems are

used to on high priority sites. Table 8.20 shows reductions in annual loadings if a waste storage facility is used on high priority sites.

Table 8.18 Reductions from vegetated filter strips.

Location	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)	BOD (lbs/yr)
Tuscola County (High Priority)	1770	ND	ND
Sanilac County (High Priority)	800	ND	ND

ND = A reduction constant was Not Determined in the 319 method used for this table

Table 8.19 Reductions from waste management systems

Location	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)	BOD (lbs/yr)
Tuscola County (High Priority)	1,875	8,480	ND
Sanilac County (High Priority)	850	4,600	ND

ND = A reduction constant was Not Determined in the 319 method used for this table

Table 8.20 Reductions from waste storage facilities

Location	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)	BOD (lbs/yr)
Tuscola County (High Priority)	1,250	6,890	ND
Sanilac County (High Priority)	565	3,740	ND

ND = A reduction constant was Not Determined in the 319 method used for this table

8.6 Description of the management measures needed to achieve the proposed load reductions (EPA Element C)

Goals for the Middle Cass River Watershed (EPA, C1)

1. Restore warmwater fishery designated use for Butternut Creek
2. Restore other indigenous aquatic life and wildlife use for Moore Drain
3. Prevent further degradation of fishery in Scott Drain and Cedar Run White Creek from streambank erosion
4. Restore and protect forested riparian buffer

Management Measures are Applicable & Feasible (EPA, C2-3)

Streambank Erosion can be addressed through a variety of means. These include installation of vegetative buffers to slow overland runoff and stabilization of the bank itself using natural materials such as logs or brush mattresses to hard armoring options such as gabion baskets or rip rap in extreme erosion cases.

Livestock Access: Livestock can be restricted to accessing surface water by installation of fencing along river corridors, and installation of alternate watering facilities. Manure stacking facilities may also need to be installed to prevent surface runoff into local waterways.

Gully Erosion can be addressed through stabilization practices including installation of vegetative buffers, swales or contour farming practices, or drop structures.

Agricultural NPS is a broad category that includes the following causes of impairments: Cropland erosion/runoff, Conventional Tillage, Surface ditching, Manure spreading. These can be addressed through a combination of **Agricultural BMP's**:

- Conservation tillage / Mulch-till
- Grassed Buffers
- Cover cropping

Stormwater management: A suite of management measures are available to reduce pollution and impacts to water quality in the Middle Cass River. Management measures are listed by priority for Caro, Mayville and Vassar. Chapter 4 details the urban stormwater analysis and appropriate management measures for the three urbanized areas in the Middle Cass River that were inventoried as a part of the urban hydrologic assessment, detailed in Chapter 4. There are structural recommendations to keep runoff on-site and managerial recommendations for planning commissions to enact to reduce stormwater runoff.

Recommended Managerial Strategies

Point of sale septic system ordinance: Bacteria pollution is a pervasive problem in Michigan and the Cass River Watershed. Michigan is only one of two states in the union that do not have a statewide ordinance relating to the inspection of septic systems at the time of sale. Several counties have adopted or are working on developing time of sale ordinances for their communities. A sample ordinance from the Barry-Eaton District Health Department is included in the watershed plan for local health departments to consider for adaptation and adoption.

Low impact development: A recent study performed by the Planning and Zoning Center at Michigan State University, evaluated the use of Low Impact Development in the Cass River Watershed. Full recommendations are included in the appendix E. Stormwater management is also considered a component of low impact development and is detailed in Chapter 4.

Critical Locations for Management Measures_(EPA, C.4)

Critical locations are those that have been identified as impaired by the Michigan DEQ: Butternut Creek and Moore Drain. Additional hot-spots have been identified in Clark Drain, Cedar Run, White Creek, and Scott Drain. All locations are mapped by 12-HUC code.

Priority 1:

Butternut Creek, streambank stabilization

Moore Drain, streambank stabilization

Cedar Run, streambank stabilization

Scott Drain, streambank stabilization

Priority 2:

Clark Drain, Livestock fencing, manure stacking, and alternative water facilities

Priority 3:

Moore Drain, stabilization of gully erosion sites

Priority 4:

Moore Drain, implement cover cropping and conservation tillage

Clark Drain, implement cover cropping and conservation tillage

Load reductions linked to management measures (EPA, C.5)

Several practices have the ability to reduce loading by nearly 100% (e.g. permanent sediment reduction by fencing livestock out of riparian areas, stabilization of streambanks, removal of gullies). See the STEPL Modeling results for reductions in sediment/nutrient reductions through installation of agricultural BMP's. The percent reduction for agricultural BMP's are demonstrated in the STEPL Model calculations. We assume practices installed for livestock exclusions, e. coli reduction, gully stabilization, tile outlet erosion, and streambank stabilization have the ability to reduce loading by at or near 100% (e.g. permanent sediment reduction by fencing livestock out of riparian areas and are calculated using the MDEQ 319 Manual.

8.7 Implementation Schedule and Assistance (EPA Elements D, F, G, H)

EPA Elements D, F, G, and H are presented below by priority subwatershed and impairment in Table 8.21.

Priority Sub-shed	MGMT Measure	Technical Assistance Type	Technical Cost	*Project Lead Partners	Quantity	Material / Installation Cost	Total Cost and Potential Funding	Regulatory Agencies
1 Butter-nut Creek	Streambank Erosion Stabilization	engineering and construction	full time technician with conservation district (estimated at 90K for two years)	*Tuscola C.D., Saginaw bay RC&D, Cass River Greenway	4,675 linear feet	est \$20 foot = \$93,500	\$116,000.00 Great Lakes Commission (GLC)	MDEQ, Soil Erosion
1 Moore Drain				*Tuscola C.D., Saginaw bay RC&D, Cass River Greenway	2,620 linear feet	est \$20 foot = \$52,400	\$74,900.00 GLC	MDEQ, Soil Erosion
1 Cedar Run				*Tuscola C.D., Saginaw bay RC&D, Cass River Greenway	6,045 linear feet	est \$20 foot = \$120,900	\$143,400.00 GLC	MDEQ, Soil Erosion
1 Scott Drain				*Tuscola C.D., Saginaw bay RC&D, Cass River Greenway	3,265 linear feet	est \$20 foot = \$65,300	\$87,800.00 GLC	MDEQ, Soil Erosion

Priority Sub-shed	MGMT Measure	Technical Assistance Type	Technical Cost	*Project Lead Partners	Quantity	Material / Installation Cost	Total Cost and Potential Funding	Regulatory Agencies
2 Clark Drain	Manage feedlot runoff, exclusionary fencing, alternate watering facilities	livestock mgmt plan	support to current technician	*Tuscola C.D., MMPA, Farm Bureau	862 Animals	est \$15,000 per site * 5 sites	\$75,000.00 319, Farm Bill, USDA-NRCS	MDA, FSA, Drain Office
3 Moore Drain	Gully erosion stabilization	engineering and construction	support to current technician	*Tuscola C.D., Saginaw bay RC&D, Cass River Greenway	3 gullies	est \$5,000 per site * 3 sites	\$15,000.00 CZMP, 319, Farm Bill	MDA, Drain Office, FSA
4 Moore Drain	Conservation tillage and cover cropping	landowner outreach and assistance	support to current technician	*Tuscola C.D., Saginaw Bay RC&D, Farm Bureau	430 Acres	\$10-\$14 acre = \$4,300 to \$6,020	\$6,020.00 319, Farm Bill, USDA-NRCS	MDA, FSA
4 Clark Drain	Conservation tillage and cover cropping	landowner outreach and assistance	support to current technician	*Tuscola C.D., Saginaw Bay RC&D, Farm Bureau	1340 Acres	\$10-\$14 acre = \$13,040-\$18,760	\$18,760.00 319, Farm Bill, USDA-NRCS	MDA, FSA

The public information and education plan can be found in Chapter 6 (EPA Element E). The education plan is broken to address each of the pollutant sources and causes by target audience, message, and delivery tools. The schedule for implementation and milestones are presented below in Table 8.22.

Table 8.22 Schedule for Implementation and Milestones (EPA Element F & G)

Priority	Sub-shed	Management Measure	Implementation Schedule	Interim Measurable Milestones	Evaluation Dates
1	Butternut Creek	Streambank Erosion Stabilization	2014-2016	800 feet (severe sites)	2014 - funding applied for, 2017 - milestones completed
1	Moore Drain	Streambank Erosion Stabilization	2014-2016	760 feet (severe sites)	
1	Cedar Run	Streambank Erosion Stabilization	2014-2016	2,000 feet (severe sites)	
1	Scott Drain	Streambank Erosion Stabilization	2014-2016	225 feet (severe sites)	
2	Clark Drain	Manage feedlot runoff, exclusionary fencing, alternate watering facilities	2015	600 animals fenced out	2019 milestone completed
3	Moore Drain	Gully erosion stabilization	2015	3 gullies	2021 confirm gullies remediated
4	Moore Drain	Conservation tillage and cover cropping	2016-2018	200 acres	2023 confirm acreage targets met
4	Clark Drain	Conservation tillage and cover cropping	2016-2018	800 Acres	

The three short-term actions required for each management measure are similar:

5. Submit funding proposal (Year One)
6. Landowner Outreach (Year Two)
7. Site Design and Implementation (Year Two - Year Three)
8. Monitoring, Re-Evaluation of WMP Status and Next Steps (Year Three - Year Four)

8.8 Load Reduction Criteria (EPA Element H)

The same criteria used to determine pollutant loading calculations will be used to calculate reductions from installation of BMP's. This includes the RUSLE equation and the STEPL Model and improvement in results of Michigan DEQ's five-year sampling of biological and chemical indicators.

Criteria used to determine achievement of load reductions for sediment and improvements in dissolved oxygen are described above in section A. Numeric criteria are delineated by the state of Michigan Water Quality Standards. The planning committee should revisit the plan and TMDL's every two years to evaluate progress on achieving milestones and subsequent load reductions. A monitoring request will be made in TMDL watersheds after priority impairment sources have been corrected to determine if designated uses have been restored.

8.9 Monitoring (EPA Element I)

Chapter 3 provides an overview of previous monitoring done in Middle Cass River. From this evaluation data gaps have been identified that should be looked at within the context of a comprehensive monitoring strategy for this watershed. Table 3.2 shows data available for all of the subwatersheds of the Middle Cass River. Expanded and continued monitoring should occur in TMDL watersheds given information identified during the 2008 and 2011 inventory in Butternut Creek and Moore Drain. Additional monitoring should also occur in Clark Drain, Cedar Run, and Scott Drain given impairments identified during the 2011 inventory.

Two major monitoring initiatives continue in the watershed. The first is the five-year basin monitoring program stewarded by the Michigan DEQ and the continuation of the TMDL process. The second is initiated by the Cass River Greenway committee, based in Frankenmuth. Together, monitoring data will in theory measure improvements of Cass River water quality. It is assumed that major restoration projects completed during implementation will have separate monitoring plans and Quality Assurance Project Plans (QAPPs) established as a part of their funding requirements. This is not limited to pre- and post- implementation sampling of parameters including turbidity, phosphorous, nitrogen, and dissolved oxygen.

As projects are implemented in impaired subwatersheds, it will be requested that MDEQ conduct monitoring in these stretches to verify water quality improvements in the Butternut Creek and Moore Drain. Inventory data collected in 2008 and 2011 implies that further monitoring be conducted in Clark Drain, Cedar Run, and Scott Drain to verify that all designated uses are being met.

A comprehensive monitoring plan for the Middle Cass River is also recommended to fully evaluate necessary monitoring to fill data gaps, gather background information, and identify other potential water quality impairments or threats. Funding should be sought to develop and implement this Cass River Watershed monitoring plan from the MICorps program or similar funding opportunity. Building off of past monitoring efforts, the following parameters should be monitored at public access sites, and within each subwatershed to determine improvements or declines in water quality:

- E. Coli
- Total dissolved solids
- Total suspended solids
- pH
- COD
- Nitrite
- Nitrate + Nitrate
- Total Phosphorus
- Ortho Phosphorus
- Total number of macroinvertebrate taxa

9.1 Lower Cass River Summary

The Lower Cass River includes areas of Vassar and downstream to the confluence with the Saginaw River in James Township, Saginaw County and includes the tributaries of Goodings Creek, Perry Creek, Millington Creek, Dead Creek and Cole Creek. The Lower Cass River sub-basin occupies 20.4% of the total watershed totaling 118,516 acres. The Lower Cass River is further divided into six sub-watersheds that are described in Table 9.1.

Sub- watersheds	Acres	Sq. Miles	% of Total Watershed
Lower Cass River	118,516		20.4
01-Goodings Creek	19,761	30.9	3.4
02-Perry Creek	25,471	39.8	4.4
03-Millington Creek	20,455	32	3.5
04-Dead Creek	21,462	33.5	3.7
05-Cole Creek	15,899	24.8	2.7
06-Cass River	15,468	24.2	2.7

The Lower Cass River is part of two ecoregions: the Southern Michigan/Northern Indiana Drift Plains whose soils and landforms make for an agricultural industry that typically produces feed grain, soybeans, and livestock and the Huron/Erie Lake Plains ecoregion dominated by broad, flat lands that are characteristically fertile. Originally this ecoregion's soil had very poor drainage, but there are now several man-made drains. The characteristically fertile soils of this ecoregion have led to high farming activity that mainly produces corn, soybeans, and livestock.

The Lower Cass River most accurately reflects the average land use of the entire watershed. This sub-basin's agricultural land use is about 54.4 percent and its natural land use is about 37.8 percent. Subwatersheds with the greatest agricultural land cover are the Cole Creek (66%), Perry Creek (65%), Dead Creek (57%) and Millington Creek (53%). Goodings Creek has the highest percentage of natural land cover at 55% in the Lower Cass River.

9.2 Lower Cass River causes and sources of impairments and threats (EPA Element A) Water body use designations (EPA, A.1)

Designated Uses

A stream or site in the watershed is listed as impaired if it is failing to meet one or several designated uses as defined by the State of Michigan. Designated uses for the Lower Cass River and its tributaries include:

- **Agriculture** – Irrigation water for crops or water for livestock
- **Wildlife and Other Indigenous Aquatic Life** –Aquatic life and wildlife can thrive and reproduce. (Comment: Minimum Flows and levels should be maintained in order to sustain environmental conditions and wildlife throughout the year. (Water balance)
- **Total and Partial Body Contact** – Recreational (swimming, fishing, boating) all waters protected for recreation shall not exceed specific levels of E.coli from May to October.
- **Warm Water Fishery** – Water supports warm water fish species including reproduction and sustainability,

Table 9.2 compiles information from the impaired waterbodies list provided by MDEQ and information gathered during the 2011 inventory. Sub-watersheds were inventoried via in-stream surveys and/or windshield surveys. Chapter 3 describes the methodology used for each of the inventory methods. Goodings Creek are the Cass River sub-watersheds listed as attaining all designated use by MDEQ. Goodings Creek was not inventoried based on the high percentage of undeveloped land use (wetlands, forests, etc). The Cass River sub-watershed was inventoried in 2008 for streambank erosion.

Impaired sub-watersheds were priority for in-stream inventory to identify sources of pollution. Four sub-watersheds in the Lower Cass River: Perry Creek, Millington Creek, Dead Creek, and Cole Creek are listed as impaired by the MDEQ and were inventoried via in-stream surveys by the Tuscola Conservation District during the 2011 field season.

Two initial criteria were looked at to determine which sub-watersheds should be inventoried for agricultural NPS pollution sources and causes, a known impairment and the percentage of agricultural land use. Each sub-watershed was then assigned a priority between one and three, with priority one sub-watersheds having both impaired waterways and agricultural land use at 75% or greater. This rationale resulted in two sub-watersheds being inventoried using the windshield survey: Dead Creek and Cole Creek.

Table 9.2 Impaired, partially impaired, and/or threatened uses (EPA A.3)
Subwatersheds that are noted with an "" are listed as impaired by the MDEQ*

Lower Cass River Sub-basin	Impaired Uses per MDEQ in-stream surveys	Potentially Impacted (Suspected)	Notes
12-HUC: 0408020503	Fish Consumption		
Goodings Creek AUID: 0408020503-01	Attaining		
Perry Creek* AUID: 0408020503-02	Total Body Contact Recreation Partial Body Recreation		E. coli, 2013 TMDL DRAFT Exceeded water quality standards and human biomarkers found
Millington Creek* AUID: 0408020503-03	Total Body Contact Recreation Partial Body Recreation		E. coli, 2013 TMDL DRAFT Exceeded water quality standards and human biomarkers found
Dead Creek* AUID: 0408020503-04	Other Indigenous Aquatic Life and Wildlife Total Body Contact Recreation Partial Body Recreation		E. coli, 2013 TMDL DRAFT Will be added as impaired in 2014 update of 303(d) list, particularly Smith Drain
Cole Creek – Cass River* (headwaters) AUID: 0408020503-05	Total Body Contact Recreation Partial Body Recreation		E. coli, 2013 TMDL DRAFT Exceeded water quality standards and human biomarkers found
Cass River (mouth) AUID: 0408020503-06	Total Body Contact Recreation	Other Indigenous Aquatic Life and Wildlife Warmwater fishery	E. coli, 2013 TMDL DRAFT Verifies no water quality standards were exceeded Extensive streambank erosion

Water quality criteria (EPA, A.2)

The water quality criteria used to evaluate the environmental health of water bodies in the Lower Cass River are defined below.

Bacteria – Partial and Total Body Contact (Taken from the 2013 TMDL for *E. coli*, developed by MDEQ for Portions of the Cass River and Tributaries, including Millington, Cole, Perry, and Dead Creeks)

For Partial Body Contact, all the waters of the State shall have not more than 1000 E. coli bacteria per 100 milliliters of water. For Total Body Contact, the waters of the State shall have not more than 130 E. coli bacteria per 100 milliliters of water, as a 30-day average and 300 E. coli per 100 ml water at any time. Each sampling event shall consist of three or more samples taken at representative locations within a defined sampling area. At no time shall the waters of the state protected for total body contact recreation contain more than a maximum of 300 E. coli per 100 ml. Compliance shall be based on the geometric mean of three or more samples taken during the same sampling event at representative locations within a defined sampling area.

In addition, sanitary wastewater discharges have an additional target: Discharges containing treated or untreated human sewage shall not contain more than 200 fecal coliform bacteria per 100 ml, based on the geometric mean of all of five or more samples taken over a 30-day period, nor more than 400 fecal coliform bacteria per 100 ml, based on the geometric mean of all of three or more samples taken during any period of discharge not to exceed seven days. Other indicators of adequate disinfection may be utilized where approved by the department.

Sediment

Total Suspended Solids (TSS) - Rule 50 of the Michigan Water Quality Standards (Part 4 of Act 451) states that waters of the state shall not have any of the following unnatural physical properties in quantities which are or may become injurious to any designated use: turbidity, color, oil films, floating solids, foam, settleable solids, suspended solids, and deposits. This kind of rule, which does not establish a numeric level, is known as a "narrative standard." Most people consider water with a TSS concentration less than 20 mg/l to be clear. Water with TSS levels between 40 and 80 mg/l tends to appear cloudy, while water with concentrations over 150 mg/l usually appears dirty. The nature of the particles that comprise the suspended solids may cause these numbers to vary.

