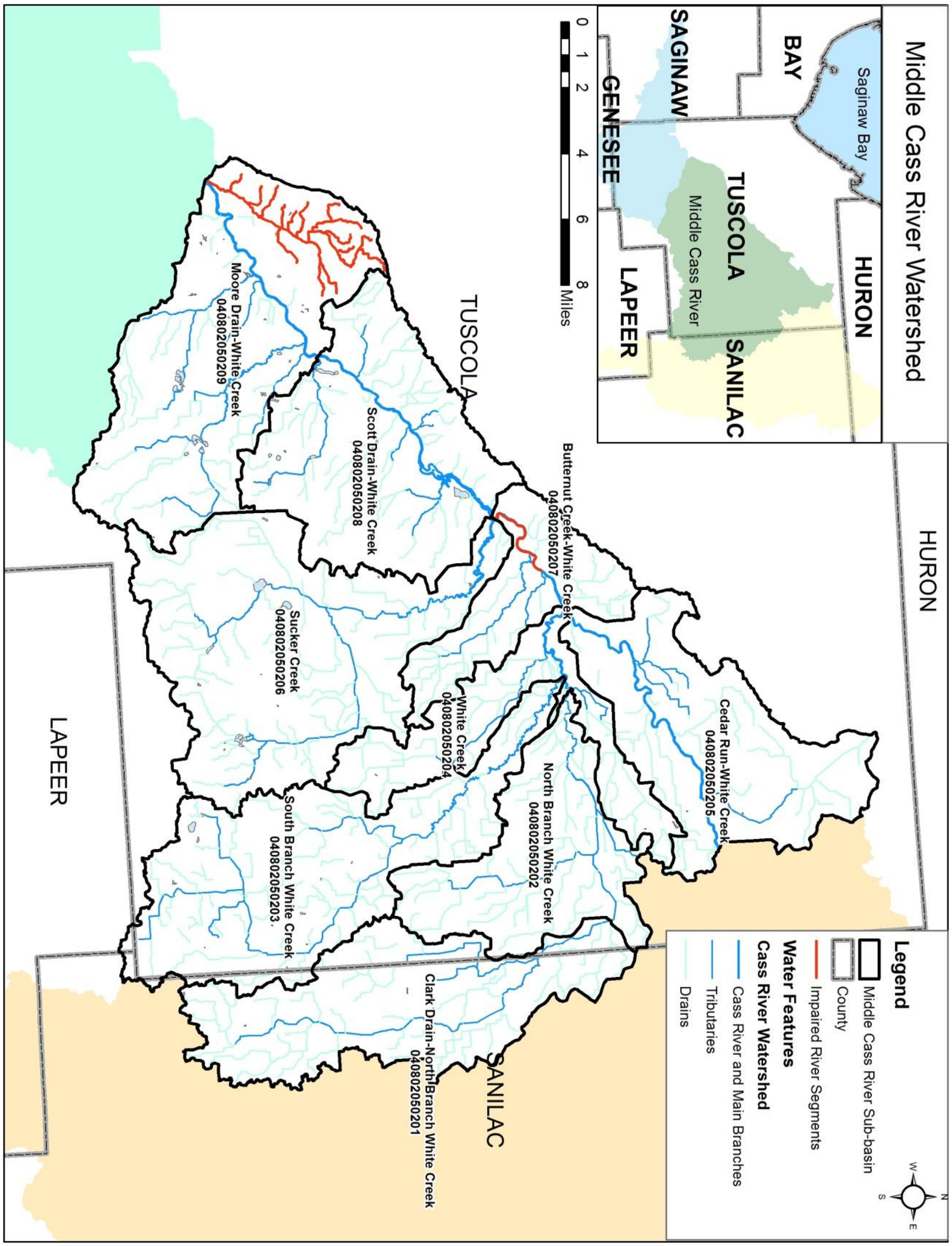
**Chapter 8: Middle Cass River**

*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 Middle Cass Sub-Watersheds**

| 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)

| Middle Cass River Sub-basin | Impaired Uses per MDEQ in-stream surveys | Potentially Impacted | Notes |
|---|---|---|---|
| **2012 Integrated Report (IR)** | | | |
| **10-HUC:0408020502** | Fish Consumption | | PCB's in Water Column; 2013 TMDL |
| **Clark Drain** | | | |
| **AUID: 040802050201-01** | Not assessed by MDEQ | Total and partial body contact | Extensive Ag NPS problems per 2011 Inventory |
| **Cedar Run White Creek** | | | |
| **AUID: 040802050205-01** | Total and partial body contact were not assessed, other uses listed as fully supporting by MDEQ | Warmwater fishery | Extensive streambank erosion per 2011 Inventory |
| **Butternut Creek*** | | | |
| **AUID: 040802050207-01** | Warmwater fishery | | 2008 TMDL for Dissolved Oxygen, Aquatic Plants (Macrophytes), and Sedimentation/Siltation |
| **Scott Drain** | | | |
| **AUID: 040802050208-01** | Total and partial body contact were not assessed, other uses listed as fully supporting by MDEQ | Warmwater fishery | Extensive streambank erosion per 2011 Inventory |
| **Moore Drain*** | | | |
| **AUID: 040802050209-03** | Other indigenous aquatic life and wildlife | | Direct habitat alterations, Other flow regime alterations |

**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)<br>Dissolved Oxygen | 1. Agriculture<br>2. Streambank erosion (threat) |
| **Moore Drain-White Creek** | Other Indigenous Aquatic Life and Wildlife | Direct Habitat Alterations<br>Other flow regime alterations | 1. Channelization<br>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.

