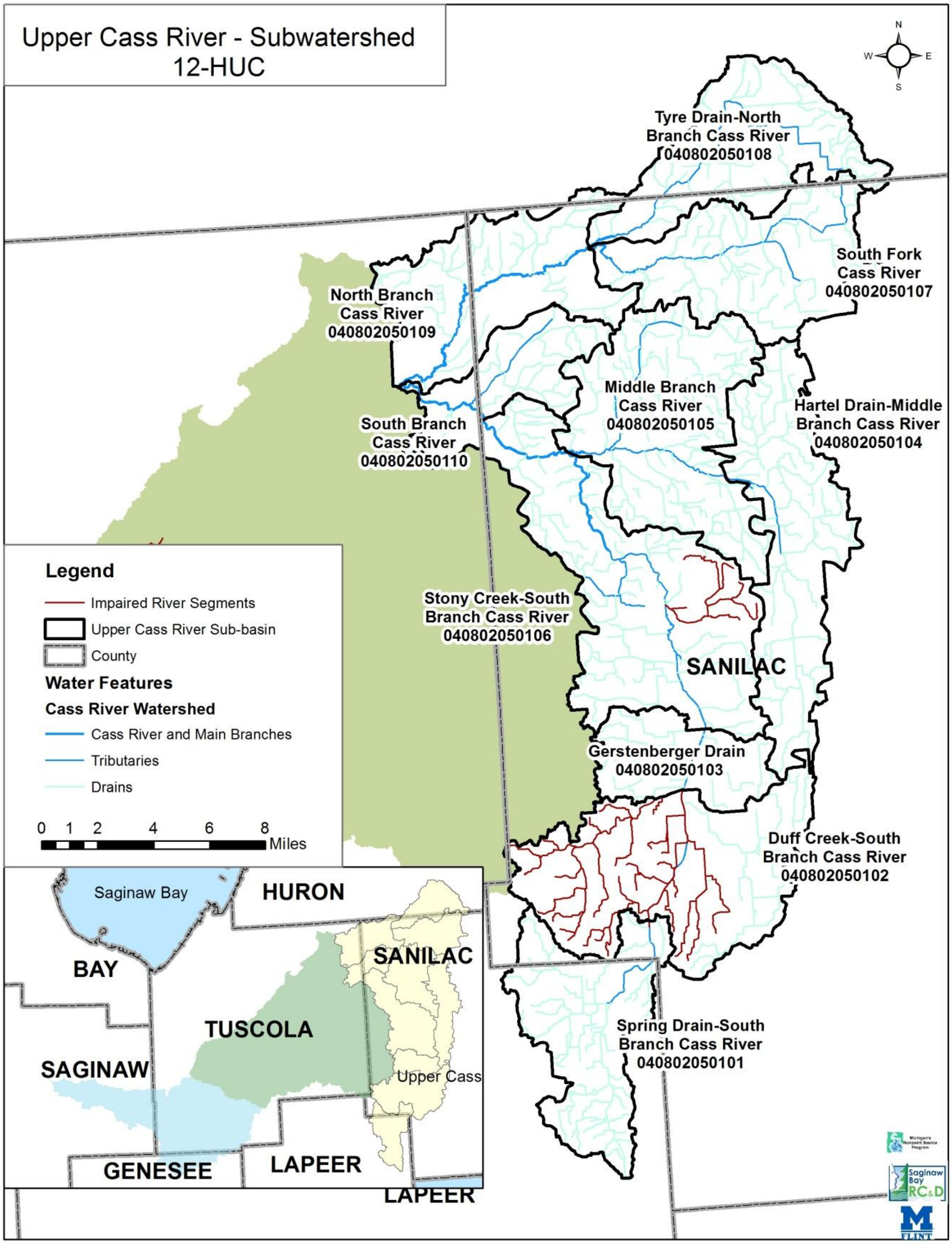
Chapter 7: UPPER CASS RIVER

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.

Table 7.1: Upper Cass River Sub-watersheds			
Sub-watersheds	**Acres**	**Sq. Miles**	**% of Total Watershed**
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)