Table 9.3 Specific causes and sources of impairments and/or threats (EPA, A.4)

The statuses of designated uses presented in Table 9.2 are correlated with the causes and sources of impairments for each sub-watershed in Table 7.3.

Sub-watershed name	Use Description	Cause name	Source(s)
Perry Creek	Partial Body Contact Total Body Contact	E. coli	1. Illicit discharges, 2. Wildlife and pet waste, 3. Agriculture, 4. Contaminated runoff, 5. Failing sewage treatment systems
Millington Creek	Partial Body Contact Recreation Total Body Contact Recreation	E. coli	1. Illicit discharges, 2. Wildlife and pet waste, 3. Agriculture, 4. Contaminated runoff, 5. Failing sewage treatment systems
Dead Creek	Other Indigenous Aquatic Life and Wildlife	Other anthropogenic substrate alterations Other flow regime alterations	1. Channelization
Dead Creek	Partial Body Contact Recreation Total Body Contact Recreation	E. coli	1. Illicit discharges, 2. Wildlife and pet waste, 3. Agriculture, 4. Contaminated runoff, 5. Failing sewage treatment systems
Cole Creek – Cass River (headwaters)	Partial Body Contact Recreation Total Body Contact Recreation	E. coli	1. Illicit discharges, 2. Wildlife and pet waste, 3. Agriculture, 4. Contaminated runoff, 5. Failing sewage treatment systems
Cass River	Total Body Contact Recreation THREAT: Warm water fishery THREAT: Other Indigenous Aquatic Life and Wildlife	E. coli Sediment (suspected)	1. Agriculture 2. Wildlife and pet waste 3. Streambank erosion (known)

Causes of impairment (or threats) quantified (EPA, A.5)

The causes of threats to water quality and known impairments are quantified by E. Coli, tiling and ditching, and streambank erosion. Causes were quantified through data presented in the 2013 TMDL for the Cass River and Tributaries, GIS analysis of surface water, and analysis of the 2008 streambank erosion inventory.

E. Coli

Water quality testing was performed in 2010 and 2012 as a part of the 2013 Draft TMDL for E. coli in portions of the Cass River and Tributaries, including Millington, Cole, Perry, and Dead Creeks. This information is included in Table 1 (2010) and Table 3 (2012) of the 2013 TMDL draft and summarized below in table 9.4:

Table 9.4 Summary of sampling site locations, site geometric means, and water quality exceedances for sites sampled in 2010 and 2012.

Note that site geometric means are the geometric means of all sample results for each site, and are calculated to facilitate comparisons among sites and are not intended to be compared to the water quality standards to determine exceedances.

Sampling Year	Site ID	Site Description	Site Geometric Means	Number of total body contact exceedances	Number of partial body contact exceedances
2010	1	Cass River @ Bray Rd	105	0	0
2010	2	Cass River @ Main St	55	1	0
2010	3	Cass River @ Dixie Hwy	132	1	0
2010	4	Cass River @ Fort Rd	85	1	0
2010	5	Cass River @ M-13	58	0	0
2010	6	Zehnder/Dead Cr @ Curtis Road	463	14	2
2010	7	Cole Cr @ Ormes Rd	470	11	2
2010	8	Perry Cr @ Ormes Rd	340	9	0
2010	9	Millington Cr @ Loren Rd	376	11	1
2010	10	Unnamed Tributary @ Van Cleve (Tuscola Rd)	1017	9	7
2012	C1	Cole Cr @ Bray Rd (north)	253	1	1
2012	C2	Calkins Dr @ Bray Rd (south)	1981	5	4
2012	S1	Smith Dr @ Murphy Lake Rd	2344	5	5
2012	D1	Dead Cr @ Lewis Rd	480	5	0
2012	P1	Burns Dr @ Birch Run Rd	253	2	0
2012	P2	Perry Cr @ Vassar Rd	254	5	1
2012	P3	Pedlow Dr/Perry Cr @ Irish Rd	544	5	1

Sampling Year	Site ID	Site Description	Site Geometric Means	Number of total body contact exceedances	Number of partial body contact exceedances
2012	M1	Millington Cr @ Millington Rd	920	5	2
2012	M2	Millington Cr @ Murphy Lake Rd	399	3	1

Tiling and Ditching

Dead Creek is an agricultural watershed (nearly 60% of land cover), with approximately 50 miles of agricultural drains that have been channelized.

Streambank Erosion

The 2008 streambank inventory identified 46 sites within the Cass River subwatershed totaling 8,205 feet in length and contributing an estimated 11,920 tons of sediment annually. A total of 23 sites were identified in Cole Creek totaling 1,565 feet in length and contributing and estimated 4,392 tons of sediment annually.

Locations of Impairments (EPA, A.6-8)

Figure 9.2 shows the known locations of impairment sources from the 2011 in-stream and windshield inventories and the 2008 streambank inventory. Additional potential sources were identified in the 2013 Draft TMDL for the Lower Cass River detailing potential sites for livestock access and impairment in the Perry Creek and Millington Creek subwatersheds.

Priority livestock sites were those identified during the 2011 windshield surveys. High priority sites are those where known surface water impairments were observed and pollutant loading estimates could be calculated. Medium priority sites are those where surface water quality impairments are suspected and pollutant loading estimates can be calculated. Low priority sites are those where surface water quality impairments are suspected but pollutant loading estimates could not be calculated due to lack of adequate site details.

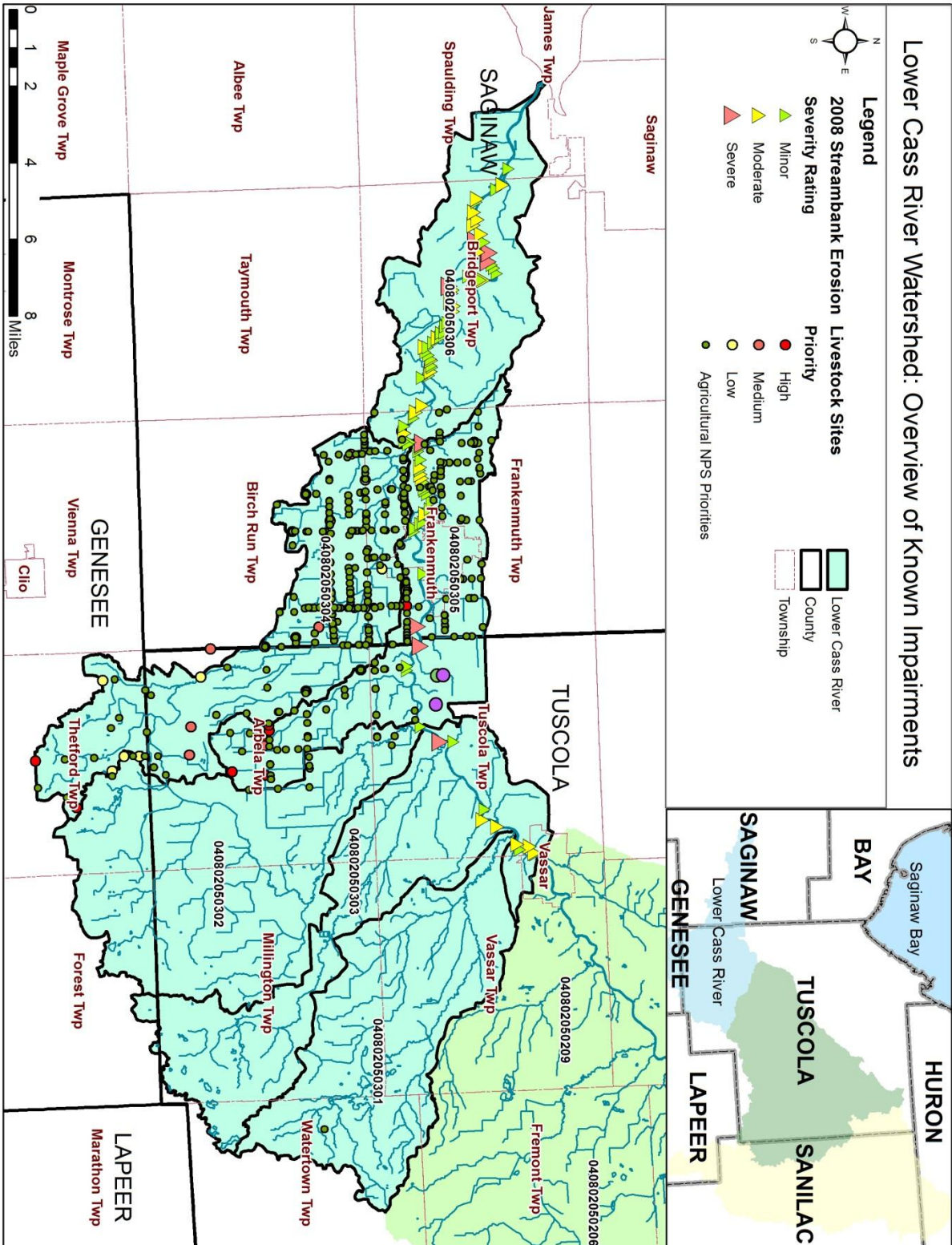
The 2011 In-stream survey results are those sites identified while conservation district staff were wading stretches of impaired waterways. Impairment locations were delineated by sources. Sources identified in the Upper Cass River include gully erosion, livestock access, stream crossing (eroding), streambank erosion, tile outlets, urban nps (urban nonpoint source or stormwater runoff), and ag nps (agricultural nonpoint source or field runoff).

Ag NPS priorities were those identified during the 2011 in-stream survey when conservation district staff identified priority areas to reduce field runoff. These locations are important to target for BMP's because a known impairment was observed. Ag NPS priority sites include field runoff, manure spreading, or inadequate buffer strips.

During the windshield survey, agricultural sites were classified by the practices that were installed on each site. Fields that were listed as having conventional tillage and 25% or less field residue are highlighted to aide in targeting of outreach programs for conservation tillage, grassed buffers, and cover crops.

Table 9.5 further summarizes information shown in Figure 9.2 by subwatershed and recommended management measures.

Figure 9.2 All Impairment Locations, Lower Cass River



9.3 Implementation Priorities and Schedule

The inventories conducted in 2008 and 2011 were reviewed and prioritized by a technical committee for the Lower Cass River watershed. Representatives present at the meeting included the Cass River Greenway Committee, Saginaw Conservation District, Environmental Science consultant, Spicer Group, and UM-Flint. These priorities have been combined with those set forth in the draft 2013 TMDL authored by the MDEQ. A summary of the priorities is shown in Table 9.5.

Further discussion on how sites were prioritized is included in Chapter 7 regarding the Upper Cass River. The same methods were employed in prioritizing sites for the Lower Cass River.

Table 9.5 Lower Cass River Implementation Priorities

Priority	Sub-shed	Problem or Management Measure	Technical Assistance Type	Quantity	Schedule	Site Specific Table and Maps
1	Cole Creek	Restrict livestock access, Manure Management	Landowner outreach and assistance for fencing, crossings, stacking facilities, MAEAP certification, etc.	966 animals; 15 sites	2014-2016	Table 9.5 Figure 9.3
1	Dead Creek	Restrict livestock access, Manure Management		1,265 animals; 10 sites		Table 9.6 Figure 9.4
1	Perry Creek	95 potential sites for livestock exclusion		95 sites		*Table 12 of 2013 TMDL
1	Millington Creek	30 potential sites for livestock exclusion		30 sites		*Table 12 of 2013 TMDL
2	Cole Creek	Streambank erosion	Landowner outreach, engineering and construction	1,565 linear feet; 23 sites	2016-2018	Table 9.9 Figure 9.5
2	Cass River	Streambank erosion		8,205 linear feet; 46 sites		Table 9.10 Figure 9.6
3	Cass River	Wetland restoration (over 90% wetland loss)	Landowner outreach, engineering and construction	**See LLFWA	2018-2020	Figure 9.7

Priority	Sub-shed	Problem or Management Measure	Technical Assistance Type	Quantity	Schedule	Site Specific Table and Maps
4	Dead Creek	Conservation tillage and cover crops, vegetated buffers	Landowner outreach and assistance	8,600 Acres; 230 sites	2020-2023	Table 9.11 Figure 9.8
4	Cole Creek	Conservation tillage and cover crops, vegetated buffers		5,675 acres; 126 sites		Table 9.13 Figure 9.9

*2013 TMDL, Total Maximum Daily Load for *E. coli* in Portions of the Cass River and Tributaries, including Millington, Cole, Perry, and Dead Creeks; Genesee, Saginaw, and Tuscola Counties. Michigan Department of Environmental Quality, Water Resources Division. Draft April 2013. http://www.michigan.gov/documents/deq/wrd-assesment-TMDL-CassRiver_DRAFT_420027_7.pdf

**LLFWA, The Landscape Level Functional Wetland Assessment is available through the Michigan Department of Environmental Quality, Wetland Restoration and Watershed Planning, http://www.michigan.gov/deq/0,4561,7-135-3313_3687-10419--,00.html

9.4 Priority Source Loadings

Sources of pollutant loadings are discussed by priority: livestock access, streambank erosion, wetland restoration and cropland runoff.

Priority 1: Livestock Access

Inventory

Livestock access was chosen as the top priority for the Lower Cass River watershed due to findings during the 2011 field inventory and testing information presented in the draft 2013 TMDL. Impacts from livestock are believed to be contributing *E. coli* to surface waters and are impairing the designated uses of partial body and total body contact recreation. Sites were identified in Cole Creek and Dead Creek in the 2011 field inventory and suspected sites were identified in the draft 2013 TMDL in Millington Creek and Perry Creek.

A total of 15 sites were identified in Cole Creek that potentially impact water quality. These 15 sites have a total of 966 animals that are being raised for agricultural purposes. Sites have been prioritized based upon if a known impairment is observed and proximity to surface water, table 9.7 provides a breakdown of these sites; all sites in Cole Creek are shown in Figure 9.3.

A total of 10 livestock impairment sites were identified in the Dead Creek subwatershed, with a total of 1,265 animals being raised for agricultural purposes. Sites have been prioritized based upon if a known impairment is observed and proximity to surface water, table 9.8 provides a breakdown of these sites; all sites are mapped in Figure 9.4.

Millington Creek was identified as a priority in the draft 2013 TMDL, a full listing of sites is available in Table 12 of the draft TMDL. Perry Creek was also identified as a priority in the draft 2013 TMDL and the suspected sites are included in Table 12 of the draft TMDL.

Load Estimate Methodology

The Pollutant controlled calculation and documentation for Section 319 Watersheds Training Manual, June, 1999 section on Feedlot Pollution Reduction was utilized. The steps outlined in this document were developed into an Excel spreadsheet calculator. The calculation requires the determination of the average rainfall (R) per day by selecting the state and county in which the feedlot is located. The variable R is then calculated, in this case it is approximately $R = 0.2848$, as the watershed locations are within the same rainfall isopleths. The spreadsheet was set up so there were input areas for Slaughter Beef (feeder cattle); Dairy Cattle, Horses, Feeder Pigs (it was assumed that all pigs were feeders in the watershed), and sheep. So for Table 9.7 Cole Creek Impairments from Livestock Access, the pollutant loading calculator is set up to determine the Annual average mass load of pollutants in runoff using the following formula; the Mass load x Rain days per year x Correction Factor for number of rain days assuming the cows are "feeders" that yields approximately 57 lbs-P per year, and 308 lbs-N per year which could make its way to the watershed drainage system. Additionally, almost 387 lbs-BOD (biological oxygen demand) could be introduced into the surface water system annually from these feeder cattle and sheep on this site. A copy of the calculator is available for viewing in APPENDIX C, it is set up to show the above mentioned calculation.

Summary Tables & Maps

Table 9.7 Cole Creek sites with potential impacts from livestock

Map Label	Lat. (UTM-X)	Long. (UTM-Y)	# animals	Acres	Type	Priority 1=High 2 = Med. 3= Low	Estimated Annual "P" Load (lbs/yr) ¹	Estimated "N" Load (lbs/yr) ¹	Estimated BOD Load (lbs/yr) ¹	Reduction Target %
17	(4795444)	(283171)	40	NR	20 cattle; 20 sheep	1	57.0	308.0	387.0	100
19	(4790372)	(285553)	25	NR	25 sheep	1	4.0	47.0	34.0	100
42	(4790516)	(284384)	200	NR	200 sheep	1	32.0	378.0	270.0	100
43	43.27888	- 83.75502	2	15	2 horses	1	2.0	23.0	38.0	100
4	43.27909	- 83.70019	20	30	20 horses	2	0.0	4.0	7.0	100
5	43.28789	- 83.70533	200	NR	200 cattle	2	540.0	2,699.0	3,599.0	100
6	43.30198	- 83.79434	350	10	350 cattle	2	118.0	589.0	785.0	100
20	43.19204	- 83.62073	33	20	15 cattle; 3 horses; 15 pigs	2	47.0	249.0	354.0	100
18	43.19434	- 83.61529	18	40	10 cattle; 3 horses; 5 pigs	3	31.0	173.0	246.0	0
21	43.28447	- 83.77433	2	12	horses	3	2.0	23.0	38.0	0
23	43.26737	-	50	50	cattle	2	135.0	675.0	900.0	0

Map Label	Lat. (UTM-X)	Long. (UTM-Y)	# animals	Acres	Type	Priority 1=High 2 = Med. 3= Low	Estimated Annual "P" Load (lbs/yr) ¹	Estimated "N" Load (lbs/yr) ¹	Estimated BOD Load (lbs/yr) ¹	Reduction Target %
		83.69579								
24	43.31254	-83.7347	5	5	cattle	3	13.0	67.0	90.0	0
71	43.19619	- 83.68073	11	NR	3 horse 8 pigs	3	1.0	5.0	9.0	0
76	43.29329	- 83.76105	6	55	cattle	3	19.0	119.0	135.0	0
78	43.30715	- 83.78113	4	30	horse	3	5.0	46.0	77.0	0