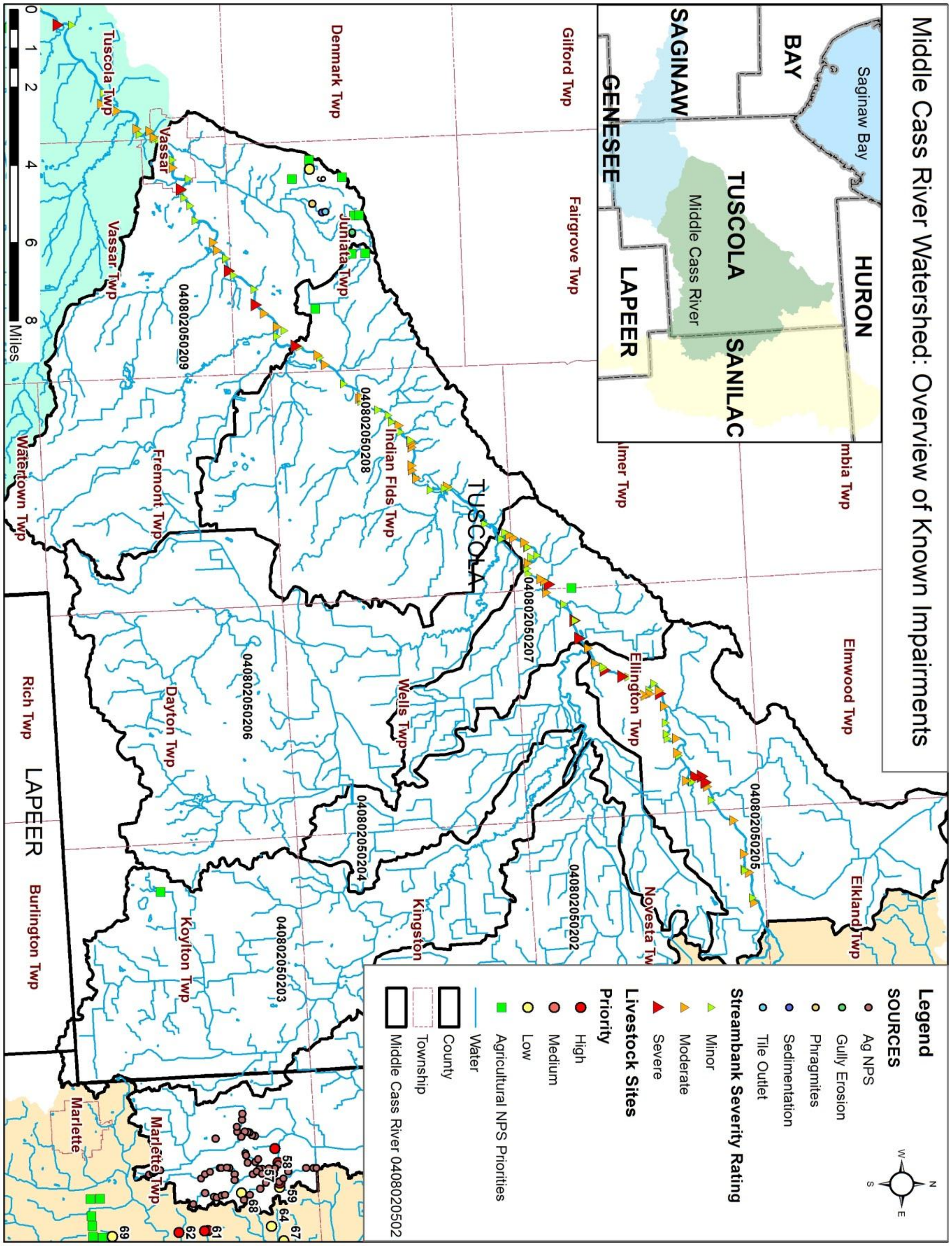
The 2011 In-stream survey results are those sites identified while conservation district staff were wading stretches of impaired waterways. Impairment locations were delineated by sources. Sources identified in the Upper Cass River include gully erosion, livestock access, stream crossing (eroding), streambank 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 | 1,340 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.

<u>Priority 1: Streambank erosion</u>

*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/ft$^3$, when this is divided by 2000 lbs/Ton the conversion factor of 0.055 Tons/ft$^3$ 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 | 1,750 | 1,925 | 3,850 |
| **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 | 4,500 | 4,950 | 9,900 |
| **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 | 1,933 |
| **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 |
| **68** | 1 | 8 | 40 | 1:1 | Bank Eroding, Toe Unstable, Undercutting, deflection, high water, roots exposed | Minor | 20 | 22 | 44 |

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| **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 | 1,031 | 2,062 |
| **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 | 81.3 | 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 |
| **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 | Moderate | 187.5 | 206.3 | 412.5 |

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | exposed | | | | |
| **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 | 1,750 | 1,925 | 3,850 |
| **715** | NR | NR | NR | NR | Agricultural Runoff, Illicit discharge, Tiles,<br>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 |