Upper Cass River Sub-watersheds	**Impaired Uses per MDEQ in-stream surveys**	**Potentially Impacted (Suspected) Uses**	**Notes**
10-HUC: 0408020501	Fish Consumption		Mercury in fish tissue, PCB in Fish Tissue, PCB in water column
Spring Drain			
AUID: 040802050101-01	Total and Partial Body Contact Recreation		2004 TMDL for E. coli; incorrectly listed in 2010 Integrated Report; listed as insufficient information per 2014 Integrated Report
Duff Creek			
AUID: 040802050102-02	Total and Partial Body Contact Recreation		2004 TMDL for E. coli
Gerstenberger Drain			
AUID: 040802050103-01	Total and Partial Body Contact Recreation (2014 IR)		Inventory Data 2011 and listed as impaired in the 2014 IR
Middle Branch Cass River			
AUID: 040802050105-01	Not assessed for Total and Partial Body Contact Recreation	Total and Partial Body Contact Recreation	Inventory Data 2011
Stony Creek*			
AUID: 040802050106-02	Total and Partial Body Contact Recreation		2018 TMDL for E. coli; TMDL listed for 2028 in 2014 Integrated Report
	Other Indigenous Aquatic Life and Wildlife		2028 TMDL for Organic Enrichment in 2014 Integrated Report; Other anthropogenic substrate 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 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 statuses of each designated use 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).

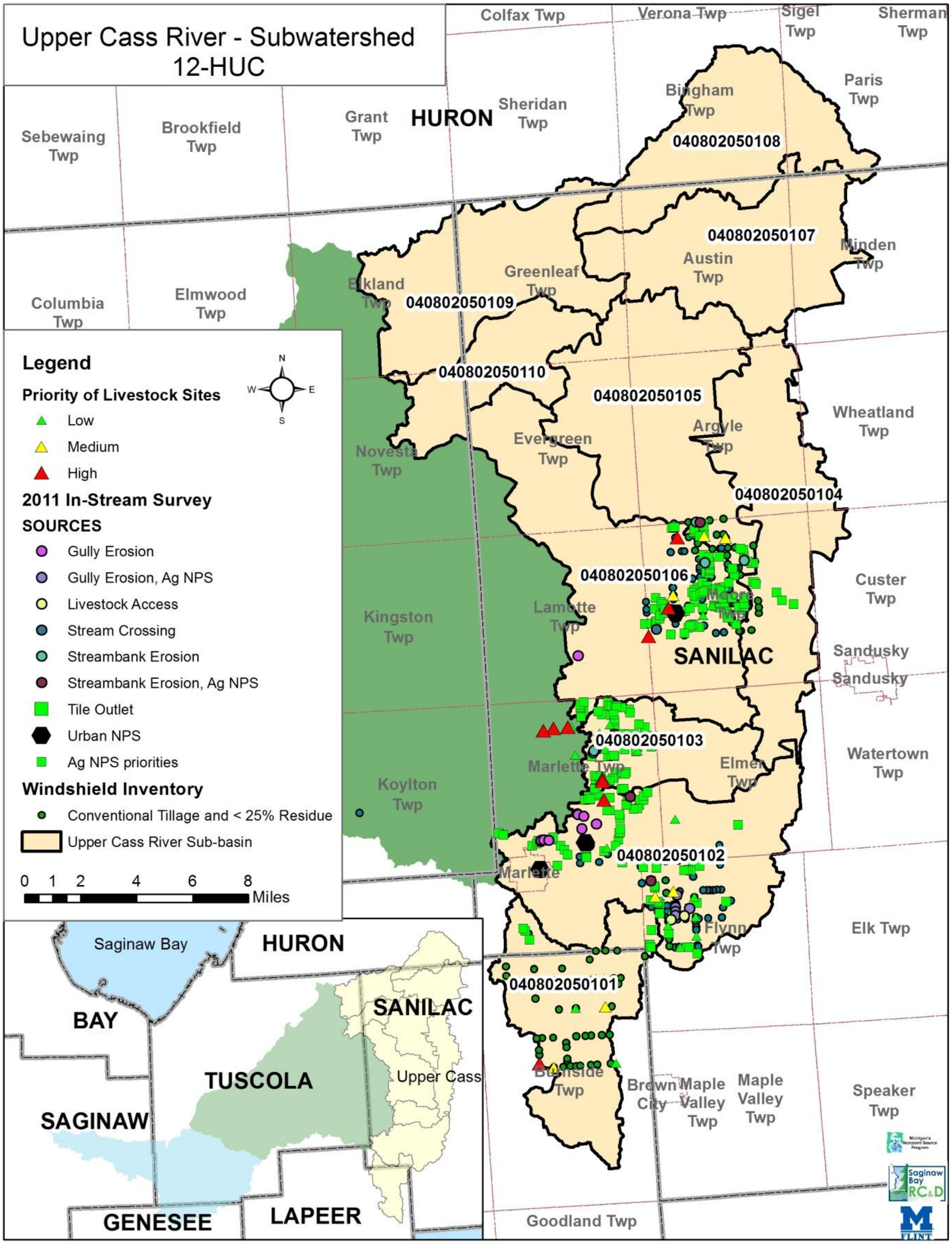
Priority livestock sites were those identified during the 2011 windshield surveys. High priority sites are those where known surface water impairment was observed and pollutant loading estimates could be calculated. Medium priority sites are those where surface water quality impairment is suspected and 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
4	Stony Creek	Conservation Tillage and Cover Crops	Landowner outreach and assistance	4,730 acres	2016-2018	Table 7.13 Figure 7.8

Priority	Sub-shed	Management Measure	Technical Assistance Type	Quantity	Schedule	Site Specific Table and Maps
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.