Figure 9.3 Livestock Impairments, Cole Creek

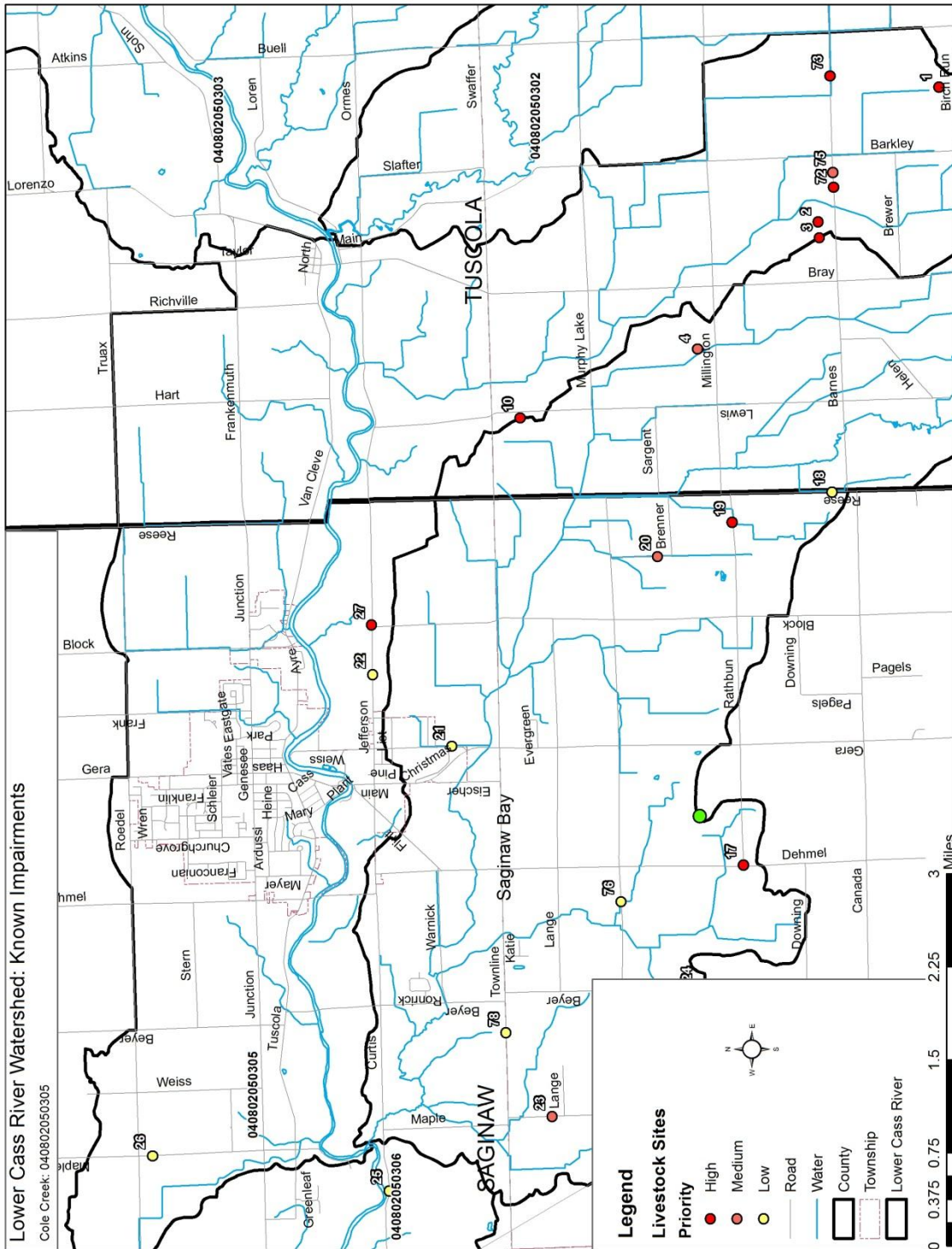
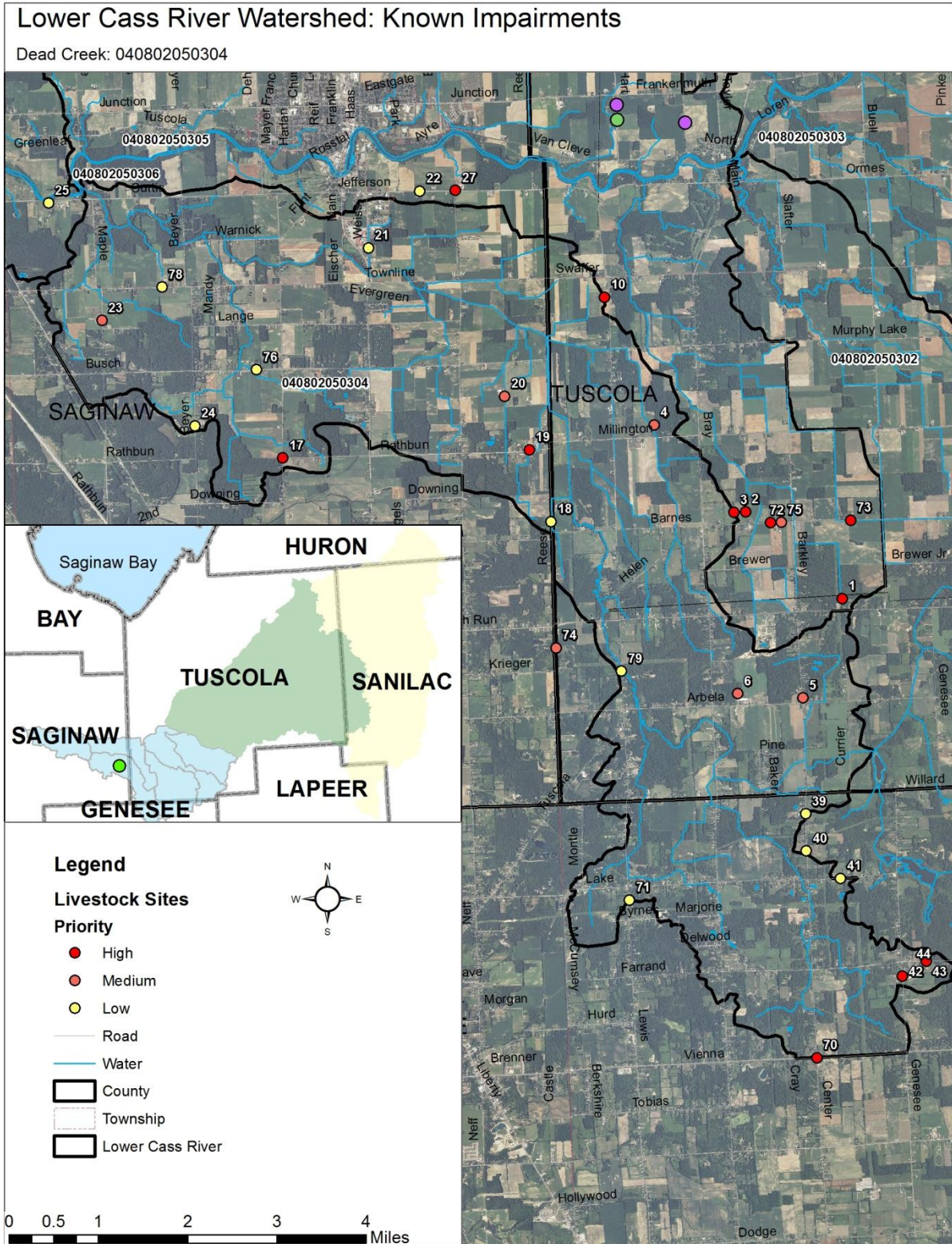


Table 9.8 Dead Creek sites with potential impacts from livestock

Map Label	Lat. (UTM-X)	Long. (UTM-Y)	# animals	Acres	Type	Priority 1=High 2 = Med. 3= Low	Estimated Annual "P" Load (lbs/yr) ¹	Estimated "N" Load (lbs/yr) ¹	Estimated BOD Load (lbs/yr) ¹	Reduction Target %
1	(4792116)	(286374)	5	NR	pigs	1	1.0	4.0	9.0	100
2	(4793782)	(284722)	250	NR	150 cattle 100 sheep	1	421.0	2,213.0	2,834.0	100
3	(4793781)	(284516)	204	NR	200 cattle 4 pigs	1	541.0	2,703.0	3,606.0	100
10	(4797794)	(282417)	50	NR	sheep	1	8.0	94.0	67.0	100
27	43.32149	-83.715	353	20	200 cows; 3 horse 150 sheep	1	568.0	3,017.0	3,859.0	100
72	(4793766)	(28511)	120	NR	100 cattle 20 sheep	1	273.0	1,387.0	1,827.0	100
73	(4793737)	(286625)	16	NR	10 cattle 6 sheep	1	28.0	146.0	188.0	100
75	(4793805)	(253473)	204	NR	200 cattle 4 pigs	2	541.0	2,703.0	3,606.0	100
22	43.32154	-83.723	40	20	cattle	3	108.0	540.0	720.0	0
26	43.34876	-83.7989	23	70	3 horse 20 sheep	3	7.0	72.0	84.0	0

Figure 9.4 Livestock Sites, Dead Creek



Priority 2: Streambank Erosion

Inventory

Streambank erosion was chosen as high priority due to the findings of the 2008 streambank inventory and the support and interest from the Cass River Greenway committee in coordinating streambank restoration projects along the Lower Cass River that further promote the Cass River as a recreation destination and enhance habitat for aquatic life. Numerous streambank erosion sites were identified in Cole Creek and the Cass River subwatersheds in 2008.

A total of 23 streambank erosion sites were identified along the Cass River in the Cole Creek subwatershed totaling 1,565 linear feet. Nutrient and sediment loading estimates for each site are shown in table 9.9; Figure 9.5 shows where streambank erosion sites are located within the Cole Creek subwatershed.

A total of 46 streambank erosion sites were identified along the Cass River totaling 8,205 linear feet. Nutrient and sediment loading estimates for each site are shown in table 9.10; each site is mapped for the Cass River subwatershed in Figure 9.6.

Loading Estimate Methodology

The loading reduction target for all streambank erosion sites is 100% assuming that the bank is stabilized to mitigate future erosion from occurring. Using the *Pollutants Controlled Calculation and Documentation for Section 319 Watersheds Training Manual* (June, 1999), we are able to provide information on the nutrient aspect of sediment loading in a watershed in Tables 9.9, 9.10. Using the data gathered by field survey crews, the sediment loading could be estimated from the length, width and depth of the visible erosion. This would be developed, first into a volume, then a mass. From the mass and general type of soils, we used a ratio of 1.1 pounds of phosphorus per ton of sediment to obtain the pounds of phosphorus loading.

This erosion volume estimate has to be converted to Tons, therefore, using the geotechnical reference manual *GeoTechnical Engineering-Principles and Practices, 1999 by D.P.Coduto* the soils in this area are well represented by a factor of 110 lbs/ft³, when this is divided by 2000 lbs/Ton the conversion factor of 0.055 Tons/ft³ is obtained.

Table 9.9 Cole Creek Streambank Erosion Sites

Site ID	Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank) Impacts Potential Causes Additional Comments	Rating Chart	Sediment Load (tons/yr)	P Load (lbs/yr)	N Load (lbs/yr)	Load Reduction %
15	1	20	100	1:1	Bank Eroding, Toe Unstable, Undercutting, wake from boats	Minor	125	137.5	275	0
725	2	10	35	1:1	Bank Eroding, Toe Unstable, high water, visible due to about 1 foot water level drop	Minor	43.75	48.1	96.3	0
726	1.5	8	10	3:1	Bank Eroding, Toe Stable, Foot Traffic	Minor	7.50	8.3	16.5	0
728	2	15	25	2:1	Bank Eroding, Toe Unstable, Foot Traffic, aquatic vegetation not growing; roots exposed	Minor	46.88	51.6	103.1	0
729	1.5	15	100	1:1	Bank Eroding, Agric Runoff, River Bend, high water carving out roots, toe beginning to stabilize; human activity above bank	Minor	140.63	154.7	309.4	0
731	2	8	15	1:1	Undercutting, high water, toe beginning to stabilize; roots exposed	Minor	15.00	16.5	33.0	0
732	2	10	20	1:1	Bank Eroding, Toe Stable, run-off	Minor	25.00	27.5	55.0	0
733	1.5	10	50	1:1	Bank Eroding, Toe Unstable, Trampled, Undercutting, Foot Traffic, high water 2 sites in 1; carved out bank by humans	Minor	46.88	51.6	103.1	0
734	1.5	8	10	2:1	Bank Eroding, Toe Unstable, high water, roots exposed	Minor	7.50	8.3	16.5	0
759	1.5	10-15	80	2:1	Bank Eroding, Toe Stable, high water, roots exposed; trees leaning in; dead tree debris in water; bank is re-vegetating	Minor	93.75	103.1	206.3	0
760	1.5	15	10	2:1	Bank Eroding, Foot Traffic, Sediment Dropped, toe beginning to stabilize	Minor	14.06	15.5	30.9	0

Site ID	Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank) Impacts Potential Causes Additional Comments	Rating Chart	Sediment Load (tons/yr)	P Load (lbs/yr)	N Load (lbs/yr)	Load Reduction %
763	1	8	60	2:1	Bank Eroding, Toe Unstable, Sediment Dropped, high waters, toe beginning to grow vegetation; residence above bank	Minor	30.00	33.0	66.0	0
765	1.5	15	60	2:1	Bank Eroding, Foot Traffic, toe beginning to stabilize; residence above bank; roots exposed	Minor	84.38	92.8	185.6	0
766	1	8-10	110	2:1	Bank Eroding, Toe Stable, Foot Traffic, Seepage, high water, roots exposed	Minor	61.88	68.1	136.1	0
767	<1	8	40	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend	Minor	20.00	22.0	44.0	0
768	1.5	10	30	2:1	Bank Eroding, Toe Unstable, River Bend, roots exposed; trees leaning into river; bank beginning to re-vegetate in some areas; right bank - 15 ft	Minor	28.13	30.9	61.9	0
727	1.5	12	50	1:1	Bank Eroding, Undercutting, highwater, Toe stabilizing	Moderate	56.25	61.9	123.8	100
761	1.5	15	120	1:1	Bank Eroding, Sediment Dropped, toe somewhat stable; large cement blocks on top of bank (dumping); roots exposed; left bank - too 10 ft	Moderate	168.75	185.6	371.3	100
762	2	12	60	2:1	Bank Eroding, Toe Unstable, high water, unknown human impact above bank; trees falling in	Moderate	90.00	99.0	198.0	100
764	2	12	400-500	1:1	Bank Eroding, Toe Unstable, Foot Traffic, Sediment Dropped, Seepage, high water, run-off; residence above bank - mowed to bank	Moderate	675.00	742.5	1,485.0	100

Site ID	Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank) Impacts Potential Causes Additional Comments	Rating Chart	Sediment Load (tons/yr)	P Load (lbs/yr)	N Load (lbs/yr)	Load Reduction %
13	1.5	40	80	1:1	Bank Eroding, Toe Unstable, River Bend, sediment fall was undercutting; deer	Severe	300.00	330.0	660.0	100
14	2	40	250-300	1:1	Bank Eroding, Toe Unstable	Severe	1375.00	1,512.5	3,025.0	100
769	1.5	20	500	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, high water; run-off from road above bank huge cement block above bank; toe re-vegetating in patchy area; left bank - 35 ft	Severe	937.50	1,031.3	2,062.5	100

Figure 9.5 Cole Creek Streambank Erosion Sites

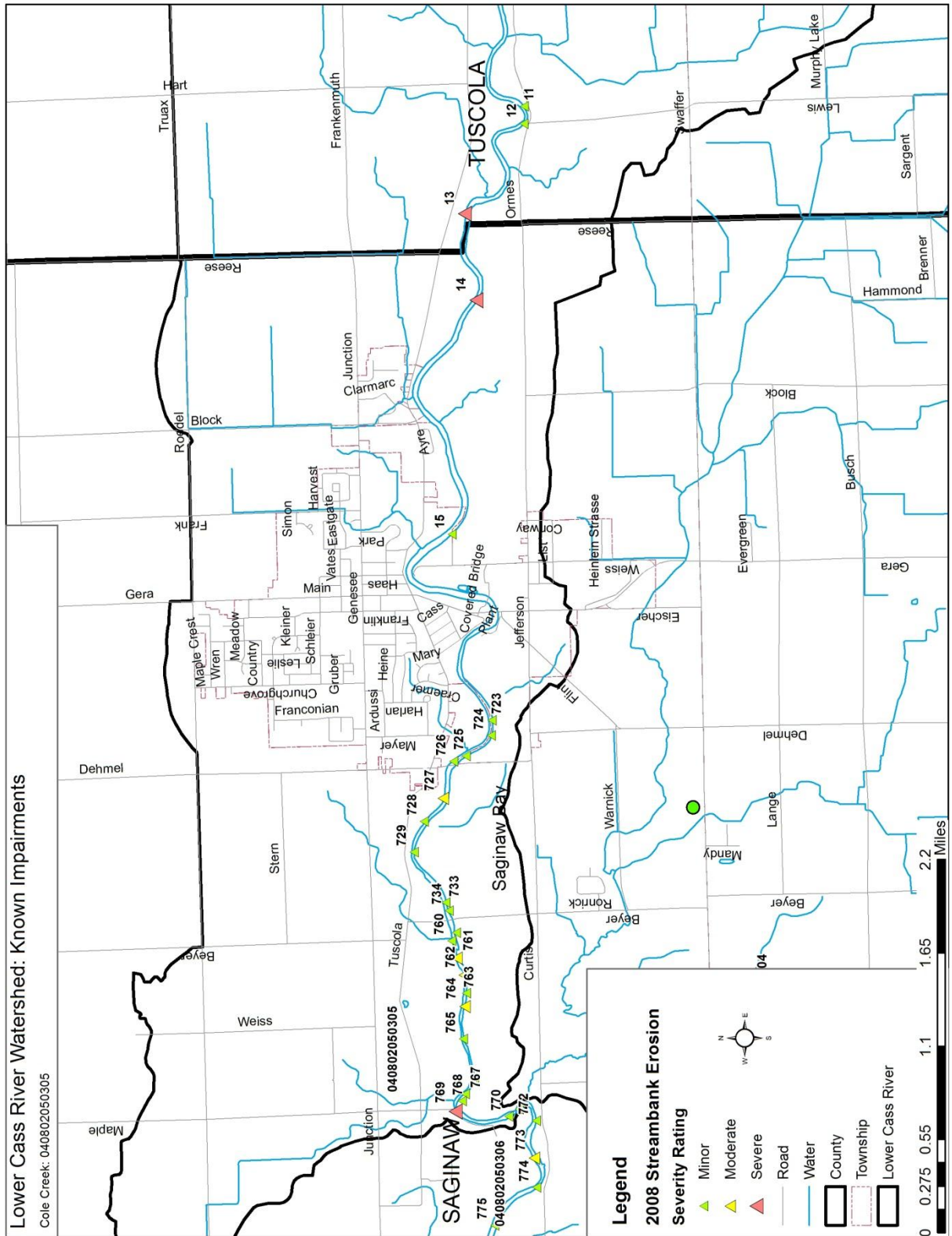


Table 9.10 Cass River Streambank Erosion Sites

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, Additional Comments	Rating Chart	Sediment load (tons/yr)	Est P Load (lbs/yr)	Est N Load (lbs/yr)	Load Reduction %
772	1.5	8	40	2:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, Sediment Dropped, high water	Minor	30.00	33.0	66.0	0
774	1	18	30	2:1	Bank Eroding, Toe Stable, River Bend, Seepage, road up above; high water before rapid; roots exposed; immersive aquatic vegetation is patchy	Minor	33.75	37.1	74.3	0
775	1.5	8	230	1:1	Bank Eroding, Toe Unstable, high water land may be mowed; roots exposed; trees leaning in	Minor	172.50	189.8	379.5	0
779	1.5	8	300	2:1	Undercutting, Agric Runoff, Illicit disch, River Bend, Seepage, high water, roots exposed	Minor	225.00	247.5	495.0	0
793	3.5	10	350	1:1	Bank Eroding, River Bend, Sediment dropped, high water, toe stabilizing	Minor	765.63	842.2	1,684.4	0
795	2	8	10	2:1	Undercutting, high water, no toe; tree at bank's edge; large cottonwood; could create obstruction when it falls in	Minor	10.00	11.0	22.0	0
796	35	10	145	2:1	Bank Eroding, Toe Unstable, Trampled, Undercutting, Foot Traffic, high water, patchy toe stabilization; roots exposed	Minor	317.19	348.9	697.8	0
798	2	10	150	1:1	Bank Eroding, Undercutting, outside of river bend; high water, roots exposed; toe stabilizing; trees leaning in	Minor	187.50	206.3	412.5	0