**Figure 8.3 Butternut Creek Impairments**

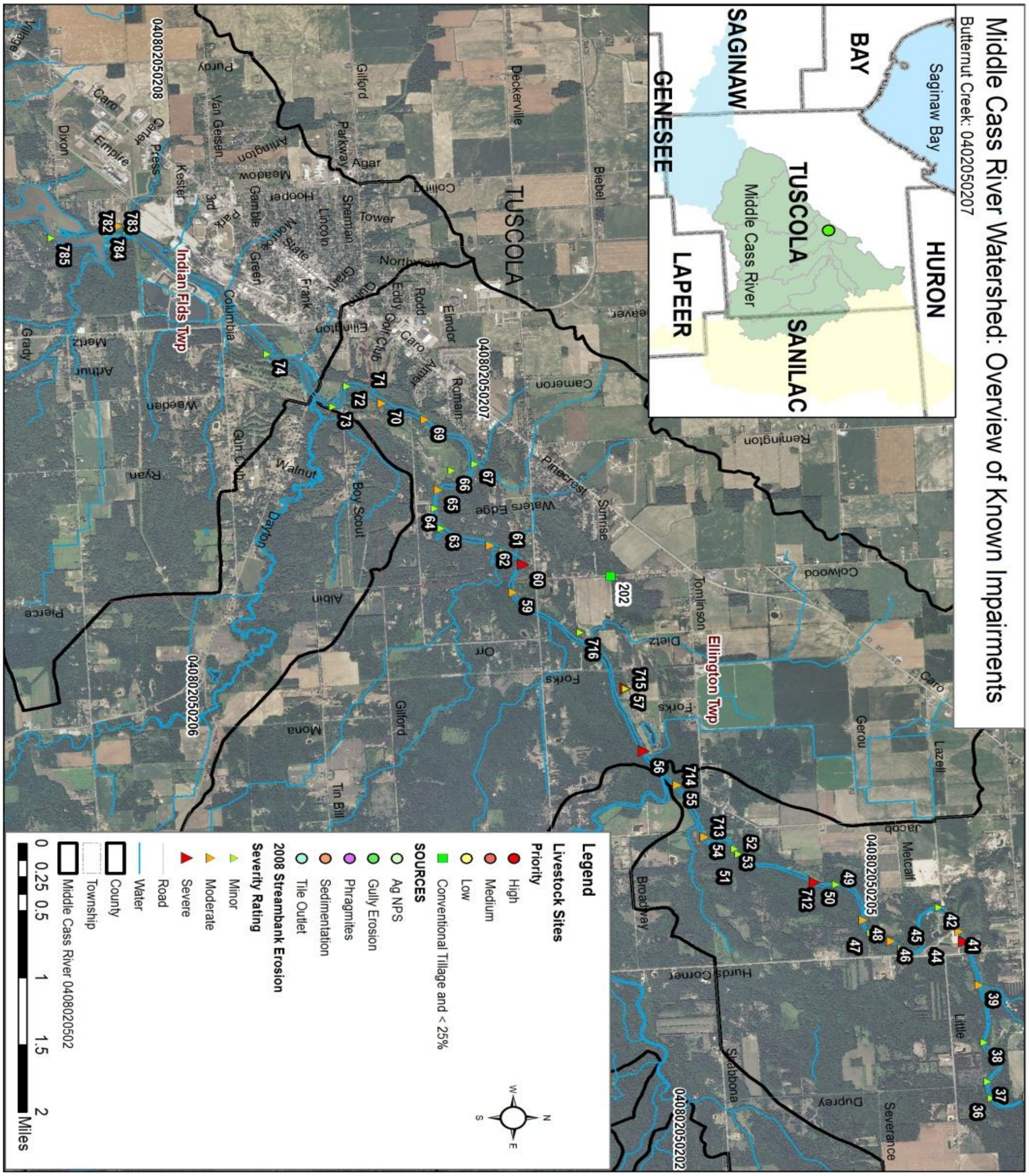


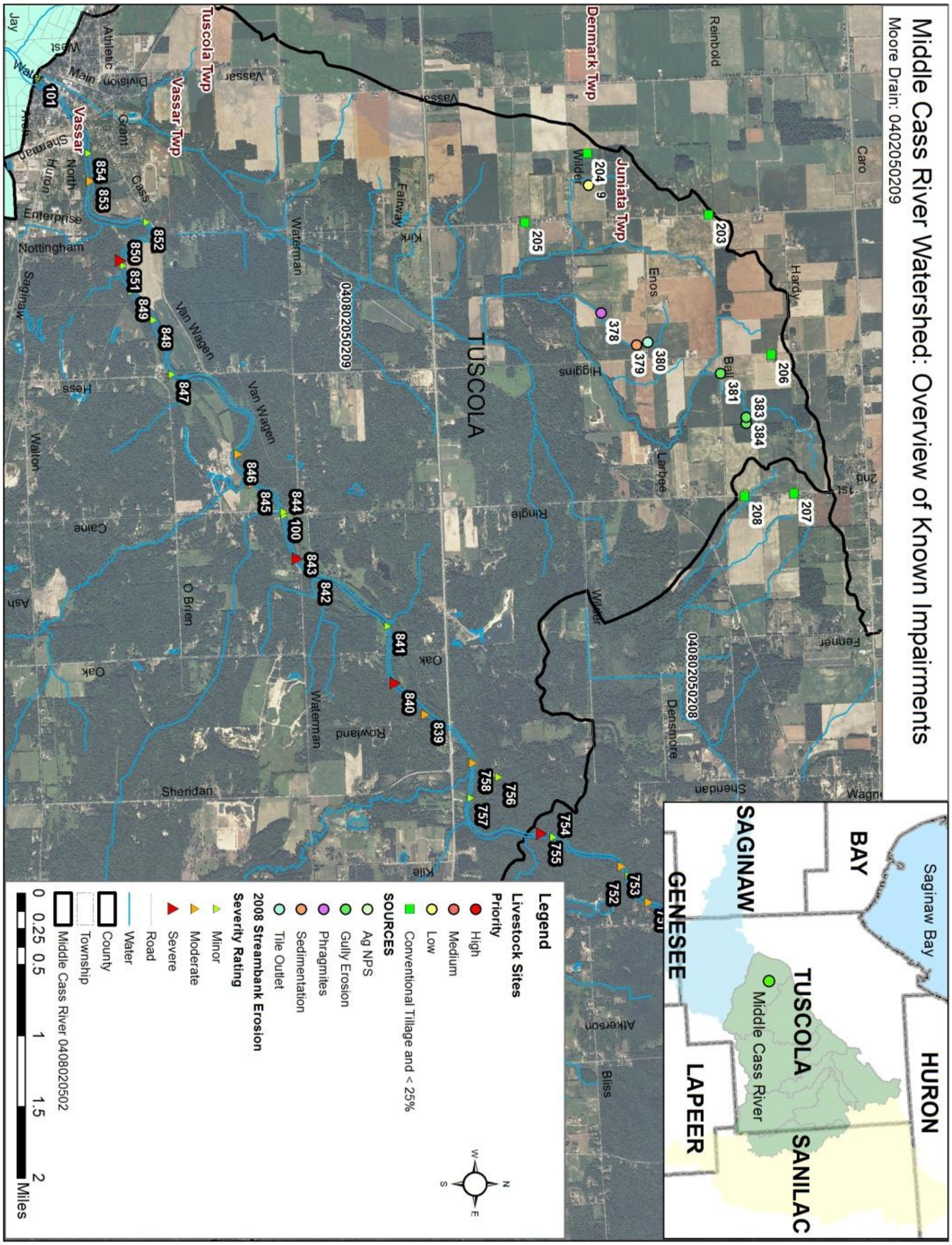
**Table 8.6 Moore Drain impairments from Streambank erosion**

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| **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 | 281.3 | 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 | 229.7 | 252.7 | 505.3 |
| **841** | 2 | 6-7 | 40 | 1:1 | Bank Eroding, River Bend, toe stabilizing; natural run-off; beginning of riverbend | Minor | 32.50 | 35.8 | 71.5 |
| **842** | 2 | 5-10 | 200 | 1:1 | Bank Eroding, Sediment Dropped, high water<br>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 | 39.4 | 43.3 | 86.6 |

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| **847** | 2 | 4-5 | 60 | 1:1 | Bank Eroding, Toe Unstable, Undercutting, River Bend, high water | Minor | 33.8 | 37.1 | 74.3 |
| **848** | 1.5 | 5 | 40 | 1:1 | Bank Eroding, Toe Unstable, Sediment Dropped, high water, left bank 65ft | Minor | 18.8 | 20.6 | 41.3 |
| **849** | 1.5 | 10 | 90 | 1:1 | Bank Eroding, Toe Unstable, Trampled, Foot Traffic, Sediment Dropped, high water | Minor | 84.4 | 92.8 | 185.6 |
| **850** | 2 | 5 | 30 | 2:1 | Bank Eroding, River Bend, Sediment Dropped, high water; big river bend, toe stabilizing | Minor | 18.8 | 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 | 6.6 | 7.2 | 14.4 |
| **758** | 1.5 | 10 | 65 | 1:1 | Bank Eroding, Toe Stable, Undercutting, Sediment Dropped, high water | Moderate | 60.9 | 67.0 | 134.1 |
| **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 |

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| **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<br>foot path above bank | Moderate | 128.9 | 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 |
| **840** | 1 | 5-25 | 400 | 1:1 | Bank Eroding, Toe Unstable, Undercutting<br>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,<br>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; residence/camp above bank; wood stains put into bank | Severe | 234 | 257 | 515 |

**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 | 112.5 | 123.8 | 247.5 |
| **20** | 1.5 | 20 | 50 | 2:1 | Bank Eroding, Toe Stable, Seepage | Minor | 93.8 | 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 | 56.3 | 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 |
| **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 | Minor | 6,000 | 6,600 | 13,200 |