<u>Priority 1: Livestock access</u>

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 920 pounds of Phosphorous per year, 4,963 pounds of Nitrogen per year, and 6,245 pounds of biological oxygen demand (BOD) per year (Table 7.5). Duff Creek inventory identified 22 sites where livestock are impacting or have the potential to be impacting water quality with an estimated contribution of 1,233 pounds of Phosphorous per year, 9,453 pounds of Nitrogen per year, and 10,051 pounds of biological oxygen demand (BOD) per year (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%

[1]See Appendix C for excel spreadsheet model

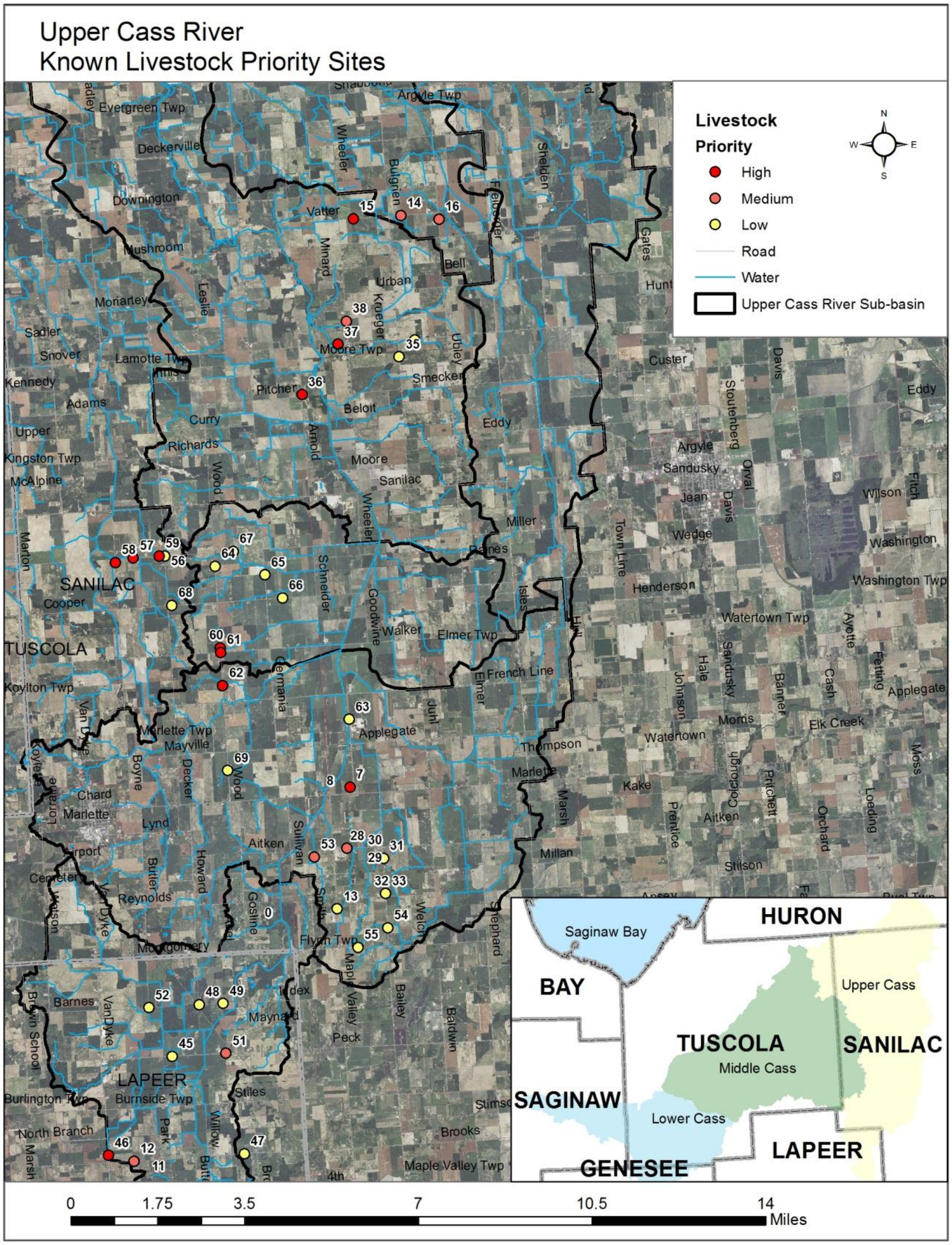
Table 7.6 Duff Creek Impairments from Livestock Access (Sanilac County)

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%
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%
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%

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)
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	43.299783	-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 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 x 0.055 T/ft^3 ÷ 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.