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, Additional Comments	Rating Chart	Sediment load (tons/yr)	Est P Load (lbs/yr)	Est N Load (lbs/yr)	Load Reduction %
799	1.5	12	20	2:1	Bank Eroding, Toe Stable, high water	Minor	22.50	24.8	49.5	0
800	3	8	45	1:1	Undercutting, high water, toe stabilizing in one area; roots exposed	Minor	67.50	74.3	148.5	0
802	2	7	280	2:1	Bank Eroding, Undercutting, River Bend, high water, toe stabilizing; trees falling in	Minor	245.00	269.5	539.0	0
803	2	7-8	120	2:1	Bank Eroding, Toe Unstable, high water, toe stabilizing in some areas; roots exposed	Minor	112.50	123.8	247.5	0
805	4	8	70	1:1	Toe Unstable, river bend - cut bank, roots exposed	Minor	140.00	154.0	308.0	0
806	3	10	150	2:1	Bank Eroding, high water; river bend outside	Minor	281.25	309.4	618.8	0
807	2	8-10	200	1:1	Bank Eroding, River Bend, high water, toe stabilizing; roots exposed	Minor	225.00	247.5	495.0	0
808	2	7	100	1:1	Bank Eroding, Toe Unstable, Undercutting, Sediment Dropped, high water, toe stabilizing in one area; roots exposed	Minor	87.50	96.3	192.5	0
809	3	10	160	1:1	Bank Eroding, Toe Unstable, Undercutting, high water, tree roots exposed	Minor	300.00	330.0	660.0	0
817	3	15-20	65	1:1	Bank Eroding, Toe Unstable, R.R. tracks above bank	Minor	213.28	234.6	469.2	0
819	2	6-7	30	2:1	Toe Unstable, Undercutting, high water, tree roots exposed	Minor	24.38	26.8	53.6	0
821	2.5	8-10	150	1:1	Tiles, Sediment Dropped, toe stabilizing; runoff; mowed to edge above bank; several	Minor	210.94	232.0	464.1	0

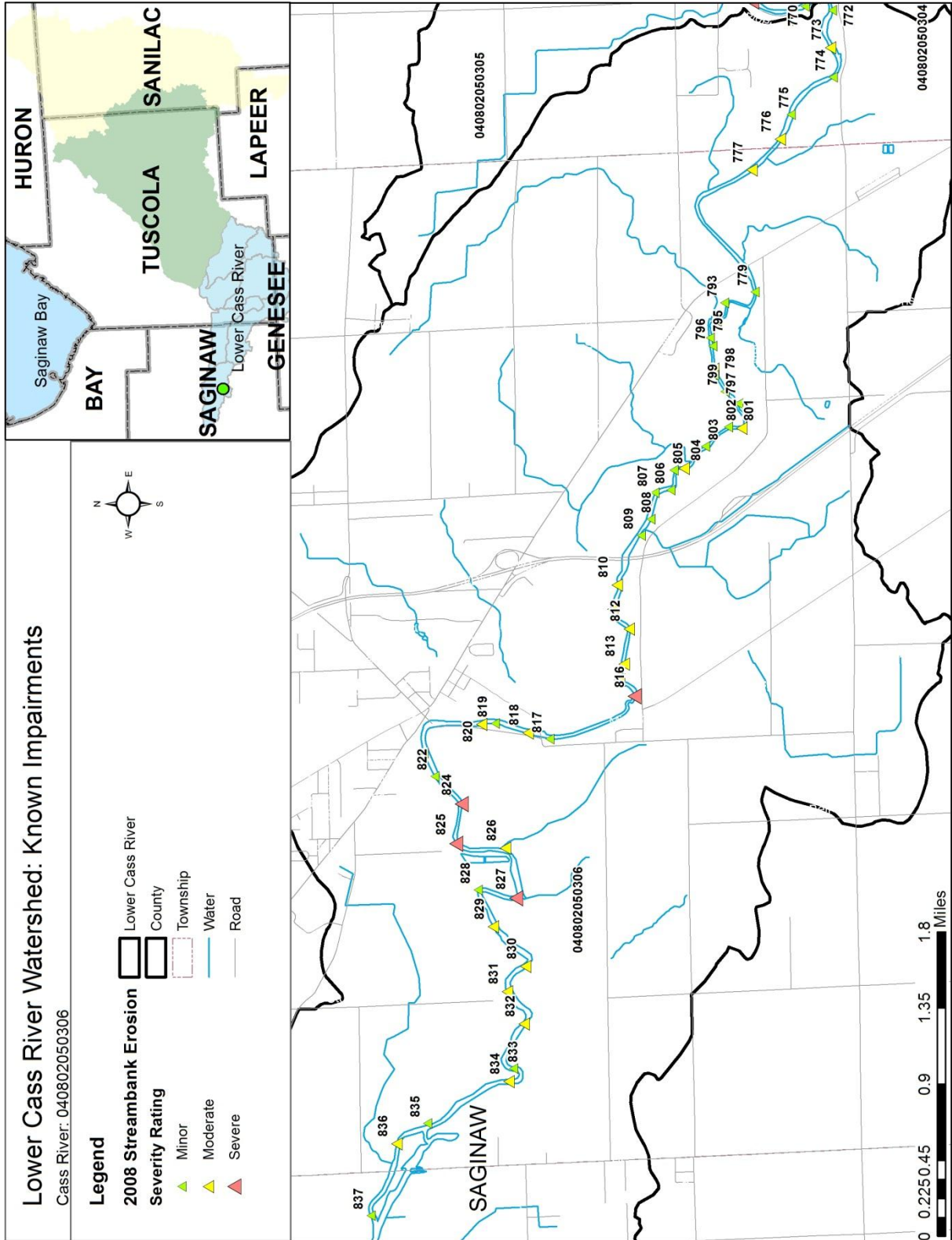
Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, Additional Comments	Rating Chart	Sediment load (tons/yr)	Est P Load (lbs/yr)	Est N Load (lbs/yr)	Load Reduction %
					drains (tiles) in bank					
822	2.5	6	120	1:1	Bank Eroding, Sediment Dropped, high water toe stabilizing	Minor	112.50	123.8	247.5	0
823	4.5-5	6	120	1:1	Bank Eroding, Undercutting, Sediment Dropped, high water, toe stabilizing in some areas; roots exposed; log jams may be creating diverted movement of water	Minor	213.75	235.1	470.3	0
828	3	10	130	2:1	Bank Eroding, Agric Runoff, Tiles, River Bend, Sediment Dropped, high water, several spots of agricultural run-off; sharp river bend; storm run-off; trees leaning in; tiled above; stabilized with large cement chunk in one area	Minor	243.75	268.1	536.3	0
833	1.5	5	230	2:1	Bank Eroding, River Bend, Sediment Dropped, high water, patchy toe stabilization; storm run-off	Minor	107.81	118.6	237.2	0
776	2-5	10-12	50	1:1	Bank Eroding, Toe Unstable, Trampled from Foot Traffic, Sediment Dropped, high water; pool formed by dead, fallen trees	Moderate	98.44	108.3	216.6	100
777	<1	8	55	1:1	Bank Eroding, Toe Stable, high water, roots exposed; large bed of L. Tail growing in	Moderate	27.50	30.3	60.5	100

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, Additional Comments	Rating Chart	Sediment load (tons/yr)	Est P Load (lbs/yr)	Est N Load (lbs/yr)	Load Reduction %
					front					
794	3	12	100	1:1	Bank Eroding, Toe Unstable, River Bend, Sediment Dropped, high water, roots exposed; river meanders	Moderate	225.00	247.5	495.0	100
797	3	7	100	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, high water, roots exposed; trees leaning in	Moderate	131.25	144.4	288.8	100
801	4	5-7	250	2:1	Bank Eroding, Toe Unstable, Undercutting, Sediment Dropped, high water; river bend outside – cutbank, roots exposed	Moderate	375.00	412.5	825.0	100
804	3	8	120	1:1	Bank Eroding, Toe Unstable, Undercutting , high water; river bend - cut bank, roots exposed	Moderate	180.00	198.0	396.0	100
810	2	7	90	1:1	Bank Eroding, Toe Unstable, high water; river bend due to sediment and partial log jam SNWR property	Moderate	78.75	86.6	173.3	100
811	2	8	250	2:1	Bank Eroding, Toe Unstable, Undercutting, many log jams affecting water flow; beginning of river bend, roots exposed; trees leaning in; right bank - 30 ft	Moderate	250.00	275.0	550.0	100

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, Additional Comments	Rating Chart	Sediment load (tons/yr)	Est P Load (lbs/yr)	Est N Load (lbs/yr)	Load Reduction %
812	4	15	350	1:1	Bank Eroding, Toe Unstable, Buffer Absent, River Bend, high water; mowed to edge run-off; mowed to edge; residence; trees leaning in	Moderate	1312.50	1,443.8	2,887.5	100
813	3	8	100	1:1	Bank Eroding, Toe Unstable, Undercutting, Sediment Dropped, high water trees leaning in; left bank - 65 ft	Moderate	150.00	165.0	330.0	100
815	4.5	8-10	160	2:1	Bank Eroding, Toe Unstable, high water; river bend - cut bank, roots exposed	Moderate	405.00	445.5	891.0	100
818	1.5	8	200	1:1	Bank Eroding, Undercutting, Seepage, high water, toe stabilizing	Moderate	150.00	165.0	330.0	100
820	3	7	40	1:1	Bank Eroding, Toe Unstable, Sediment Dropped, high water, roots exposed; tree leaning in	Moderate	52.50	57.8	115.5	100
826	2	6	1000	1:1	Bank Eroding, Toe Unstable, River Bend, high water, roots exposed; trees leaning in; drain/creek comes out here	Moderate	750.00	825.0	1,650.0	100
829	2.5-3	8-10	160	1:1	Bank Eroding, Toe Unstable, Agric Runoff, River Bend, Obstruction, high water; toe stabilizing in areas; possible seepage; log jam deflecting water; cleared area above bank; powerlines visible	Moderate	247.50	272.3	544.5	100
830	3	12	60	1:1	Bank Eroding, Toe Unstable, River Bend, high water	Moderate	135.00	148.5	297.0	100

Site ID	Average Depth (ft)	Height (ft)	Length (ft)	Slope	Condition of Toe (bank), Impacts, Potential Causes, Additional Comments	Rating Chart	Sediment load (tons/yr)	Est P Load (lbs/yr)	Est N Load (lbs/yr)	Load Reduction %
831	2.5	12	80	1:1	Bank Eroding, Toe Unstable, Agric Runoff, River Bend, Sediment Dropped, high water	Moderate	150.00	165.0	330.0	100
832	4.5	3-5	230	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, high water, trees leaning in	Moderate	258.75	284.6	569.3	100
816	3	35	65	1:1	Bank Eroding, Toe Unstable, River Bend, Sediment Dropped, high water, upper and lower bank eroding	Severe	426.56	469.2	938.4	100
824	3	6	200	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, Sediment Dropped, high water, roots exposed	Severe	225.00	247.5	495.0	100
825	3.5	6	1000	1:1	Toe Unstable, Undercutting, River Bend, high water, patchy toe stabilization	Severe	1312.50	1,443.8	2,887.5	100
827	4.5	7	300	1:1	Bank Eroding, Toe Unstable, Undercutting, River Bend, Sediment Dropped, Seepage, high water roots exposed	Severe	590.63	649.7	1,299.4	100

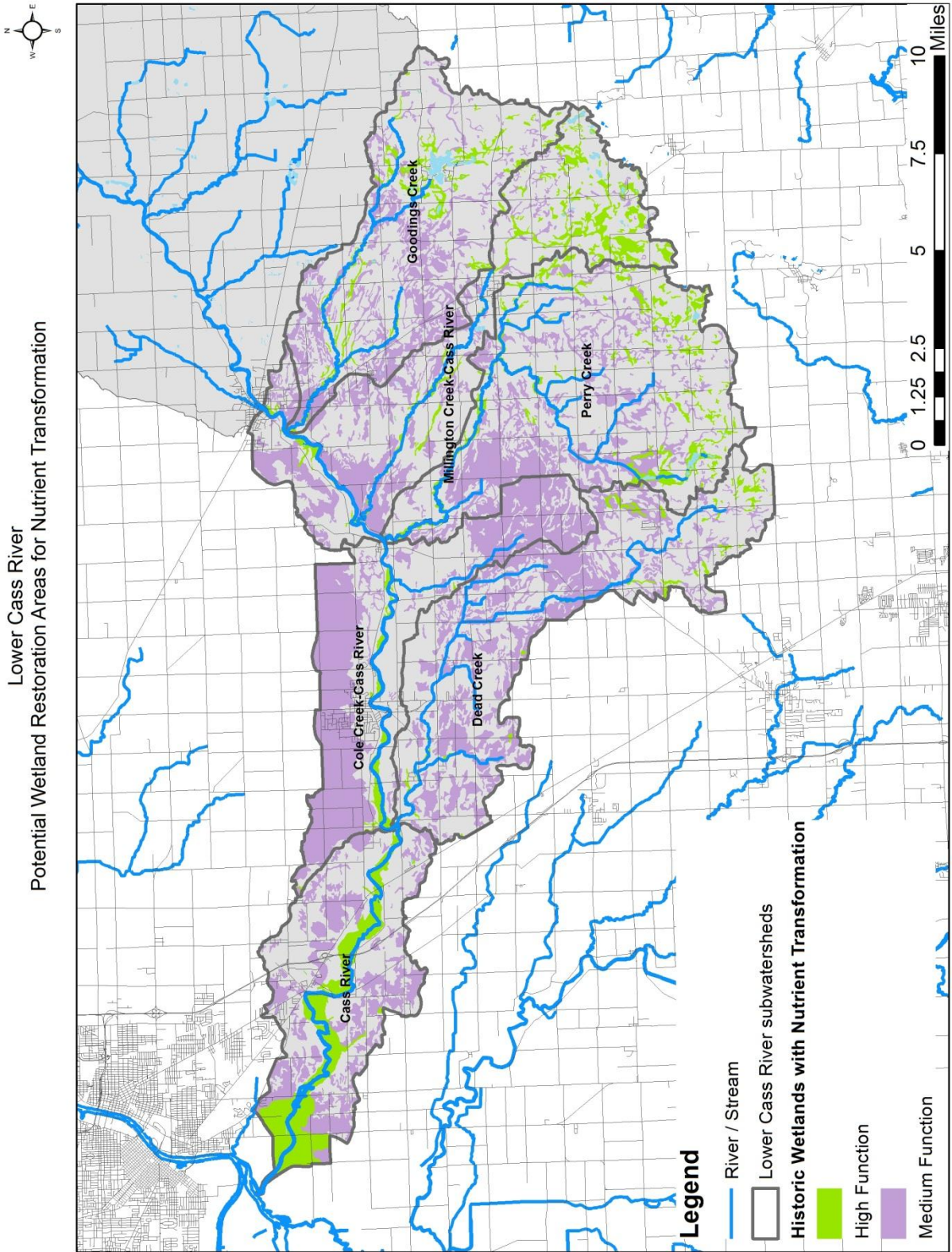
Figure 9.6 Cass River Streambank Erosion Sites



Priority 3: Wetland Restoration

Wetland restoration in the Lower Cass River was identified as a priority in the Landscape Level Wetland Functionality Assessment performed by the MDEQ and as a priority in the draft 2013 TMDL for nutrient reduction. Over 90% of wetlands have been removed in the Lower Cass River; the LLWFA tool can be used to identify potential sites for restoration. The LLWFA was used to create Figure 9.7 that shows areas where wetlands were historically present and had the function of transferring nutrients. The map of historic wetlands is only a representation of potential restoration areas. Field verification is necessary to determine that current land use permits the practice of wetland restoration.

Figure 9.7 Historic Wetland Sites with Nutrient Transformation Function



Priority 4: Cropland Runoff

Inventory

Sites were selected that employed Conventional tilling methods and had minimal field residue, below is a summary by HUC-12 Code (Table 9.11). These sites were identified during the 2011 field inventory and are assumed to be the worst areas for agricultural runoff in each of the subwatersheds.

Table 9.11 Summary of sites identified for Agricultural Best Management Practices

HUC Name	HUC-12 CODE	Total HUC-12 Acres	Known Sites	Total Acreage of known sites	Supporting Tables and Maps
Dead Creek	402050304	21,462	230	8,600	Figure 9.8 Figure 9.9 Table 9. 12 Table 9.13 Table 9.14
Cole Creek	402050305	15,899	126	5,675	Figure 9.10 Figure 9.11 Table 9. 15 Table 9.16 Table 9.17

Sites have been identified in the Dead Creek and Cole Creek subwatersheds for installation of Best Management Practices that reduce agricultural nonpoint source runoff. Pollutant reductions are estimated for each subwatershed based on the HIT Model and are presented following tables and figures showing individual sites.

Loading Estimate Methodology

The STEPL model was used to calculate the total contribution of nitrogen load in pounds per year, phosphorous load in pounds per year, biological oxygen demand in pounds per year, and sediment in tons per year by subwatershed for known acreage of problem sites.

Estimated reductions for three practices were calculated at the subwatershed level using the HIT Model. Sediment and phosphorous reductions were estimated for mulch-till, no-till and 30 feet grass buffers. Spring Drain has 46 fields totaling 2,842 acres of agricultural land in production using conventional tiling and cropping practices while Duff Creek has 64 fields totaling 3,873 acres, and Stony Creek has 65 sites totaling 4,730 acres. The HIT model was used to calculate pollution reductions that would occur should the worst 5% and/or 10% total agricultural area be put into a type of conservation tillage.

Summary Tables and Map

A series of tables and figures follows for each of the subwatersheds that were inventoried during the 2011 windshield survey.

Dead Creek

A total of 230 sites totaling 8,600 acres were identified in the Dead Creek subwatershed that have attributes that can contribute to agricultural nonpoint source runoff, these attributes include conventional tillage and less than 25% crop residue on the field. These sites are described in Table 9.12 and mapped in Figures 9.8 and 9.9. Table 9.13 provides pollutant loads estimates and Table 9.14 provides an estimation of pollutant reduction and a cost benefit analysis.

Cole Creek

A total of 126 sites totaling 5,675 acres were identified in the Cole Creek subwatershed that have attributes that can contribute to agricultural nonpoint source runoff, these attributes include conventional tillage and less than 25% crop residue on the field. These sites are described in Table 9.15 and mapped in Figures 9.10 and 9.11. Table 9.16 provides pollutant loads estimates and Table 9.17 provides an estimation of pollutant reduction and a cost benefit analysis.