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | river | | | | |
| **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<br>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 | 26.3 | 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 |
| **53** | 2.5 | 10 | 75 | 1:1 | Bank Eroding, Toe Stable, Sediment slump, Deflection, exposed roots, veg re-growing | Minor | 117.2 | 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 |

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| **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 | 103.1 | 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 |
| **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 | 131.3 | 144.4 | 288.8 |
| **27** | 2 | 15-20 | 60 | 1:1 | Undercutting, high water | Moderate | 131.3 | 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 | 1,335.9 | 1,469.5 | 2,939.1 |

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| **34** | 1.5-2 | 20 | 110 | 1:1 | Bank Eroding, winter damage not much vegetation on bank due to shade cover | Moderate | 240.6 | 264.7 | 529.4 |
| **35** | 1.5 | 45-50 | 120 | 1:1 | Bank Eroding, River Bend,s ediment fell in large area several trees down. Possible human activity (trash site) above bank | Moderate | 534.4 | 587.8 | 1,175.6 |
| **39** | 1.5 | 7 | 75 | 1:1 | Undercutting, Seepage | Moderate | 49.2 | 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<br>drainage | Moderate | 75 | 82.5 | 165 |
| **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<br>River Bend, Road above, Trees & sediment falling in road above on top of bank. Cut-bank | Moderate | 837.5 | 921.3 | 1,842.5 |
| **46** | 1 | 8 | 110 | 1:1 | Bank Eroding, Toe Unstable, Undercutting,<br>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,<br>Seepage, high water, trees slanting in | Moderate | 106.3 | 116.9 | 233.8 |

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| **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 |
| **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<br>River Bend, Seepage, Sediment fell in<br>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 | 843.8 | 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 | 1,012.5 | 1,113.8 | 2,227.5 |
| **50** | 2 | 30 | 500 | 1:1 | Bank Eroding, Toe Stable, Undercutting, high water, Sediment slump, roots exposed | Severe | 1,875 | 2,062.5 | 4,125 |
| **51** | 1.5 | 35 | 180 | 2:1 | Bank Eroding, Toe Unstable, Undercutting,<br>River Bend, water flow | Severe | 590.63 | 649.7 | 1,299.4 |

## Figure 8.5 Cedar Run Impairments

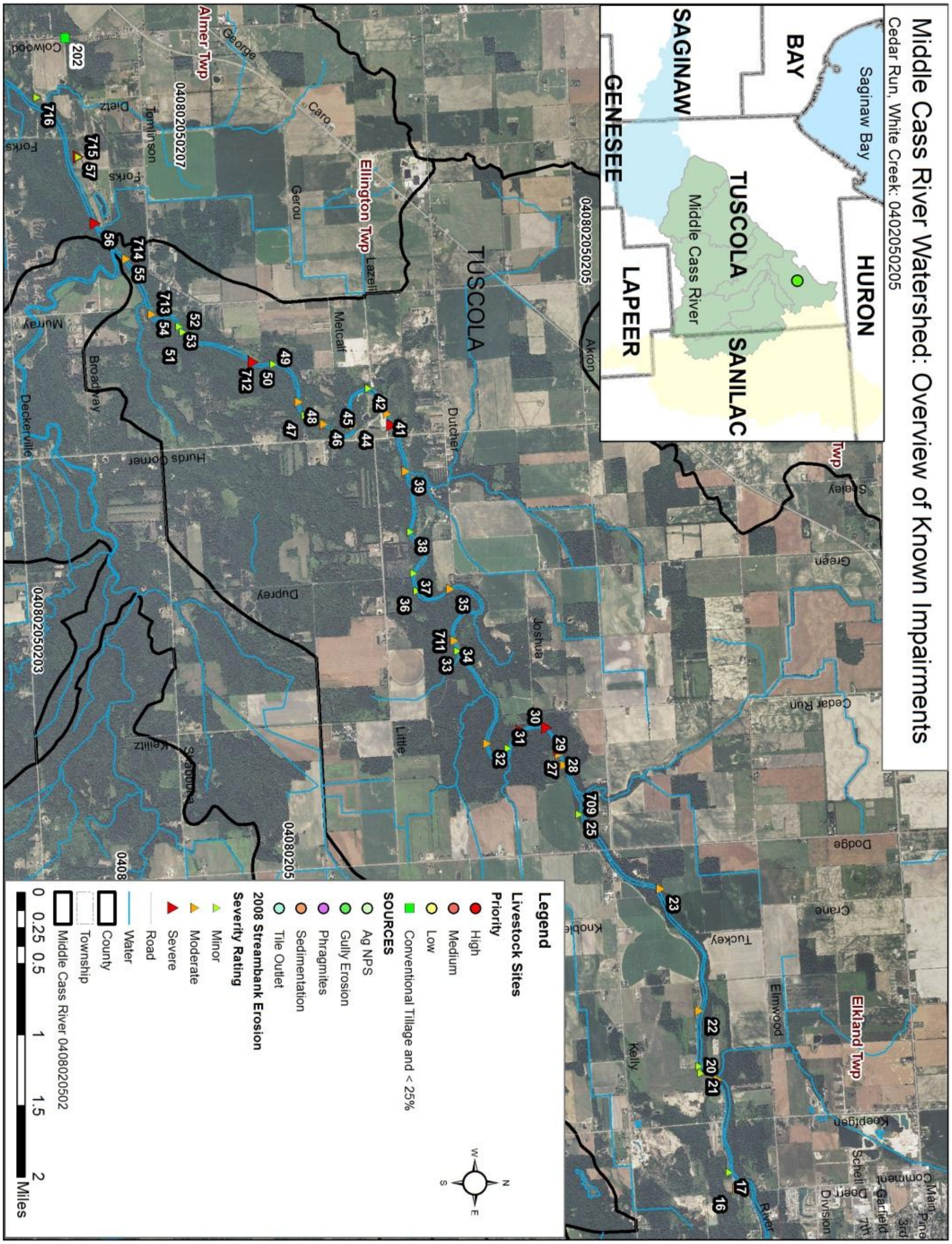


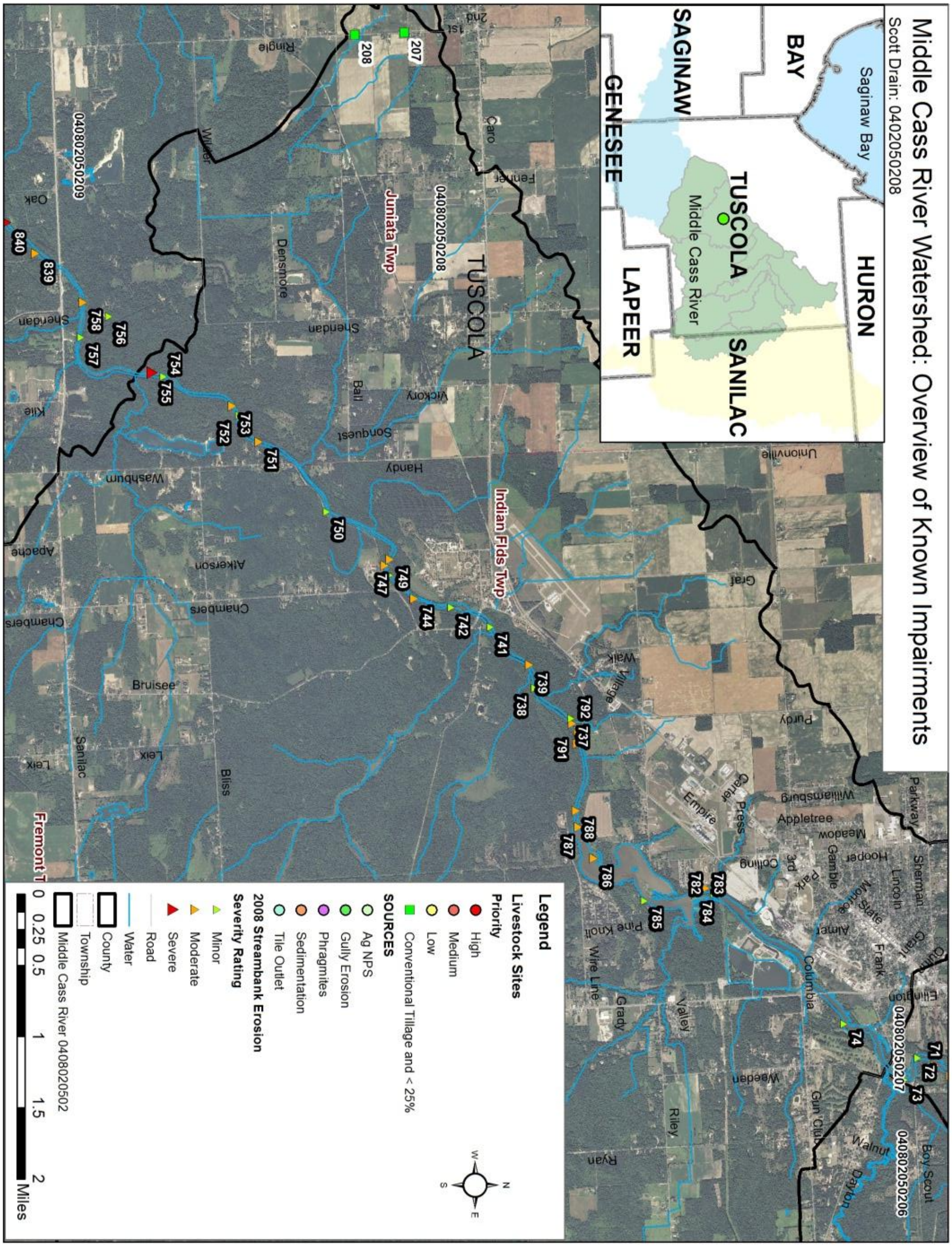
**Table 8.8 Scott Drain impacts from Streambank erosion**

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| **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 | 39.8 | 43.8 | 87.7 |
| **740** | 1 | 5 | 125 | 1:1 | Bank Eroding, Toe Unstable, River Bend, Sediment Dropped, high water | Minor | 39 | 43 | 85.9 |
| **741** | 1.5 | 6 | 50 | 1:1 | Bank Eroding, Toe Unstable, Undercutting, high water-residence above bank | Minor | 28.1 | 30.9 | 61.9 |
| **742** | 1 | 8-10 | 60 | 1:1 | Bank Eroding, Toe Stable, Sediment Dropped, high water, animal traffic | Minor | 33.8 | 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 | 106.3 | 116.9 | 233.8 |
| **750** | 2 | 8 | 50 | 1:1 | Bank Eroding, Toe Unstable, Undercutting, River Bend, deflection/pool; high water, roots exposed | Minor | 50 | 55 | 110 |

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| **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 | 11.3 | 12.4 | 24.8 |
| **784** | 1 | 3 | 80 | 1:1 | Undercutting, roots exposed | Minor | 15 | 16.5 | 33 |
| **785** | 1 | 5 | 60 | 2:1 | Bank Eroding, Toe Unstable, Trampled, Illicit discharge, Tiles,<br>Foot Traffic, high water<br>residence; private property; mowed to edge; trees falling in; dead tree debris on bank | Minor | 18.8 | 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 Dropped, old cement structure. | Moderate | 90 | 99 | 198 |
| **749** | 2 | 15-20 | 75 | 1:1 | Bank Eroding, Toe Unstable, Undercutting River Bend, Sediment Dropped, deflection, roots exposed | Moderate | 164 | 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 | Moderate | 375 | 412.5 | 825 |

| 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) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | put in stairs, etc. | | | | |
| **753** | 1.5 | 5 | 110 | 1:1 | Bank Eroding, Toe Unstable, Undercutting, Sediment Dropped, high water | Moderate | 51.6 | 56.7 | 113.4 |
| **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 | 9.3 | 10.3 | 20.6 |
| **787** | 1.5 | 7 | 800-1000 | 1:1 | Bank Eroding, Toe Unstable, Undercutting,<br>Sediment Dropped, high water, This portion cannot be traveled from the upstream portion due to dangerous dam portage and no access at dam. | Moderate | 590.6 | 649.7 | 1,299.4 |
| **788** | 1.5 | 10 | 1000 | 1:1 | Bank Eroding, Toe Unstable, Undercutting, Seepage, high water (dam) | Moderate | 937.5 | 1,031.3 | 2,062.5 |
| **789** | 1 | 10 | 450 | 1:1 | Bank Eroding, Undercutting, Sediment Dropped, high water, roots exposed | Moderate | 281.3 | 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 | 1,054.7 | 1160.2 | 2,320.3 |

**Figure 8.6 Scott Drain Impairments**



Priority 2: Livestock Access

*Inventory*

A total of five sites identified during the watershed inventory are impacting water quality in the Clark Drain (Table 8.9). These five sites contain 862 animals and are contributing and estimated 647 pounds of phosphorus per year, 3,951 pounds of nitrogen per year and 4,493 pounds per year of BOD. 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.