Table 9.12 Dead Creek Priority Sources of Agricultural NPS

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
315	Birch Run	43.307110	-83.799030	14	N/S	Flat		0-25%
316	Birch Run	43.307140	-83.800920	20	N/S	Flat	Corn	0-25%
317	Birch Run	43.307080	-83.802150	5	N/S	Flat		0-25%
318	Birch Run	43.307080	-83.804250	5	N/S	Flat		0-25%
319	Birch Run	43.301290	-83.794320	10	E/W	Flat	Corn	0-25%
320	Frankenmuth	43.307090	-83.763640	0	N/S	Flat		0-25%
321	Frankenmuth	43.321700	-83.773490	120	N/S	Flat	Corn	0-25%
322	Frankenmuth	43.320710	-83.771390	20	N/S	Flat	Sugar Beet	0-25%
323	Frankenmuth	43.321720	-83.767300	55	N/S	Flat	Bean	0-25%
324	Frankenmuth	43.321810	-83.759230	100	E/W	Flat	Bean	0-25%
325	Frankenmuth	43.321710	-83.791650	40	N/S	Mod	Bean	0-25%
326	Frankenmuth	43.321760	-83.763300	100	N/S	Flat	Corn	0-25%
327	Frankenmuth	43.321810	-83.759230	100	E/W	Flat	Bean	0-25%
328	Frankenmuth	43.321810	-83.759230	100	E/W	Flat	Bean	0-25%
329	Frankenmuth	43.321760	-83.763300	100	N/S	Flat	Corn	0-25%
330	Frankenmuth	43.321710	-83.791650	40	N/S	Mod	Bean	0-25%
331	Frankenmuth	43.321810	-83.759230	100	E/W	Flat	Bean	0-25%
332	Frankenmuth	43.321720	-83.767300	55	N/S	Flat	Bean	0-25%
333	Frankenmuth	43.321710	-83.771390	40	N/S	Mod	Bean	0-25%
334	Frankenmuth	43.321700	-83.773490	120	N/S	Flat	Corn	0-25%
335	Thetford	43.190550	-83.640510	40	E/W	Flat	Corn	0-25%
336	Thetford	43.190830	-83.620670	30	E/W	Flat	Bean	0-25%
337	Thetford	43.179938	-83.626170	100	N/S	Mod	Bean	0-25%
338	Thetford	43.201610	-83.640910	50		Mod	Corn	0-25%
339	Thetford	43.221620	-83.675020	100	N/S	Flat		0-25%
340	Thetford	43.210180	-83.681120	30	N/S	Flat	Wheat	0-25%

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
341	Thetford	43.208190	-83.656020	20	E/W	Mod	Corn	0-25%
342	Thetford	43.211550	-83.661210	120	E/W	Mod	Bean	0-25%
343	Thetford	43.221880	-83.653520	80	N/S	Flat	Bean	0-25%
344	Thetford	43.220840	-83.641070	80	E/W	Hilly	Bean	0-25%
345	Arbela	4792873.0	283946.00	30		Flat	Bean	0 - 25%
346	Arbela	4794265.0	283963.00	80		Flat	Corn	0 - 25%
347	Arbela	4795428.0	283115.00	80		Flat	Corn	0 - 25%
348	Arbela	4793786.0	284428.00	60		Flat	Wheat	0 - 25%
349	Arbela	4794212.0	283961.00	20		Flat	Bean	0 - 25%
350	Arbela	4793826.0	282182.00	30		Flat	Corn	0 - 25%
351	Arbela	4793811.0	282925.00	30		Flat	Corn	0 - 25%
352	Arbela	4795444.0	283171.00	80		Flat	Bean	0 - 25%
353	Arbela	4795426.0	283257.00	80		Flat	Corn	0 - 25%
354	Arbela	4794903.0	283962.00	80		Flat	Corn	0 - 25%
355	Arbela	4791602.0	283947.00	30		Flat	Corn	0 - 25%
356	Arbela	4792194.0	281986.00	30		Flat	Bean	0 - 25%
357	Arbela	4788898.0	282947.00	30		Flat	Bean	0 - 25%
358	Arbela	4794265.0	283963.00	60		Flat	Corn	0 - 25%
359	Arbela	4789048.0	285527.00	20		Flat	Corn	0 - 25%
360	Arbela	4788847.0	285984.00	80		Flat	Corn	0 - 25%
361	Arbela	4789324.0	286344.00	80		Flat	Corn	0 - 25%
362	Birch Run	43.278940	-83.747990	40	E-W	Flat	0	0 - 25%
363	Birch Run	43.293220	-83.745670	20	N-S	Flat	Corn	0 - 25%
364	Birch Run	43.290540	-83.754670	80	N-S	Flat	0	0 - 25%
365	Birch Run	43.284350	-83.754830	40	E-W	Flat	Corn	0 - 25%
366	Birch Run	43.278880	-83.755020	15	N-S	Flat	0	0 - 25%
367	Birch Run	43.293070	-83.738810	40	N-S	Flat	Corn	0 - 25%

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
368	Birch Run	43.278870	-83.713310	10	E-W	Flat	0	0 - 25%
369	Birch Run	43.279210	-83.697380	40	N-S	Flat	0	0 - 25%
370	Birch Run	43.279210	-83.697380	40	N-S	Flat	0	0 - 25%
371	Birch Run	43.273590	-83.695670	20	N-S	Flat	Corn	0 - 25%
372	Birch Run	43.267370	-83.695790	50	E-W	Flat	0	0 - 25%
373	Birch Run	43.295120	-83.707650	100	N-S	Flat	0	0 - 25%
374	Birch Run	43.293690	-83.698410	100	N-S	Flat	0	0 - 25%
375	Birch Run	43.285000	-83.754920	40	E-W	Flat	Corn	0 - 25%
376	Birch Run	43.280130	-83.755160	80	E-W	Mod	Corn	0 - 25%
377	Birch Run	43.285000	-83.754920	40	E-W	Flat	Corn	0 - 25%
378	Birch Run	43.293280	-83.757990	160	N-S	Flat	Corn	0 - 25%
379	Birch Run	43.293180	-83.762030	10	N-S	Flat	Corn	0 - 25%
380	Birch Run	43.293140	-83.764650	40	N-S	Flat	0	0 - 25%
381	Birch Run	43.293310	-83.770500	40	N-S	Flat	0	0 - 25%
382	Birch Run	43.301550	-83.714060	40	E-W	Flat	Corn	0 - 25%
383	Birch Run	43.273280	-83.713390	20	N-S	Flat	0	0 - 25%
384	Birch Run	43.293310	-83.711390	40	N-S	Flat	0	0 - 25%
385	Birch Run	43.293470	-83.704730	100	N-S	Flat	Corn	0 - 25%
386	Birch Run	43.297000	-83.695570	80	N-S	Flat	0	0 - 25%
387	Birch Run	43.303360	-83.695420	20	E-W	Flat	0	0 - 25%
388	Birch Run	43.306860	-83.698270	60	N-S	Flat	0	0 - 25%
389	Birch Run	43.306900	-83.702130	40	N-S	Flat	Corn	0 - 25%
390	Birch Run	43.299970	-83.735410	40	E-W	Flat	0	0 - 25%
391	Birch Run	43.293110	-83.708720	40	N-S	Flat	0	0 - 25%
392	Birch Run	43.293860	-83.715310	80	E-W	Flat	0	0 - 25%
393	Birch Run	43.296000	-83.715080	10	E-W	Flat	Corn	0 - 25%
394	Birch Run	43.299230	-83.714890	10	E-W	Flat	Corn	0 - 25%

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
395	Birch Run	43.303050	-83.714720	40	N-S	Flat	0	0 - 25%
396	Birch Run	43.306890	-83.718290	30	E-W	Flat	0	0 - 25%
397	Birch Run	43.306740	-83.726450	80	E-W	Flat	0	0 - 25%
398	Birch Run	43.293070	-83.738830	40	N-S	Flat	Corn	0 - 25%
399	Birch Run	43.293390	-83.753260	20	N-S	Flat	0	0 - 25%
400	Birch Run	43.302220	-83.754630	80	E-W	Flat	0	0 - 25%
401	Birch Run	43.307290	-83.740080	80	N-S	Flat	Corn	0 - 25%
402	Birch Run	43.302310	-83.735410	40	N-S	Flat	0	0 - 25%
403	Birch Run	43.278860	-83.721340	30	N-S	Flat	0	0 - 25%
404	Birch Run	43.283040	-83.715340	40	E-W	Flat	Corn	0 - 25%
405	Birch Run	43.285260	-83.715400	50	E-W	Flat	Corn	0 - 25%
406	Birch Run	43.286530	-83.715410	40	E-W	Flat	0	0 - 25%
407	Birch Run	43.290230	-83.715350	20	N-S	Flat	Corn	0 - 25%
408	Birch Run	43.293190	-83.715460	40	N-S	Flat	0	0 - 25%
409	Birch Run	43.293040	-83.732650	80	E-W	Flat	0	0 - 25%
410	Birch Run	43.293070	-83.728410	40	N-S	Flat	Corn	0 - 25%
411	Birch Run	43.293120	-83.723340	40	N-S	Flat	0	0 - 25%
412	Birch Run	43.293160	-83.719810	40	N-S	Flat	0	0 - 25%
413	Birch Run	43.291150	-83.715310	30	E-W	Flat	Corn	0 - 25%
414	Birch Run	43.290850	-83.715350	30	E-W	Flat	0	0 - 25%
415	Birch Run	43.288470	-83.715460	0	E-W	Flat	0	0 - 25%
416	Birch Run	43.284350	-83.715570	40	E-W	Flat	Corn	0 - 25%
417	Birch Run	43.279090	-83.700190	30	N-S	Flat	0	0 - 25%
418	Birch Run	43.286340	-83.702100	80	E-W	Flat	0	0 - 25%
419	Birch Run	43.286490	-83.697390	80	E-W	Flat	Corn	0 - 25%
420	Birch Run	43.291530	-83.754630	81	E-W	Flat	0	0 - 25%
421	Birch Run	43.301310	-83.754590	40	E-W	Flat	Corn	0 - 25%

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
422	Birch Run	43.303060	-83.754580	30	E-W	Flat	0	0 - 25%
423	Birch Run	43.303790	-83.754570	40	E-W	Flat	0	0 - 25%
424	Birch Run	43.307080	-83.756420	40	N-S	Flat	0	0 - 25%
425	Birch Run	43.307130	-83.762990	20	N-S	Flat	Corn	0 - 25%
426	Birch Run	43.273370	-83.769240	20	N-S	Flat	0	0 - 25%
427	Frankenmuth	43.319420	-83.729870	12	N-S	Flat	-99	0 - 25%
428	Frankenmuth	43.317540	-83.715250	25	N-S	Flat	Corn	0 - 25%
429	Birch Run	43.306890	-83.717830	30	E-W	Flat	0	0 - 25%
430	Frankenmuth	43.306870	-83.721370	37	N-S	Flat	0	0 - 25%
431	Frankenmuth	43.306990	-83.723590	40	N-S	Flat	-99	0 - 25%
432	Frankenmuth	43.308920	-83.740430	30	E-W	Flat	-99	0 - 25%
433	Frankenmuth	43.314330	-83.740340	12	N-S	Flat	Corn	0 - 25%
434	Frankenmuth	43.311800	-83.736460	2	N-S	Flat	-99	0 - 25%
435	Frankenmuth	43.318500	-83.736600	25	N-S	Flat	-99	0 - 25%
436	Frankenmuth	43.308960	-83.754550	24	E-W	Flat	0	0 - 25%
437	Frankenmuth	43.307340	-83.744850	15	N-S	Flat	0	0 - 25%
438	Frankenmuth	43.306960	-83.743650	10	N-S	Flat	Corn	-99
439	Frankenmuth	43.309830	-83.740560	25	N-S	Flat	0	0 - 25%
440	Frankenmuth	43.313160	-83.740550	7	E-W	Flat	Corn	0 - 25%
441	Frankenmuth	43.314370	-83.754360	30	E-W	Flat	0	0 - 25%
442	Frankenmuth	43.317830	-83.754590	50	N-S	Mod	Corn	0 - 25%
443	Birch Run	43.284840	-83.774310	3	E-W	Flat	-99	0 - 25%
444	Birch Run	43.293290	-83.770370	25	N-S	Mod	-99	0 - 25%
445	Birch Run	43.290550	-83.754690	150	N-S	Flat	-99	0 - 25%
446	Birch Run	43.301290	-83.794320	10	E-W	Flat	Corn	0 - 25%
447	Birch Run	43.305080	-83.794350	20	N-S	Flat	-99	0 - 25%
448	Birch Run	43.291680	-83.794230	9	N-S	Flat	-99	0 - 25%

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
449	Birch Run	43.293370	-83.790800	7	N-S	Flat	-99	0 - 25%
450	Birch Run	43.293400	-83.781850	30	E-W	Flat	-99	0 - 25%
451	Birch Run	43.293390	-83.781000	20	N-S	Flat	0	0 - 25%
452	Birch Run	43.288440	-83.774380	70	E-W	Flat	Corn	0 - 25%
453	Birch Run	43.284470	-83.774330	12	none - site is a pasture	Flat	-99	0 - 25%
454	Frankenmuth	43.315620	-83.715180	15	E-W	Mod	Corn	0 - 25%
455	Birch Run	43.307080	-83.784450	40	N-S	Flat	0	0 - 25%
456	Frankenmuth	43.306800	-83.696720	38	N-S	Flat	-99	0 - 25%
457	Birch Run	43.306890	-83.697750	30	E-W	Flat	0	0 - 25%
458	Birch Run	43.306900	-83.701510	40	N-S	Flat	Corn	0 - 25%
459	Birch Run	43.306890	-83.704280	30	E-W	Flat	0	0 - 25%
460	Frankenmuth	43.306930	-83.709630	35	E-W	Flat	-99	-99
461	Frankenmuth	43.309060	-83.715070	20		Flat	-99	-99
462	Frankenmuth	43.311590	-83.715130	35	E-W	Flat	-99	-99
463	Birch Run	43.303730	-83.794300	70	N-S	Flat	Corn	0 - 25%
464	Birch Run	43.300540	-83.792870	10	N-S	Flat	-99	0 - 25%
465	Birch Run	43.297230	-83.794230	3	none--grass covered field	Flat	-99	0 - 25%
466	Birch Run	43.305130	-83.774370	55	E-W	Flat	-99	0 - 25%
467	Birch Run	43.306660	-83.774410	3	E-W	Flat	-99	0 - 25%
468	Birch Run	43.293290	-83.761050	25	N-S	Mod	-99	0 - 25%
469	Birch Run	43.293140	-83.764340	40	N-S	Flat	0	0 - 25%
470	Birch Run	43.293250	-83.767450	17	N-S	Flat	-99	0 - 25%
471	Birch Run	43.300590	-83.773070	10	N-S	Flat	Corn	0 - 25%
472	Birch Run	43.300580	-83.769840	5	N-S	Flat	-99	0 - 25%
473	Birch Run	43.300610	-83.763180	20	N-S	Flat	-99	0 - 25%

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
474	Birch Run	43.293330	-83.758220	10	N-S	Flat	-99	0 - 25%
475	Birch Run	43.307050	-83.759720	10	N-S	Flat	-99	0 - 25%
476	Frankenmuth	43.307090	-83.756730	10	N-S	Flat	-99	0 - 25%
477	Frankenmuth	43.314460	-83.767780	14	N-S	Flat	-99	76% +
478	Frankenmuth	43.313630	-83.754620	8	N-S	Flat	Corn	0 - 25%
479	Frankenmuth	43.314210	-83.762660	40	N-S	Flat	-99	0 - 25%
480	Frankenmuth	43.313770	-83.754630	6	N-S	Flat	Corn	0 - 25%
481	Frankenmuth	43.314440	-83.768880	10	N-S	Flat	-99	0 - 25%
482	Frankenmuth	43.307150	-83.774990	0		Flat	Corn	0 - 25%
483	Frankenmuth	43.307160	-83.770770	60	N-S	Flat	-99	0 - 25%
484	Frankenmuth	43.321610	-83.769790	10	E-W	Flat	-99	0 - 25%
485	Frankenmuth	43.321510	-83.766370	14	E-W	Flat	-99	0 - 25%
486	Frankenmuth	43.318120	-83.754680	70	N-S	Flat	-99	0 - 25%
487	Birch Run	43.307130	-83.786380	20	N-S	Flat	Corn	0 - 25%
488	Frankenmuth	43.307150	-83.781130	0		Flat	Corn	0 - 25%
489	Frankenmuth	43.316550	-83.775860	7	E-W	Flat	Corn	0 - 25%
490	Frankenmuth	43.311750	-83.775780	15	E-W	Flat	Corn	0 - 25%
491	Frankenmuth	43.317210	-83.775820	1	E-W	Flat	-99	-99
492	Frankenmuth	43.309060	-83.795550	20		Flat	-99	-99
493	Frankenmuth	43.321670	-83.790310	40	N-S	Mod	Corn	0 - 25%
494	Frankenmuth	43.321670	-83.785390	40	N-S	Mod	Corn	0 - 25%
495	Frankenmuth	43.321630	-83.781010	20	N-S	Mod	-99	-99
496	Frankenmuth	43.321670	-83.777040	40	N-S	Mod	Corn	0 - 25%
497	Frankenmuth	43.307220	-83.800250	30	N-S	Flat	-99	0 - 25%
498	Frankenmuth	43.307140	-83.797050	20	N-S	Mod	-99	0 - 25%
499	Frankenmuth	43.307190	-83.802260	15	none	-99	-99	0 - 25%
500	Frankenmuth	43.315720	-83.795750	7	N-S	Flat	-99	0 - 25%

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
501	Frankenmuth	43.311200	-83.795610	70	N-S	Flat	Corn	0 - 25%
502	Birch Run	43.305610	-83.695410	40	E-W	Mod	-99	0 - 25%
503	Birch Run	43.303030	-83.695430	8	E-W	Flat	-99	0 - 25%
504	Birch Run	43.298850	-83.695470	8	E-W	Mod	-99	0 - 25%
505	Birch Run	43.293700	-83.698100	40	E-W	Flat	-99	0 - 25%
506	Birch Run	43.293560	-83.700870	20	N-S	Mod	-99	0 - 25%
507	Birch Run	43.293470	-83.703600	100	N-S	Flat	Corn	0 - 25%
508	Birch Run	43.293380	-83.707080	45	E-W	Flat	Corn	0 - 25%
509	Birch Run	43.293270	-83.711570	10	N-S	Flat	Corn	0 - 25%
510	Birch Run	43.293220	-83.713690	20	N-S	Flat	Corn	0 - 25%
511	Birch Run	43.300930	-83.714740	30	N-S	Flat	Corn	0 - 25%
512	Birch Run	43.309390	-83.714520	30	unknown-dense soy bean plants	Flat	-99	0 - 25%
513	Birch Run	43.306900	-83.710170	40	N-S	Flat	Corn	0 - 25%
514	Birch Run	43.306840	-83.703070	15	E-W	Flat	-99	0 - 25%
515	Birch Run	43.306240	-83.714460	17	E-W	Flat	-99	0 - 25%
516	Birch Run	43.305130	-83.714580	55	E-W	Flat	-99	0 - 25%
517	Birch Run	43.303130	-83.714650	12	N-S	Flat	Corn	0 - 25%
518	Birch Run	43.300380	-83.716810	9	N-S	Flat	-99	0 - 25%
519	Birch Run	43.300380	-83.717900	9	N-S	Flat	-99	0 - 25%
520	Birch Run	43.300360	-83.719230	12	N-S	Flat	Corn	0 - 25%
521	Birch Run	43.300350	-83.721850	5	N-S	Flat	-99	0 - 25%
522	Birch Run	43.300320	-83.724580	30	E-W	Flat	-99	-99
523	Birch Run	43.300240	-83.730810	10	N-S	Flat	-99	-99
524	Birch Run	43.300200	-83.733660	10	E-W	Flat	-99	0 - 25%
525	Birch Run	43.306900	-83.733040	40	N-S	Flat	Corn	0 - 25%