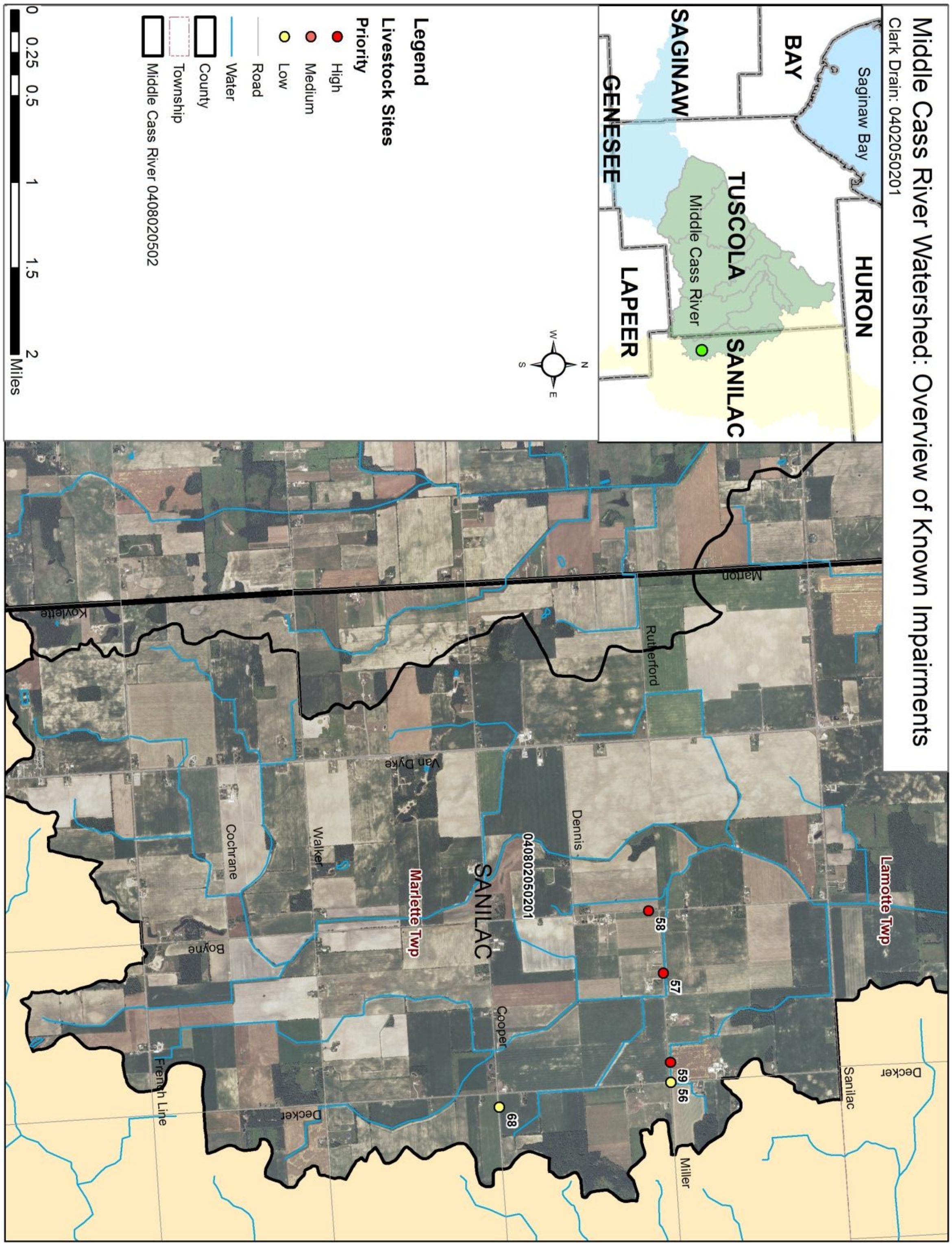
*Summary Table & Map*

**Table 8.9 Clark Drain impairments from livestock access**

| Map Label | UTM-X | UTM-Y | # animals | 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) |
|---|---|---|---|---|---|---|---|---|---|---|
| **57** | 4807411 | 333225 | 250 | Not recorded (NR) | 200 cattle 50 sheep | 1 | 548 | 2,794 | 3,667 | 100% |
| **58** | 4807342 | 332631 | 100 | NR | sheep | 1 | 16 | 189 | 135 | 100% |
| **59** | 4807409 | 33438 | 200 | NR | sheep | 1 | 32 | 378 | 270 | 100% |
| **68** | 480579 | 334379 | 12 | NR | sheep | 3 | 2 | 23 | 16 | 100% |
| **56** | 4807435 | 334246 | 300 | NR | sheep | 3 | 49 | 567 | 405 | 100% |

[1]See 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 $ft^3$ 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 $lbs/ft^3$, when this is divided by 2000 lbs/Ton the conversion factor of 0.055 $Tons/ft^3$ is obtained. With the estimate of $24\ ft^3 \times 0.055\ T/ft^3 \div 2\ yrs = 1\ Ton/Yr$ 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.

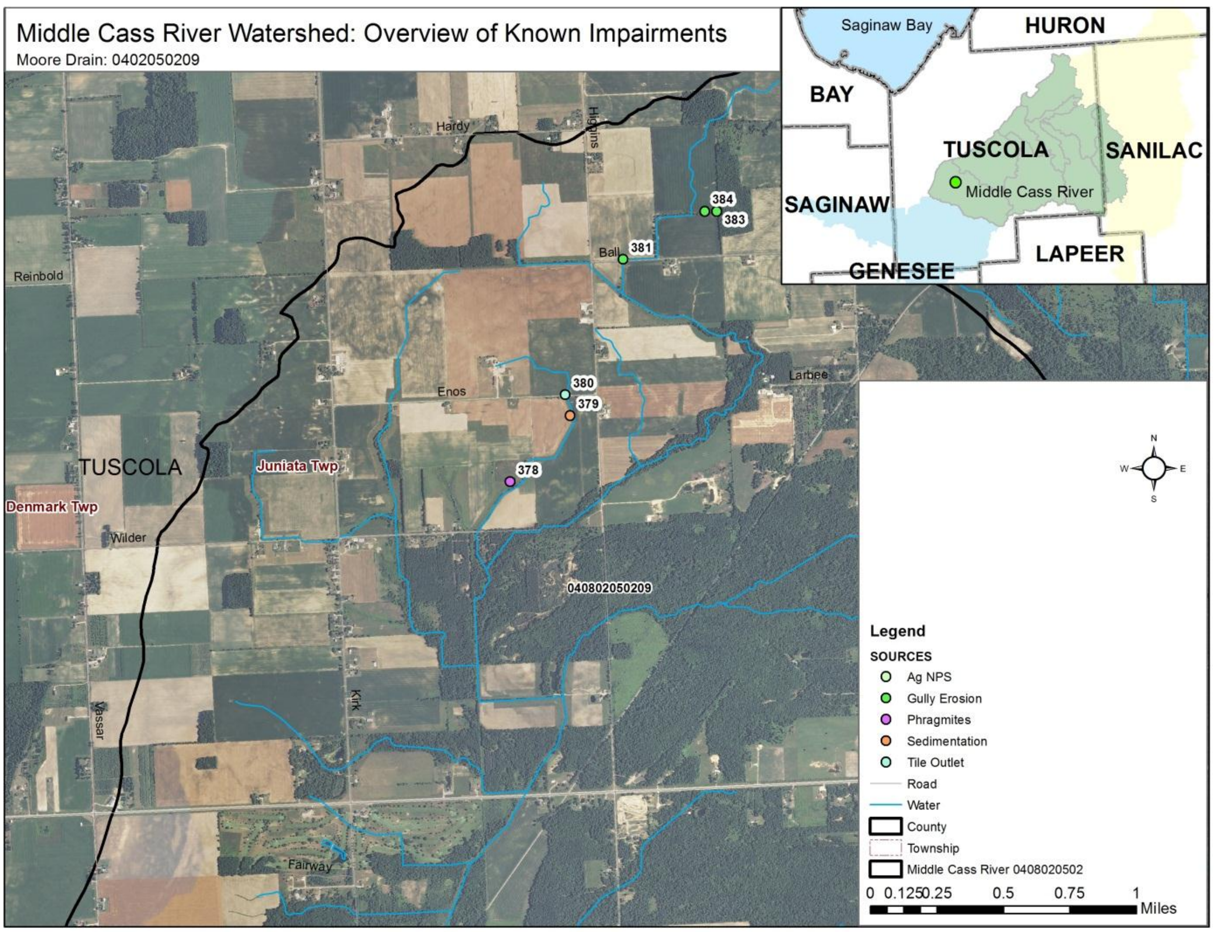
If the site was a nonpoint source of sediment, for example a field draining towards a drain or watercourse, the spreadsheet to determine nutrient and sediment loading would be correlated with the regions of the HIT model and data columns would be added for annual erosion rates and Delivery Ratios. From 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) that were identified during the 2011 field inventory.