Label	Township	Lat	Long	Field Size Acres	Field Orientation	Slope of land	Residue Type	Percent Residue
526	Birch Run	43.299670	-83.714850	10	E-W	Flat	Corn	0 - 25%
527	Birch Run	43.296390	-83.715030	12	E-W	Flat	-99	0 - 25%
528	Birch Run	43.295600	-83.715100	10	E-W	Flat	Corn	0 - 25%
529	Birch Run	43.294020	-83.715230	15	E-W	Flat	-99	0 - 25%
530	Birch Run	43.293140	-83.722560	40	N-S	Flat	0	0 - 25%
531	Birch Run	43.300250	-83.727600	12	E-W	Flat	-99	0 - 25%
532	Birch Run	43.300320	-83.722490	30	E-W	Flat	-99	-99
533	Birch Run	43.300330	-83.741330	23	N-S	Flat	Corn	0 - 25%
534	Birch Run	43.305180	-83.754570	95	E-W	Flat	Corn	0 - 25%
535	Birch Run	43.300560	-83.752510	15	E-W	Flat	-99	0 - 25%
536	Birch Run	43.293120	-83.738360	40	N-S	Flat	0	0 - 25%
537	Birch Run	43.293450	-83.753570	8	N-S	Flat	Corn	0 - 25%
538	Birch Run	43.305600	-83.754650	15	N-S	Flat	-99	0 - 25%
539	Birch Run	43.301770	-83.754650	18	E-W	Flat	-99	0 - 25%
540	Birch Run	43.301450	-83.754660	19	E-W	Flat	-99	0 - 25%
541	Birch Run	43.300620	-83.766050	25	N-S	Flat	Corn	0 - 25%
542	Birch Run	43.307070	-83.762340	15	N-S	Flat	-99	0 - 25%
543	Birch Run	43.307050	-83.759720	10	N-S	Flat	-99	0 - 25%
544	Birch Run	43.306090	-83.794330	25	E-W	Flat	Corn	0 - 25%

Figure 9.8 Dead Creek, Priority Sources of Agricultural NPS in Tuscola County

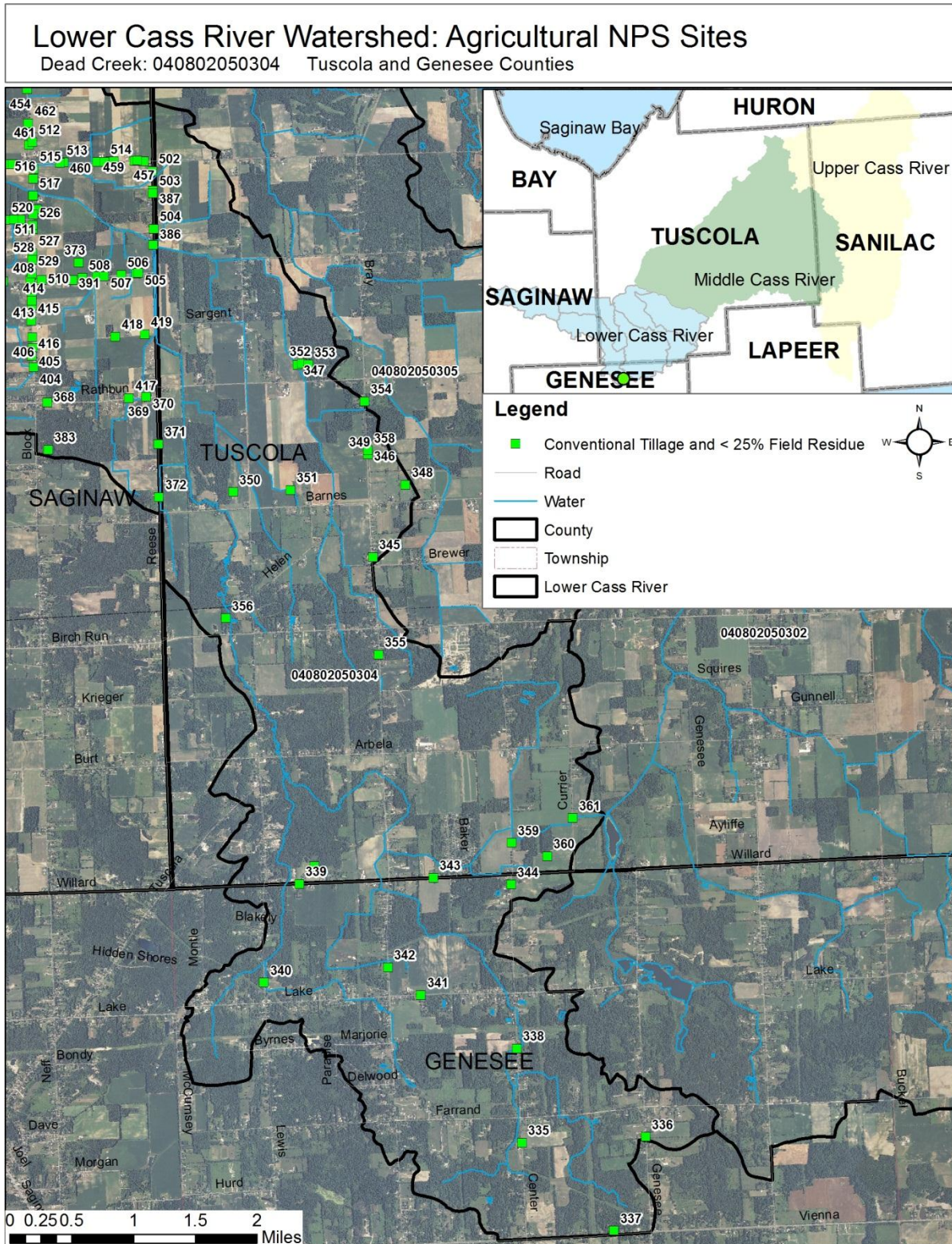
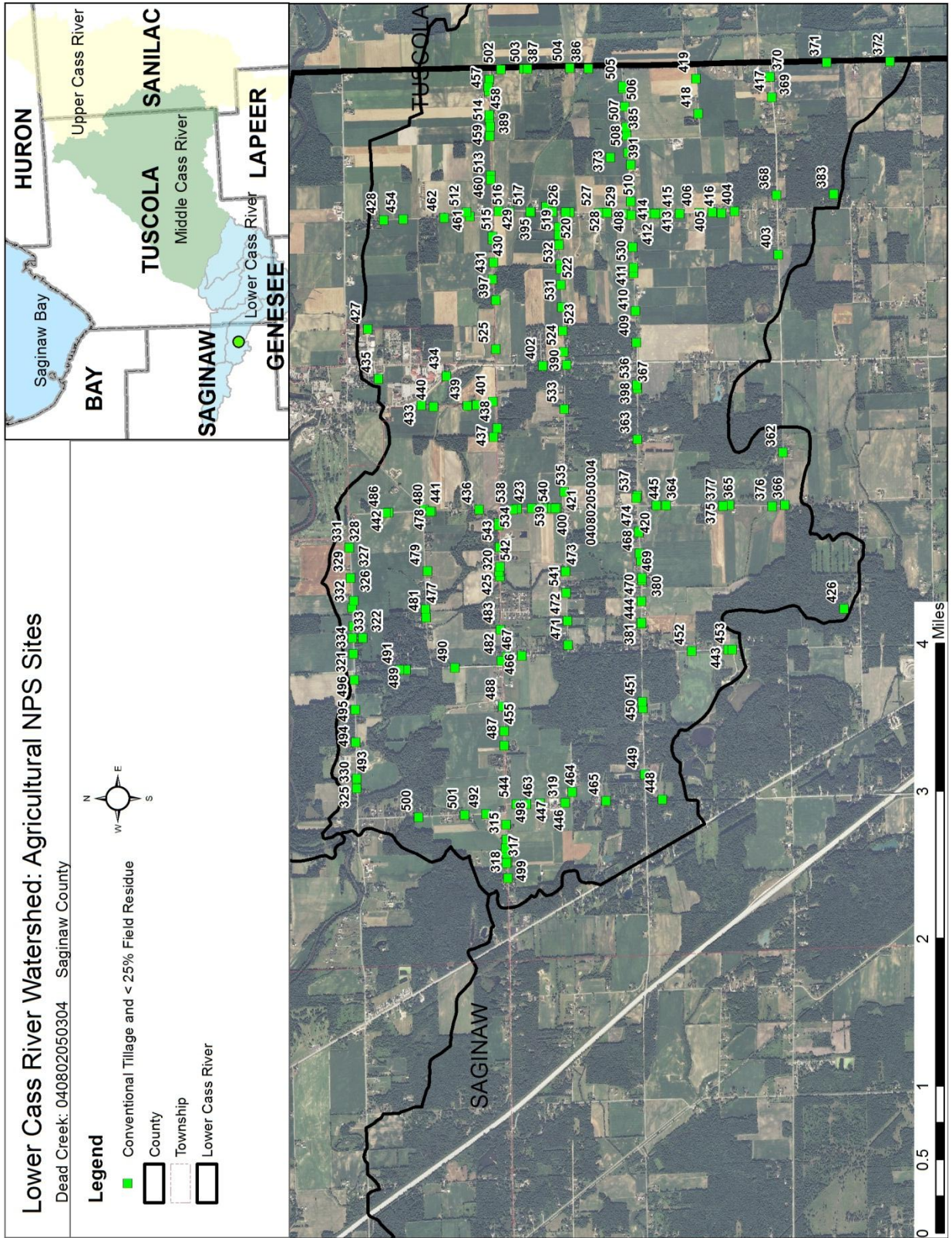


Figure 9.9 Dead Creek, Priority Sites of Agricultural NPS in Saginaw County



Pollutant loading reductions were estimated for nitrogen (N), phosphorus (P), biological oxygen demand (BOD), and sediment at the subwatershed level utilizing the STEPL Model, results are shown below in Table 9.13.

Table 9.13 Dead, Pollutant loads and reductions, STEPL Model

Acres of Cropland	N Load (no BMP) (lb/yr)	P Load (no BMP) (lb/yr)	BOD Load (no BMP) (lb/yr)	Sediment Load (no BMP) (t/yr)
8,600 acres of known sites	54,827.1	6,935.1	64,614.4	1,386.7
	N Load (with BMP) (lb/yr)	P Load (with BMP) (lb/yr)	BOD Load (with BMP) (lb/yr)	Sediment Load (with BMP) (t/yr)
	32,976.7	3,051.2	57,186.0	226.0
	% N Reduction	% P Reduction	% BOD Reduction	% Sed Reduction
	39.9	56.0	11.5	83.7

The HIT Model, developed by the Institute for Water Research at Michigan State University, results in Table 9.14 shows that the greatest sediment reduction can occur when No Till practices are placed on 10% of the most erosive areas in the Dead Creek subwatershed. The greatest return on investment is shown in the column titled ‘BMP cost benefit’ showing that No Till on the most erosive 5% of land will reduce sediment at a cost of \$41 per ton as compared to \$69 per ton for No Till on the most erosive 10% of land. Load reduction targets for sediment in the Dead Creek are aimed at reaching No Till on 5% of the subwatersheds area.

Table 9.14 Estimated Reductions in Pollutants for Dead Creek

Practice	Sediment Reduction (tons/yr)	BMP cost benefit (\$/ton reduction)	Phosphorous Reduction (lbs/yr) / \$/lb-P
mulch till on sediment for worst 5% (1,073 acres)	187	\$115	159 / \$135
mulch till on sediment for worst 10% (2,146 acres)	155	\$69	132 / \$81
No Till on sediment for worst 5% (1,073 acres)	362	\$41	308 / \$49
No Till on sediment for worst 10% (2,146 acres)	437	\$69	371 / \$81
sediment for 30ft grass buffer	394	\$80	335 / \$94

Table 9.14 Cole Creek Priority Sources of Agricultural NPS

Label	Township	UTM Y-coord	UTM X-coord	Field Size Acres	Field Orientation	Slope	Residue Type	Percent Residue
561	Arbela	4792144	284725	70	NR	Flat	Corn	0 - 25%
562	Arbela	4795412	284128	10	NR	Flat	Wheat	0 - 25%
563	Arbela	4795402	284514	100	NR	Flat	Corn	26 - 50%
564	Arbela	4795394	285051	60	NR	Flat	Bean	0 - 25%
565	Arbela	4796223	283992	0	NR	Flat	Wheat	-99
566	Arbela	4792604	285546	120	NR	Flat	Wheat	0 - 25%
567	Arbela	4792969	284791	60	NR	Flat	Wheat	0 - 25%
568	Arbela	4792144	284725	30	NR	Flat	Corn	0 - 25%
569	Arbela	4795349	285599	40	NR	Flat	Bean	0 - 25%
570	Arbela	4793762	285404	10	NR	Flat	Bean	0 - 25%
571	Arbela	4793774	285122	50	NR	Flat	Bean	0 - 25%
572	Arbela	4795351	285597	70	NR	Flat	Bean	0 - 25%
573	Arbela	4794961	285592	150	NR	Flat	Corn	0 - 25%
574	Arbela	4794437	285582	70	NR	Flat	Corn	0 - 25%
575	Arbela	4794075	285562	40	NR	Flat	Bean	0 - 25%
576	Arbela	4793755	286146	40	NR	Flat	Wheat	0 - 25%
577	Arbela	4793752	286165	80	NR	Flat	Bean	0 - 25%
578	Arbela	4793737	286625	5	NR	Flat	Corn	0 - 25%
579	Arbela	4793746	286779	40	NR	Flat	Corn	0 - 25%
580	Arbela	4797048	283459	60	NR	Flat	Bean	0 - 25%
581	Arbela	4797058	283197	80	NR	Flat	Bean	0 - 25%
582	Arbela	4795397	285118	80	NR	Flat	Wheat	0 - 25%
583	Tuscola	4797794	282417	10	NR	Mod	-99	76% +
584	Tuscola	4799425	282419	10	NR	Flat	Bean	0 - 25%
585	Tuscola	4799425	282419	10	NR	Flat	Bean	0 - 25%

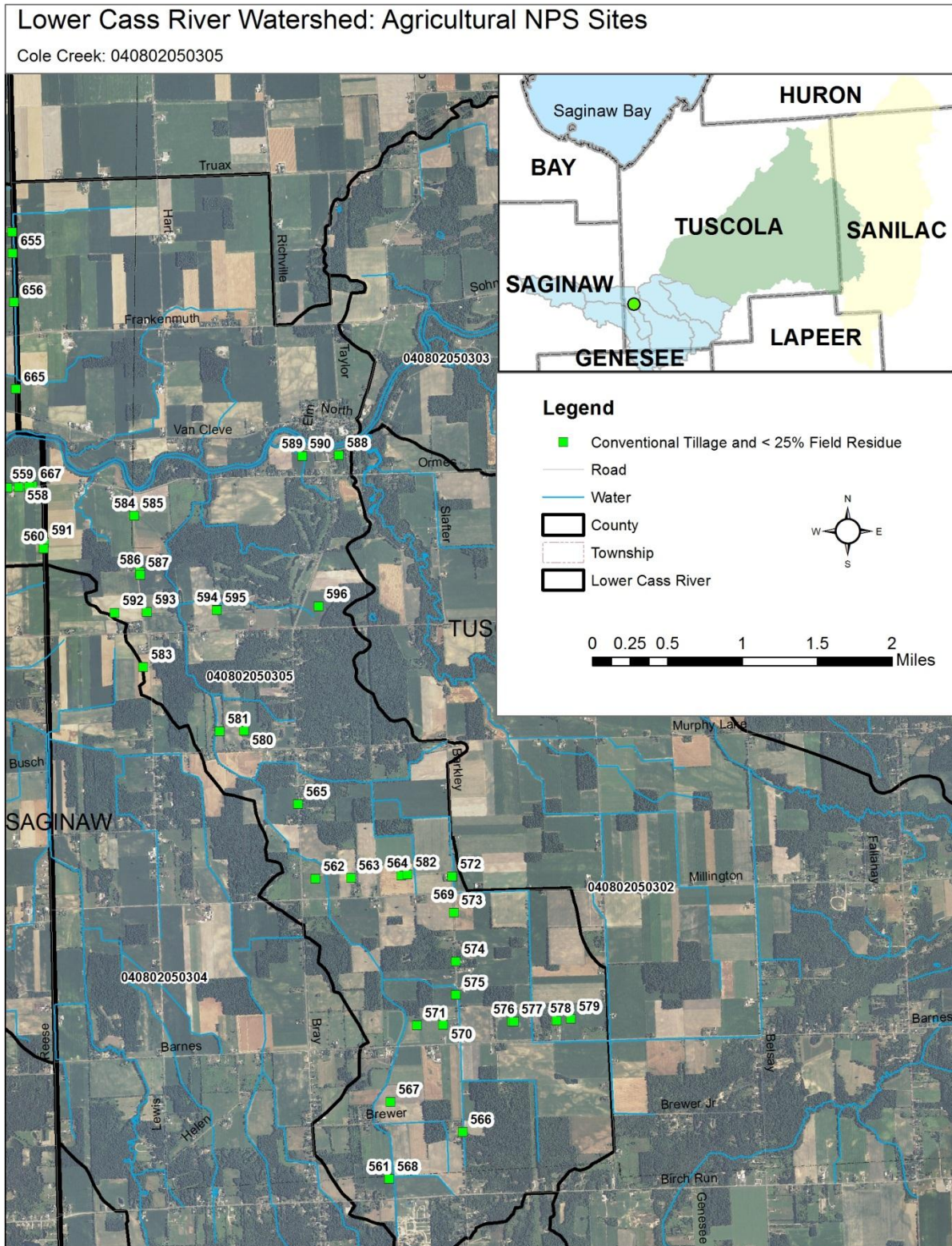
Label	Township	UTM Y-coord	UTM X-coord	Field Size Acres	Field Orientation	Slope	Residue Type	Percent Residue
586	Tuscola	4798816	282443	30	NR	Flat	Corn	0 - 25%
587	Tuscola	4798784	282443	10	NR	Flat	Bean	0 - 25%
588	Tuscola	4799944	284656	10	NR	Flat	Bean	0 - 25%
589	Tuscola	4799956	284258	20	NR	Flat	Corn	0 - 25%
590	Tuscola	4799956	284258	20	NR	Flat	Corn	0 - 25%
591	Tuscola	4799196	281431	40	NR	Flat	Corn	26 - 50%
592	Tuscola	4798395	282145	60	NR	Flat	Bean	0 - 25%
593	Tuscola	4798383	282492	20	NR	Flat	Bean	0 - 25%
594	Tuscola	4798362	283245	10	NR	Flat	Bean	0 - 25%
595	Tuscola	4798359	283245	10	NR	Flat	Corn	0 - 25%
596	Tuscola	4798334	284337	40	NR	Flat	Bean	0 - 25%
597	Frankenmuth	-83.732940	43.321560	70	N/S	Flat	Bean	0-25%
598	Frankenmuth	-83.718890	43.321440	120	E/W	Mod	Wheat	0-25%
599	Frankenmuth	-83.727300	43.321560	70	N/S	Flat	Bean	0-25%
600	Frankenmuth	-83.721760	43.330280	40	E/W	Mod	Bean	0-25%
601	Frankenmuth	-83.758650	43.342630	70	N/S	Flat	Corn	0-25%
602	Frankenmuth	-83.758670	43.344910	70	E/W	Flat	Sugar Beat	0-25%
603	Frankenmuth	-83.798370	43.350350	20	E/W	Flat	Wheat	0-25%
604	Frankenmuth	-83.788740	43.345750	40	N/S	Flat	Corn	0-25%
605	Frankenmuth	-83.788760	43.345750	40	N/S	Flat	Corn	0-25%
606	Frankenmuth	-83.788700	43.342300	80	N/S	Flat	Bean	0-25%
607	Frankenmuth	-83.788650	43.339220	40	N/S	Flat	Corn	0-25%
608	Frankenmuth	-83.788620	43.336990	20	E/W	Flat	Wheat	0-25%
609	Frankenmuth	-83.798720	43.343930	30	N/S	Flat	Bean	0-25%
610	Frankenmuth	-83.785020	43.350320	60	E/W	Flat	Bean	0-25%
611	Frankenmuth	-83.778750	43.347130	20	E/W	Flat	Bean	0-25%
612	Frankenmuth	-83.778750	43.347130	20	E/W	Flat	Bean	0-25%

Label	Township	UTM Y-coord	UTM X-coord	Field Size Acres	Field Orientation	Slope	Residue Type	Percent Residue
613	Frankenmuth	-83.778730	43.346100	40	E/W	Flat	Bean	0-25%
614	Frankenmuth	-83.778730	43.346100	40	E/W	Flat	Bean	0-25%
615	Frankenmuth	-83.778670	43.343010	5	E/W	Flat	Bean	0-25%
616	Frankenmuth	-83.778670	43.343010	5	E/W	Flat	Bean	0-25%
617	Frankenmuth	-83.778670	43.343010	5	E/W	Flat	Bean	0-25%
618	Frankenmuth	-83.781830	43.335790	80	N/S	Mod	Corn	0-25%
619	Frankenmuth	-83.776090	43.335710	40	N/S	Flat	Corn	0-25%
620	Frankenmuth	-83.773310	43.335730	40	N/S	NR	Wheat	0-25%
621	Frankenmuth	-83.773320	43.335730	40	N/S	NR	Wheat	0-25%
622	Frankenmuth	-83.765450	43.335770	100	N/S	Flat	Bean	0-25%
623	Frankenmuth	-83.761180	43.335800	60	N/S	Flat	Sugar Beat	0-25%
624	Frankenmuth	-83.759650	43.343210	20	E/W	Flat	Corn	0-25%
625	Frankenmuth	-83.771310	43.343150	20	N/S	Flat	Corn	0-25%
626	Frankenmuth	-83.758590	43.349880	70	E/W	Flat	Bean	0-25%
627	Frankenmuth	-83.782650	43.350680	40	N/S	Flat	Bean	0-25%
628	Frankenmuth	-83.793430	43.350520	60		Flat	Corn	0-25%
629	Frankenmuth	-83.785620	43.350430	40	N/S	Flat	Bean	0-25%
630	Frankenmuth	-83.790230	43.349890	60	N/S	Flat	Bean	0-25%
631	Frankenmuth	-83.799680	43.355360	60	N/S	Flat	Bean	0-25%
632	Frankenmuth	-83.806960	43.350480	40	E/W	Flat	Wheat	0-25%
633	Frankenmuth	-83.814620	43.350420	70		Flat	Bean	0-25%
634	Frankenmuth	-83.798890	43.348760	70	E/W	Flat	Bean	0-25%
635	Frankenmuth	-83.798850	43.347420	30	E/W	Flat	Corn	0-25%
636	Frankenmuth	-83.801120	43.335760	10	N/S	Hilly	Corn	51-75%
637	Frankenmuth	-83.728240	43.343160	20	E/W	Flat	Wheat	0-25%
638	Frankenmuth	-83.718120	43.338110	60	N/S	Mod	Corn	0-25%
639	Frankenmuth	-83.718260	43.346000	20	N/S	Flat	Bean	0-25%

Label	Township	UTM Y-coord	UTM X-coord	Field Size Acres	Field Orientation	Slope	Residue Type	Percent Residue
640	Frankenmuth	-83.728240	43.346460	20	E/W	Flat	Bean	0-25%
641	Frankenmuth	-83.728280	43.349990	80	E/W	Flat	Corn	0-25%
642	Frankenmuth	-83.729510	43.341360	50	E/W	Flat	Wheat	0-25%
643	Frankenmuth	-83.728220	43.339390	20	E/W	Flat	Bean	0-25%
644	Frankenmuth	-83.735900	43.350300	20	E/W	NR	Bean	0-25%
645	Frankenmuth	-83.728250	43.342090	20	E/W	Flat	Bean	0-25%
646	Frankenmuth	-83.738100	43.345010	40	E/W	Flat	Bean	0-25%
647	Frankenmuth	-83.735700	43.350310	20	E/W	Flat	Sugar Beat	0-25%
648	Frankenmuth	-83.798520	43.329820	60	N/S	Mod	Corn	0-25%
649	Frankenmuth	-83.799710	43.335800	60	N/S	Flat	Sugar Beat	0-25%
650	Frankenmuth	-83.718110	43.336550	80	N/S	Flat	Corn	0-25%
651	Frankenmuth	-83.718170	43.345220	40	E/W	Flat	Bean	0-25%
652	Frankenmuth	-83.718180	43.347170	40	N/S	Flat	Corn	0-25%
653	Frankenmuth	-83.703050	43.350210	20	E/W	Flat	Corn	0-25%
654	Frankenmuth	-83.698300	43.345910	30	E/W	Flat	Bean	0-25%
655	Frankenmuth	-83.698290	43.343880	30	E/W	Flat	Corn	0-25%
656	Frankenmuth	-83.698300	43.339140	35	E/W	Flat	Wheat	0-25%
657	Frankenmuth	-83.703880	43.335770	100	N/S	Flat	Bean	0-25%
658	Frankenmuth	-83.704810	43.335750	30	N/S	Flat	Bean	0-25%
659	Frankenmuth	-83.704810	43.335750	30	N/S	Flat	Bean	0-25%
660	Frankenmuth	-83.706890	43.335800	60	N/S	Flat	Sugar Beat	0-25%
661	Frankenmuth	-83.709510	43.335790	80	N/S	Mod	Corn	0-25%
662	Frankenmuth	-83.709860	43.335660	10	NR	Mod	Bean	0-25%
663	Frankenmuth	-83.709680	43.335710	40	N/S	Flat	Corn	0-25%
664	Frankenmuth	-83.701860	43.335690	40	N/S	Mod	Corn	0-25%
665	Frankenmuth	-83.698380	43.330740	40	N/S	Mod	Corn	0-25%
666	Frankenmuth	-83.708250	43.330180	70	E/W	Mod	Bean	0-25%

Label	Township	UTM Y-coord	UTM X-coord	Field Size Acres	Field Orientation	Slope	Residue Type	Percent Residue
667	Frankenmuth	-83.696560	43.321330	70	N/S	Mod	Corn	0-25%
668	Frankenmuth	-83.706700	43.321410	5	E/W	Flat	Bean	0-25%
669	Frankenmuth	-83.711270	43.321470	70	E/W	Flat	Corn	0-25%
670	Frankenmuth	-83.779800	43.333050	80	E/W	Flat	Wheat	0-25%
671	Frankenmuth	-83.782450	43.333300	20	N/S	Flat	Wheat	0-25%
672	Frankenmuth	-83.795370	43.332040	60	N/S	Mod	Corn	0-25%
673	Frankenmuth	-83.788980	43.335810	80	N/S	Flat	Bean	0-25%
674	Frankenmuth	-83.788980	43.335810	80	N/S	Flat	Bean	0-25%
675	Frankenmuth	-83.785830	43.335810	80	N/S	Flat	Bean	0-25%
676	Frankenmuth	-83.784380	43.335810	80	N/S	Flat	Bean	0-25%
677	Frankenmuth	-83.776470	43.331240	10	N/S	Mod	Bean	0-25%
678	Frankenmuth	-83.776450	43.331940	15	N/S	Hilly	Corn	0-25%
679	Frankenmuth	-83.769520	43.332720	10	E/W	Flat	Bean	0-25%
680	Frankenmuth	-83.774630	43.332490	10	N/S	Mod	Bean	0-25%
681	Frankenmuth	-83.772240	43.335840	80	N/S	Mod	Bean	0-25%
682	Frankenmuth	-83.761090	43.335900	70	E/W	Mod	Corn	0-25%
683	Frankenmuth	-83.776120	43.327790	10	NR	Hilly	-99.000000	0-25%
684	Frankenmuth	-83.775910	43.323020	80	N/S	Flat	Wheat	0-25%
685	Frankenmuth	-83.775910	43.323020	80	N/S	Flat	Wheat	0-25%
686	Frankenmuth	-83.776120	43.327790	10	NR	Hilly	-99.000000	0-25%

Figure 9.11 Cole Creek Priority Sites for Agricultural BMPs, Saginaw County



Pollutant loading reductions were estimated for nitrogen (N), phosphorus (P), biological oxygen demand (BOD), and sediment at the subwatershed level utilizing the STEPL Model, results are shown below in Table 9.15.

Table 9.15 Cole Creek, Pollutant loads and reductions, STEPL Model

Acres of Cropland	N Load (no BMP) (lb/yr)	P Load (no BMP) (lb/yr)	BOD Load (no BMP) (lb/yr)	Sediment Load (no BMP) (t/yr)
5,675 acres of known sites	36,477.1	4,690.9	43,233.1	1,008.0
	N Load (with BMP) (lb/yr)	P Load (with BMP) (lb/yr)	BOD Load (with BMP) (lb/yr)	Sediment Load (with BMP) (t/yr)
	21,809.3	2,032.1	37,833.1	164.3
	% N Reduction	% P Reduction	% BOD Reduction	% Sed Reduction
	40.2	56.7	12.5	83.7

The HIT Model results in Table 9.15 shows that the greatest sediment reduction can occur when No Till practices are placed on 10% of the most erosive areas in the Cole Creek subwatershed. The greatest return on investment is shown in the column titled ‘BMP cost benefit’ showing that No Till on the most erosive 5% of land will reduce sediment at a cost of \$26 per ton as compared to \$74 per ton for Mulch Till on the most erosive 5% of land. Load reduction targets for sediment in the Cole Creek are aimed at reaching No Till on 5% of the subwatersheds area.

Table 9.16 Estimated Reductions in Pollutants for Cole Creek

Practice	Sediment Reduction (tons/yr)	BMP cost benefit (\$/ton reduction)	P-Reduction (lbs/yr) / \$/lb-P
mulch till on sediment for worst 5% (795 acres)	214	\$74	182 / \$87
mulch till on sediment for worst 10% (1,590 acres)	185	\$73	157 / \$51
No Till on sediment for worst 5% (795 acres)	431	\$26	366 / \$30
No Till on sediment for worst 10% (1,590 acres)	500	\$45	425 / \$52
sediment for 30ft grass buffer	425	\$56	361 / \$66

9.5 Estimate of the load reductions expected from the proposed management measures (EPA Element B)

E.Coli is the only impairment that has a documented quantity needed to attain designated uses which aligns with Michigan's Water Quality Standards (WQS). Though not calculated specifically for *E.coli*, the known sites where livestock are impacting surface waters have been estimated for sediment and nutrient reductions. Correcting these sites will address *e. coli* inputs to these waterbodies. We will address the high and medium priority sites in the TMDL watersheds to remove 100% of impairments from livestock thus removing sources for *e. coli* to enter surface water.

In water bodies that are currently meeting designated uses but where significant pollutant sources were identified, percent pollutant reductions to achieve improved water quality are based on the load reductions that would be realized by remediating high and medium priority sites identified. Exceptions where load reductions are expected to be 100% are where there is few impairment sources identified. These source impairments include streambank erosion sites, wetland loss, and cropland runoff and are summarized in Table 9.16.

Load reductions needed to address each impairment and threat (EPA, B.1)

E.Coli is the only impairment that has a documented quantity needed to attain designated uses which aligns with Michigan's Water Quality Standards (WQS). Though not calculated specifically for *E.coli*, the known sites where livestock are impacting surface waters have been estimated for sediment and nutrient reductions. Correcting these sites will address *e. coli* inputs to these waterbodies.

We will address the high and medium priority sites in the TMDL watersheds (Dead Creek, Cole Creek, Perry Creek and Millington Creek) to remove 100% of impairments from livestock thus removing sources for *e. coli* to enter surface water. Table 9.17 provides a summary of the expected load reductions for each impairment source.

Table 9.17 Summary Table of Expected Load Reductions

Impairment Source	Loading Estimate for Total Sites	Loading Reductions	Loading Reduction %
Livestock Access	3,502 lbs/yr P, 18,284 lbs/yr N, 23,769 lbs/yr BOD	Dependent on practice – see tables 9.18-9.20	Variable depending on practice installed
Streambank Erosion	Tons Sediment = 4,392 + 11,811 = 16,203; lbs P = 4,832 + 13,069 = 17,901; lbs N = 9,664 + 26,138 = 35,802	Tons sediment = 846 + 7,541 = 8,387; lbs P = 931 + 8,285 = 9,216; lbs N = 1,862 + 16,570 = 18,432	51% sediment; 51% P; 51% N
Wetland Loss	Unknown	See LLFWA	Dependent on acreage feasibility
Cropland Runoff	91,304 lbs/yr N, 11,626 lbs/yr P, 107,847 lbs/yr BOD, 2,394 t/yr Sediment	36,518 lbs/yr N, 6,452 lbs/yr P, 12,828 lbs/yr BOD, 2,004 t/yr Sediment	39.9% N, 56% P, 11.8% BOD, 83.7% Sediment

Method used for determination of these nutrient loadings was the *Pollutant Controlled Calculation and Documentation for Section 319 Watersheds Training Manual, June, 1999*.

Table 9.18 shows reductions in annual loadings if vegetated filter strips are used to protect waterways. Table 9.19 shows reductions in annual loadings if waste management systems are used to on high priority sites. Table 9.20 shows reductions in annual loadings if a waste storage facility is used on high priority sites.

Table 9.18 Reductions from vegetated filter strips.

Location	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)	BOD (lbs/yr)
Tuscola County (High Priority)	1770	ND	ND
Saginaw County (High Priority)	510	ND	ND
Genesee County (High Priority)	540	ND	ND

ND = A reduction constant was Not Determined in the 319 method used for this table

Table 9.19 Reductions from waste management systems

Location	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)	BOD (lbs/yr)
Tuscola County (High Priority)	1,875	8,480	ND
Saginaw County (High Priority)	540	2,665	ND
Genesee County (High Priority)	570	580	ND

ND = A reduction constant was Not Determined in the 319 method used for this table

Table 9.20 Reductions from waste storage facilities

Location	Phosphorus (lbs/yr)	Nitrogen (lbs/yr)	BOD (lbs/yr)
Tuscola County (High Priority)	1,250	6,890	ND
Saginaw County (High Priority)	360	2,165	ND
Genesee County (High Priority)	380	475	ND

ND = A reduction constant was Not Determined in the 319 method used for this table

9.7 Description of the management measures needed to achieve the proposed load reductions (EPA Element C)

Goals for the Lower Cass River Watershed (EPA, C1)

1. Restore the designated uses of total and partial body contact on the Cole Creek and Cass River
2. Restore the designated use of other indigenous aquatic life and wildlife
3. Connect the Shiawassee National Wildlife Refuge (formally or informally) with Michigan's State Game Areas and other private natural areas along the Cass River

Management Measures are Applicable & Feasible (EPA, C2-3)

A suite of management measures are available to reduce pollution and impacts to water quality in the Upper Cass River. Management measures are listed by priority. Chapter 4 details the urban stormwater analysis and appropriate management measures for Vassar, Frankenmuth, and Bridgeport.

Livestock Access: Livestock can be restricted to accessing surface water by installation of fencing along river corridors, and installation of alternate watering facilities.

Streambank Erosion can be addressed through a variety of means. These include installation of vegetative buffers to slow overland runoff and stabilization of the bank itself using natural materials such as logs or brush mattresses to hard armoring options such as gabion baskets or rip rap in extreme erosion cases.

Naturalize drains and reconnect to floodplain where feasible to remediate loss of aquatic life in Dead Creek and Cass River.

Agricultural NPS is a broad category that includes the following causes of impairments: Cropland erosion/runoff, Conventional Tillage, Surface ditching, Manure spreading. These can be addressed through a combination of **Agricultural BMP's**:

- Conservation tillage / Mulch-till
- Grassed Buffers
- Cover cropping

Stormwater management: Vassar, Frankenmuth, and Bridgeport are the urbanized areas in the Lower Cass River that were inventoried as a part of the urban hydrologic assessment, detailed in Chapter 4. There are structural recommendations to keep runoff on-site and managerial recommendations for planning commissions to enact to reduce stormwater runoff.

Recommended Managerial Strategies

Point of sale septic system ordinance: Bacteria pollution is a pervasive problem in Michigan and the Cass River Watershed. Michigan is only one of two states in the union that do not have a statewide ordinance relating to the inspection of septic systems at the time of sale. Several

counties have adopted or are working on developing time of sale ordinances for their communities. A sample ordinance from the Barry-Eaton District Health Department is included in the watershed plan for local health departments to consider for adaptation and adoption.

Low impact development: A recent study performed by the Planning and Zoning Center at Michigan State University, evaluated the use of Low Impact Development in the Cass River Watershed. Full recommendations are included in appendix E. Stormwater management is also considered a component of low impact development and is detailed in Chapter 4.

Critical Locations for Management Measures (EPA C.4)

Critical locations coincide with areas where there is an ample amount of inventory information available and a known impairment.

Critical locations are shown in the inventory section for Dead Creek, Cole Creek, Perry Creek, Millington Creek, and the Cass River. These five subwatersheds are listed as impaired by the Michigan DEQ, inventory data from 2010-11, and HIT Modeling all support targeted restoration in these subwatersheds.