**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<br>Table 8.12<br>Table 8.13<br>Table 8.14 |
| Clark Drain-North Branch White Creek | 40802050201 | 25,803 | 107 | 1,340 | Figure 8.10<br>Table 8.15<br>Table 8.16<br>Table 8.17 |

Inventory information verified 7 fields with a total of 430 acres in Moore Drain subwatershed and 107 fields with a total of 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. Load reduction estimates were estimated using the STEPL model assuming that cover crops and reduced tillage practices were being applied to the inventoried sites. STEPL's BMP calculator was used to estimate the combined efficiency of the two BMP's. The HIT model was used to calculate a cost comparison among three BMP types (mulch-till, no-till and 30 feet grass buffers) and the estimated sediment and phosphorous load reductions. 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.

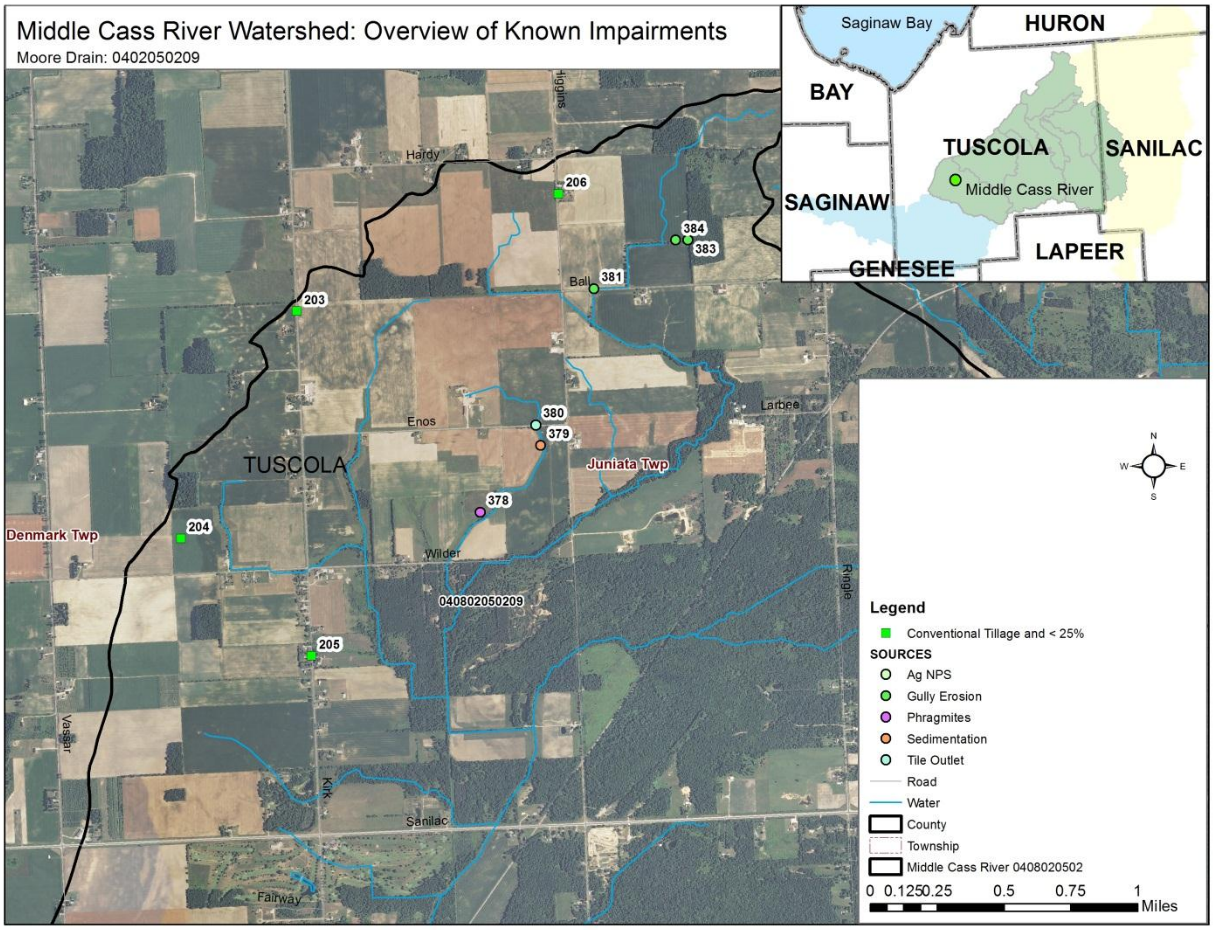
*Summary Tables and Maps*

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 site level utilizing the STEPL Model, results are shown below in Table 8.13 for the Moore Drain subwatershed.