The Lower Cass River strategy was reviewed by stakeholders on May 21, 2013 at the Saginaw County Conservation District. Priority areas for installation of management measures included:

Priority 1: Dead Creek, Cole Creek, Perry Creek, Millington Creek
Livestock fencing, manure stacking facilities, alternative watering facilities

Priority 2: Cole Creek, Cass River
Streambank Stabilization

Priority 3: Cass River
Wetland Restoration

Priority 4: Dead Creek, Cole Creek
Conservation tillage and cover crops

Load reductions linked to management measures (EPA, C5 & C6)

See STEPL Modeling results for reductions in sediment/nutrient reductions through installation of agricultural BMP's. The percent reduction for agricultural BMP's are demonstrated in the HIT Model calculations for mulch-till, no-till and grass buffer strips. We assume practices installed for livestock exclusions, e. coli reduction, gully stabilization, tile outlet erosion, and streambank stabilization have the ability to reduce loading by at or near 100% (e.g. permanent sediment reduction by fencing livestock out of riparian areas).

9.8 Implementation Schedule and Assistance (EPA Elements D, F, G, H)

EPA Elements C-H are presented by priority subwatershed and impairment in Tables 9.20 and 9.21. The public information and education section is included in Chapter 6.

Table 9.20 Implementation Assistance

Priority Subshed	MGMT Measure	Technical Assistance Type	Technical Cost	*Project Lead and Partners	Quantity	Material / Installation Cost	Total Cost and Potential Funding	Regulatory Agencies
1 Dead Creek	Livestock exclusion	Landowner outreach and assistance for fencing, crossings, stacking facilities, MAEAP certification, etc	estimated need for part-time technician over two years for outreach and technical assistance (\$45,000 each year)	*Saginaw Conservation District, MMPA, Farm Bureau, MSUE, MAEAP, USDA-NRCS	1,265 animals	est avg \$15,000 per site * 10 sites	195,000.00 319, Farm Bill, USDA-NRCS	FSA, MDA, MDEQ
1 Cole Creek	Livestock exclusion				966 animals	est avg \$15,000 per site * 15 sites	225,000.00	
1 Perry Creek	Livestock exclusion				95 sites	est avg \$15,000 per site * 95 sites	1,425,000.00	
1 Milling-ton Creek	Livestock exclusion				30 sites	est avg \$15,000 per site * 30 sites	450,000.00	
2 Cole Creek	Streambank stabilization	Landowner outreach, engineering and	est at 20,000 for .25 FTE staff position	*Saginaw Conservation District, Saginaw Bay RC&D, Cass	1,565 linear feet	est \$20 per linear ft	51,300.00 CZM, 319, SWIN	Drain Office, MDEQ, Soil

Priority Subshed	MGMT Measure	Technical Assistance Type	Technical Cost	*Project Lead and Partners	Quantity	Material / Installation Cost	Total Cost and Potential Funding	Regulatory Agencies
2 Cass River	Streambank stabilization	construction		River Greenway	8,205 linear feet	est \$20 per linear ft	164,100.00	Erosion
3 Cass River	Wetland restoration (over 90% wetland loss)	Landowner outreach, engineering and construction	USFWS, MDEQ programs	*Saginaw Conservation District, USFWS	500 acres	est \$100 per acre	500,000.00 USFWS, 319, WHIP	MDEQ
4 Dead Creek	Conservation tillage and cover crops, vegetated buffers	Landowner outreach and assistance	Full time technician for Conservation District for 2 years, estimated at 90K	*Saginaw Conservation District, Farm Bureau, Star of the West	8600 Acres	\$10-14 per acre = \$86,000 - \$120,400	210,000.00 319, Farm Bill, USDA-NRCS	FSA, MDA
4 Cole Creek	Conservation tillage and cover crops, vegetated buffers				5,675 acres	\$10-14 per acre = \$56,750 - \$79,450	79,450.00 319, Farm Bill, USDA-NRCS	FSA, MDA

The public information and education plan can be found in Chapter 6 (EPA Element E). The education plan is broken to address each of the pollutant sources and causes by target audience, message, and delivery tools.

Table 9.21 Schedule for implementation and milestones (EPA Element F & G)

Priority	Subwatershed	Management Measure	Implementation Schedule	Interim Measurable Milestones	Evaluation Dates
1	Dead Creek	Livestock access	2014-2016	7 High priority sites - # animals	2017 confirm 7 sites identified in inventory have installed BMPs
1	Cole Creek	Livestock access	2014-2016	4 High priority sites - # animals	2017 confirm 4 sites identified in inventory have installed BMPs
1	Perry Creek	95 potential sites for livestock exclusion (Table 12 of Draft 2013 TMDL)	2014-2016	50 sites within 100' of stream	2017 confirm 50 sites have installed BMPs
1	Millington Creek	30 potential sites for livestock exclusion (Table 12 of Draft 2013 TMDL)	2014-2016	18 sites within 100' of stream	2017 – confirm 18 sites have installed BMPs
2	Cole Creek	Streambank erosion	2018-2020	900 Feet stabilized (severe sites)	2021 – confirm 900 feet of bank stabilized
2	Cass River	Streambank erosion	2018-2020	1,500 feet stabilized (severe sites)	2021 – confirm 1,500 feet of bank stabilized
3	Cass River	Wetland restoration (over 90% wetland loss)	2017-20-23	500 acres	2023 – confirm acreage of restored wetland

Priority	Subwatershed	Management Measure	Implementation Schedule	Interim Measurable Milestones	Evaluation Dates
4	Dead Creek	Conservation tillage and cover crops, vegetated buffers	2019-2021	860 acres (10% of known acreage)	2022 – confirm acreage of measures installed
4	Cole Creek	Conservation tillage and cover crops, vegetated buffers	2019-2021	600 acres (~ 10% of known acreage)	2022 – confirm acreage of measures installed

The three actions required for each management measure are similar:

1. Submit funding proposal to MDEQ (Year One)
2. Landowner Outreach (Year Two)
3. Site Design and Implementation (Year Two-Year Three)
4. Monitoring, Re-evaluation of WMP Status and Next Steps (Year Three-Year Four)

9.8 Criteria to determine whether or not load reductions are being achieved (EPA Element H)

Criteria for evaluating load reductions are strictly for *E. coli* as mentioned in section A. The planning committee should revisit the plan and TMDL's every two years to evaluate progress on achieving milestones and subsequent load reductions. All known sources of bacterial contamination will be addressed and their success measured by reductions in *e.coli* levels as dictated by state water quality standards. A monitoring request will be made in the TMDL watersheds to MDEQ after these priority impairment sources have been corrected to determine if designated uses have been restored. Numeric criteria are delineated by the state of Michigan Water Quality Standards.

There is currently no water ways listed as impaired due to sediment or phosphorous in the Lower Cass River. Criteria for determining whether load reductions have been achieved for sediment and nutrient loading will be based upon the evaluation of the amount of practices installed and associated pollutant load reduction. A monitoring request will be submitted to the MDEQ for a biological assessment pre-project and post-project implementation to determine if improvements in water quality have been achieved.

9.9 Monitoring component to evaluate the effectiveness of implementation (EPA Element I)

Two major monitoring initiatives continue in the watershed. The first is the five-year basin monitoring program stewarded by the Michigan DEQ and the continuation of the TMDL process. The second is initiated by the Cass River Greenway committee, based in Frankenmuth. Together, monitoring data will in theory measure improvements of Cass River water quality. It is assumed that major restoration projects completed during implementation will have separate monitoring plans and Quality Assurance Project Plans (QAPPs) established as a part of their funding requirements.

Chapter 3 provides an overview of previous monitoring done in the Cass River. From this evaluation data gaps have been identified that should be looked at within the context of a comprehensive monitoring strategy for this watershed. Data gap analysis for the Lower Cass River shows monitoring data for all subwatersheds (Table 3.6, Chapter 3). Continued monitoring is planned for the Lower Cass River per the 2013 TMDL and efforts of the Cass River Greenway committee.

Additional inventory was conducted during the watershed planning phase in these subwatersheds to identify projects that would help achieve water quality restoration goals. Subwatersheds that were assessed by MDEQ with high water quality scores were not

inventoried due to time and budget constraints. Ongoing monitoring efforts in the watershed include: 1) MDEQ's five-year basin monitoring program and the continuation of their TMDL monitoring process, and 2) Monitoring being performed by the Cass River Greenway committee, based in Frankenmuth along the Cass River corridor.

It is assumed that major restoration projects completed during implementation will have separate monitoring plans and Quality Assurance Project Plans (QAPPs) established as a part of their funding requirements. Potential sites for restoration activities should be identified by at the beginning of any implementation effort to allow for pre-project and post-project monitoring. Monitoring should also include before and after pictures of implementation projects.

A comprehensive monitoring plan for the Lower Cass River is also recommended to fully evaluate necessary monitoring to fill data gaps, gather background information, and identify other potential water quality impairments or threats. Funding should be sought to develop and implement this Cass River Watershed monitoring plan from the MICorps program or similar funding opportunity. Building off of past monitoring efforts, the following parameters should be monitored at public access sites, and within each subwatershed to determine improvements or declines in water quality:

- E. Coli
- Total dissolved solids
- Total suspended solids
- pH
- COD
- Nitrite
- Nitrate + Nitrate
- Total Phosphorus
- Ortho Phosphorus
- Total number of macroinvertebrate taxa

Chapter 10: Next Steps and Sustainability Strategy

The Cass River Watershed Management Plan provides a framework that outlines the scope of the nonpoint source pollution problems, highlights the unique natural resource opportunities, and identifies key partnerships needed to work on these issues. The watershed management plan, however, is only a snapshot in time. It identifies the known conditions today, but these conditions will change over time. The plan outlines a 10 year action agenda that needs to be continually reviewed to determine if the priorities and actions still reflect current conditions. The purpose of this section of the watershed management plan is to first, outline immediate priority next steps that should be taken to implement the plan, and second, to develop a framework that results in the long-term sustainable implementation of the plan.

10.1 Next Steps

The following next steps should be taken to further the implementation of the Cass River Watershed Management Plan:

- 1. Lower Cass River WMP implementation proposal focused on E. coli impacts:** A recent DEQ evaluation of the lower Cass River identified the need to address E. coli issues and outlined potential sources of pollution to address. The watershed management plan inventory also has identified critical areas within this portion of the watershed and it is clear that addressing bacterial contamination is a high priority. The Cass River in this section is heavily used for recreational purposes and elevated E. coli counts are a major concern for local partners. It is recommended that the lower Cass River be the first priority sub-basin for implementation of the watershed management plan and a proposal should be submitted for funding corrective measures (Chapter 9).
- 2. Upper Cass River WMP implementation proposal:** While the initial priority for implementing the Cass River watershed management plan is the lower Cass River, the Upper Cass River sub-basin should be considered concurrently as a critical priority area. Impacts from agricultural nonpoint source are significant in this sub-basin and have a significant impact on sediment and phosphorus levels in the Cass River system overall. Additionally, livestock operations have a significant effect on E. coli levels in this sub-basin leading to several subwatersheds being listed as non-attaining waterbodies. Funding should be sought to implement the watershed management plan for this sub-basin (Chapter 7).
- 3. Middle Cass River WMP implementation proposal focused on Cass River Corridor stream bank erosion:** Much of the middle Cass River sub-basin centers around the Cass River corridor. A streambank erosion inventory conducted as part of the watershed management plan highlights the need for addressing streambank erosion throughout the corridor. Agricultural sources of erosion are also a contributor to water quality

problems in this sub-basin. It is recommended that funding be sought through the Great Lakes Soil Erosion and Sedimentation Control grants program to address these issues (Chapter 8).

- 4. Middle Cass River WMP Forestry Initiative:** A second priority in the middle Cass River sub-basin is management of extensive forested areas. Currently, the Michigan Forest Association is working to set up a Forest Owners Network in the Cass River Watershed to provide technical assistance to private forest landowners to better manage their resource. Every effort should be made to coordinate and support this effort including seeking financial resources to implement this initiative (Chapter 5).

- 5. Local Agency Action Summaries:** Watershed management plans provide a lot of site specific information on nonpoint source problem areas, however it is generally presented in a subwatershed context which is not typically how local agencies that would utilize this information are used to receiving it. In order to bridge this information sharing gap in the Cass River Watershed local agency action summaries of the site specific information need to be developed for the county health departments, drain commissioners, road commissions, and conservation districts to highlight priority sites for them to address. These action summaries were not part of the initial scope of the watershed management plan and funding will need to be sought to develop them. Once developed, they can be presented to the participating county agencies for discussion on how to best implement corrective measures to address the priority sites (Chapter 4 and priority areas from Chapters 7-9).

- 6. Digital Parcel Mapping Layer Development for Tuscola and Sanilac Counties:** The ability to digitally map information at the parcel layer is important in developing a detailed understanding of critical areas for restoration. It allows organizations implementing a watershed management plan to develop targeted outreach to specific landowners on specific issues. For example, if information on septic system permits can be prioritized for potential risk of failure and overlaid onto a parcel mapping layer, a list of critical homeowners can be generated for outreach and education on their septic systems that may be at risk.

In the Cass River only Tuscola and Sanilac Counties do not have digital parcel mapping. Currently, Tuscola County has expressed interest in developing this information and is evaluating various options to create this data layer. All efforts should be made to support their efforts and begin working with Sanilac County to determine their level of interest.

- 7. Septic System Database Management:** Most Local health departments have their septic system permit information in hard copy files. To be integrated into a mapping system to evaluate critical areas for septic systems this information must be put into a digital format using a database. In the Cass River Huron and Tuscola Counties have a database and are beginning to put these files into this system, however resources are extremely limited and additional funding is necessary to fully convert this information. Sanilac, Saginaw, and Genesee health departments do not have a database with this information in it, and would need funding to purchase a database and for staff time to input this information into their system. Once this information is in digital form it can be used to do a more detailed evaluation of critical areas for high risk septic systems.
- 8. Natural Resources and Recreation Plan:** The Cass River was initially considered for potential inclusion into the Michigan Natural Rivers program because of its beautiful forested river corridor. Several State wildlife game areas dot the landscape along the Cass River corridor which then enters into the Saginaw River in the Shiawassee National Wildlife Refuge. This corridor remains heavily forested and relatively natural. Protecting this corridor and expanding natural resource protection into adjacent tributaries is essential to the long term sustainability of water quality in this system. Resources were not available with the watershed management planning effort to fully evaluate and develop a strategy to protect the unique natural resources in the Cass River. It is a key priority that a Natural Resources and Recreation Plan be developed for this system that includes updating of the state wildlife game area master plans, prioritization of areas for protection at the parcel mapping level, and an evaluation of recreational access and use for the watershed (Chapter 5).
- 9. Stormwater Management Plans:** While most of the communities in the Cass River Watershed are relatively small and are not of a size requiring a municipal stormwater permit, they still have an impact on water quality in this system. Developing a plan to improve management of their stormwater and incorporating these concepts into local ordinances would ensure that a framework was in place to minimize impacts from urban sources in the watershed. Funding should be sought to develop individualized stormwater management plans for the urban communities (Village of Cass City, City of Caro, City of Marlette, City of Vassar, Village of Millington, City of Frankenmuth, and Bridgeport Charter Township) in the watershed (Chapter 4).
- 10. Data gap monitoring:** Water quality data is collected on a regular basis throughout the Cass River Watershed system. This plan outlines some of the data gaps that should be further evaluated. In addition, a thorough data gap analysis should be done with the

concept of developing a comprehensive monitoring strategy for the watershed. Once completed, a discussion with monitoring organizations should be coordinated to fully vet the information and determine how best to monitor the system long term (Chapter 3).

11. Upper Cass River Wetland Restoration Initiative: The upper Cass River sub-basin is almost exclusively agricultural in land use. Much of this area used to be wetland and provided the entire system with ecological benefits. There has been a 78% loss of wetlands in this area. Long-term restoration of the Cass River will benefit from wetland restoration in upper Cass River. This transition will be very difficult and expensive. A wetland restoration initiative should be started to identify and restore critical wetland functions in this sub-basin. Developing a parcel mapping layer for Sanilac County is a starting point for this initiative. Using the Landscape Level Wetland Functional Analysis and overlaying parcel layer data would allow the generation of a priority land owner list for a targeted outreach strategy on these issues. Once this targeted strategy is developed funding should be sought to implement a wetland restoration initiative in the upper Cass River sub-basin (Chapter 5 and Chapter 7).

10.2 Sustainability Strategy

A watershed management plan is intended to be implemented over time. In order to ensure adequate progress is being made toward implementation there needs to be a process to sustain these efforts. Below are elements of a strategy to sustain the implementation of the Cass River Watershed Management Plan:

- 1. Local watershed groups (Upper Cass River - Sanilac Watershed Advisory Committee; Lower/Middle Cass River - Cass River Greenways Committee):** Currently there are two primary local watershed groups that coordinate activities in the watershed. The Sanilac Watershed Advisory Committee is an advisory group to the Sanilac Conservation District on watershed management issues in Sanilac County. The geographic area that they cover corresponds closely to the Upper Cass River watershed, and this group would be a strong local advocate for activities to improve this watershed. The Cass River Greenways Committee is focused currently on the main Cass River corridor, but is coordinating various activities in the lower and middle Cass River corridor. These local watershed groups should act as the local driver for spurring action on the implementation and further development of the plan.
- 2. Annual Watershed Plan Audit:** One mechanism that the local watershed groups should consider is developing an annual audit that they can conduct in conjunction with DEQ

and local agencies to determine the status of progress on implementation of the plan. It would be helpful to have the audit criteria developed at the beginning of the year and mutually agreed upon by all organizations and agencies so that they can include them as part of their annual work plans.

- 3. Annual Cass River Watershed Summit:** Another mechanism for local watershed groups to continue implementation of the watershed management plan is to host an annual watershed summit. The summit provides an opportunity for organizations and agencies working on improving the watershed to talk about what they've done during the year. It is also a point of accountability.
- 4. Annual Cass River Watershed Awards:** At the summit and other times during the year it is important to recognize people and organizations for their contribution to your efforts. Not only do these recognitions provide a sense of accomplishment for the one receiving the award, but often these simple recognitions help to generate interest from other partners and provide justification within organizations for continued support.
- 5. 5 year plan update:** A longer term mechanism for local watershed groups to ensure the sustainability of their watershed management plan is to revisit the identified priorities periodically. The five year mark is about the half-way point for the implementation timeline and provides enough time to assess improvements to date, and evaluate gaps in the plan or changes in priorities.
- 6. Volunteer Monitoring:** Keeping local people involved in the process over the long haul is critical to success. Volunteer monitoring not only provides a way to fill data gaps and maintain good background knowledge of your watershed, but it also provides an opportunity for people to get out and participate in protecting the watershed. DEQ currently provides grant opportunities for these activities.
- 7. Volunteer Clean-up:** Another way to keep people focused on the river is to host volunteer clean-up days. The Cass River Greenways Committee has done this for the past several years and they have been very successful at generating interest and good public relations.
- 8. Recreational Activities:** Finally, one of the great benefits of a river system is recreational opportunity. Canoeing, boating, fishing, swimming, birding are all ways to get people out and active in the protection of the natural resource. Continued emphasis on developing, improving, and promoting access to the Cass River is a critical piece to maintaining local interest.

Many local, state, and federal agencies are available for assistance in implementing this plan and regularly attend the Cass River Greenway Committee and the Sanilac County Watershed Advisory Committee. The watershed management plan belongs to everyone and any committed organization or entity may take forward the initiatives set forth in this plan.