**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 |

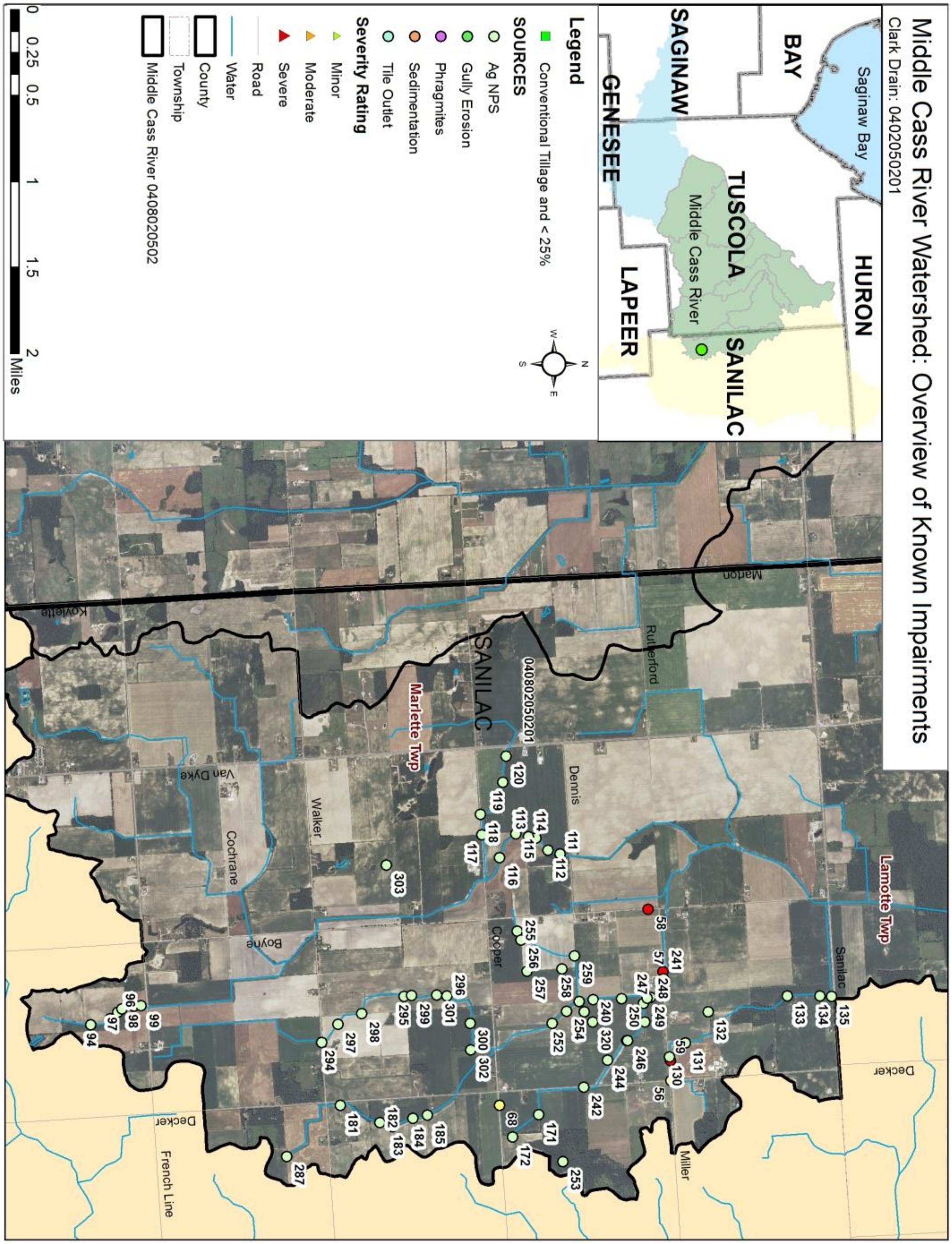
**Table 8.15 Clark Drain Priority Sources of Agricultural Nonpoint Source Pollution**

| 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 | |

**Figure 8.10 Clark 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 site level utilizing the STEPL model, results are shown below in Table 8.16 for the Clark Drain subwatershed.

**Table 8.16 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 8.17 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 8.17 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 8.18).

**Table 8.18 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 | 100% for sites rated severe-moderate 47.9% of total sites (Minor sites are not included in reduction estimates) |
| **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 8.19 shows reductions in annual loadings if vegetated filter strips are used to protect waterways. Table 8.20 shows reductions in annual loadings if waste management systems are used to on high priority sites. Table 8.21 shows reductions in annual loadings if a waste storage facility is used on high priority sites.

**Table 8.19 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 8.20 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 8.21 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 8.22.

**Table 8.22 Implementation Priorities and Management**

| 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** | Streambank Erosion Stabilization | engineering and construction | | *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** | Streambank Erosion Stabilization | engineering and construction | | *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 |
| **Entire 10-digit HUC** | Monitoring Program | Water quality monitoring and analysis | $300 per sample including staff time, each site sampled 5 times | Cass River Greenway Committee | 9 subwatershed sites and 4 on main channel | N/A | $19,500 MiCorps, MDEQ, Local match | MDEQ, EPA |

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 8.23.

**Table 8.23 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 | |
| n/a | Lower Cass River | Monitoring Program | Short term (1-3 years) | Monitoring program to coincide with implementation of priority areas mentioned above | |

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)

**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.

The Cass River Greenway monitoring effort is titled "Cass River Water Quality Monitoring Project", and was funded by State of Michigan Department of Environmental Quality –Water Resources Division-Office of Surface Water Assessment (Project # 2011-0501). The project provides baseline information regarding the main channel of the Cass River. A total of nine sampling sites were included near Cass City, Caro, Vassar, Frankenmuth, and Bridgeport (Table 8.24). Parameters tested at each site include: total phosphorus, total suspended solids, fecal coliform bacteria, nitrates, turbidity, temperature, pH, dissolved oxygen, and biological oxygen demand. A full report of the two-year study is available from Environmental Science Solutions, LLC and online at www.cassriver.org.

**Table 8.24 Sampling Sites for Cass River Water Quality Monitoring Project**

| Site Name | Site ID | Municipality | County | Latitude | Longitude | Watershed |
|---|---|---|---|---|---|---|
| Cemetery Rd. | CC2 | Cass City | Tuscola | 43.5847 | -83.1736 | Cass River |
| Dodge Rd. | CC1 | Cass City | Tuscola | 43.5698 | -83.2321 | Cass River |
| Dayton Rd. | C2 | Caro | Tuscola | 43.4901 | -83.3765 | Cass River |
| Wells Rd. | C1 | Caro | Tuscola | 43.4503 | -83.4401 | Cass River |
| Caine Rd. | V2 | Vassar | Tuscola | 43.3924 | -83.5222 | Cass River |
| Huron Rd. | V1 | Vassar | Tuscola | 43.3712 | -83.5803 | Cass River |
| Bray Rd. | F2 | Frankenmuth | Tuscola | 43.3244 | -83.6572 | Cass River |
| Beyer Rd. | F1 | Frankenmuth | Saginaw | 43.3287 | -83.7584 | Cass River |
| Fort Rd. | B1 | Bridgeport | Saginaw | 43.3486 | -83.8844 | Cass River |

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
- Fecal coliform bacteria
- Total dissolved solids
- Total suspended solids

- pH
- BOD
- Nitrates
- Total Nitrogen
- Total Phosphorus
- Ortho Phosphorus
- Turbidity
- Dissolved oxygen
- Temperature
- Diversity and quantity of macroinvertebrate taxa