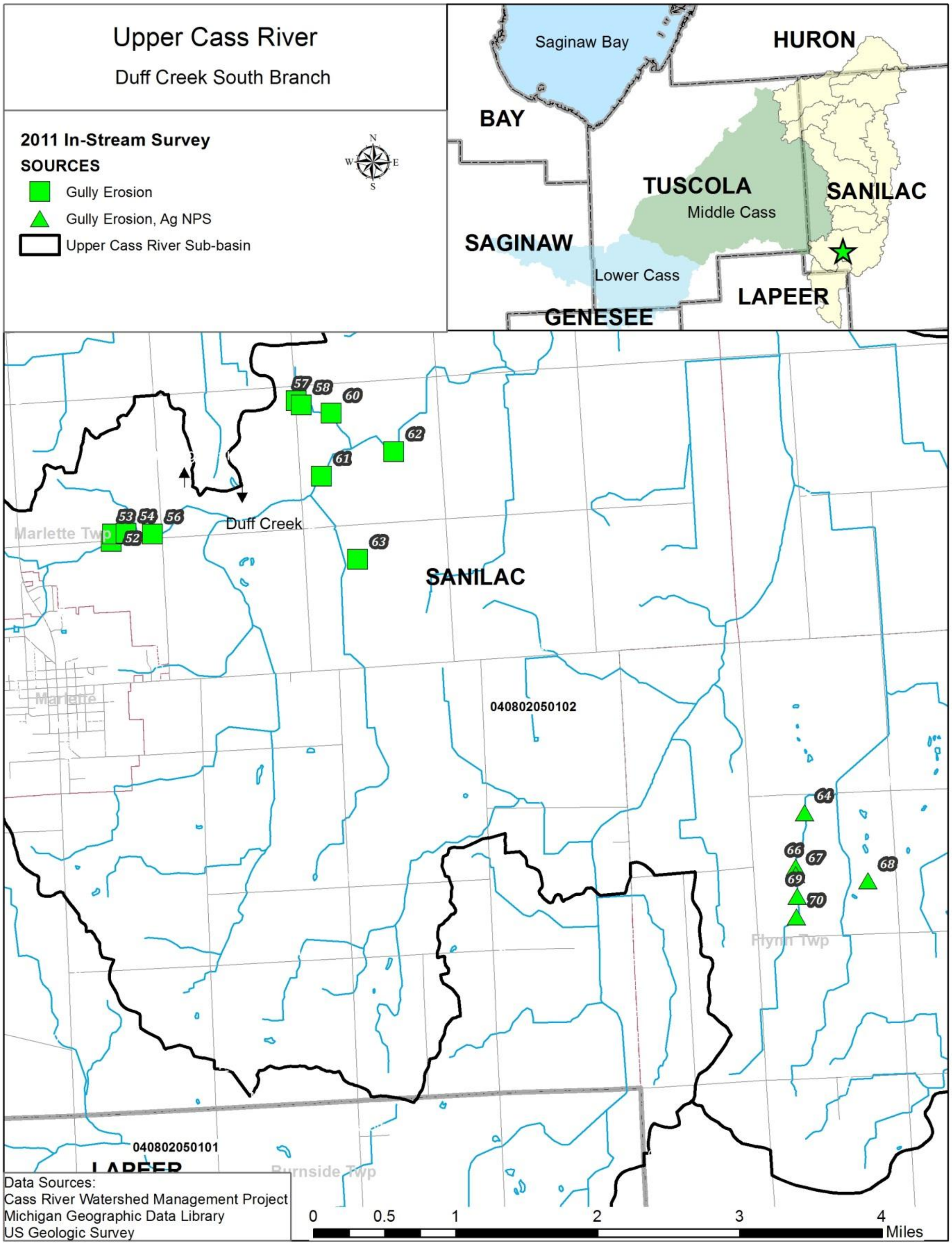
Summary Table

Table 7.7 Duff Creek Gully Erosion Sites

Site #	Latitude	Longitude	[1]Erosion volume (ft3)	Soil weight (tons/ft3)	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/ft^3, when this is divided by 2000 lbs/Ton the conversion factor of 0.055 $Tons/ft^3$ is obtained.

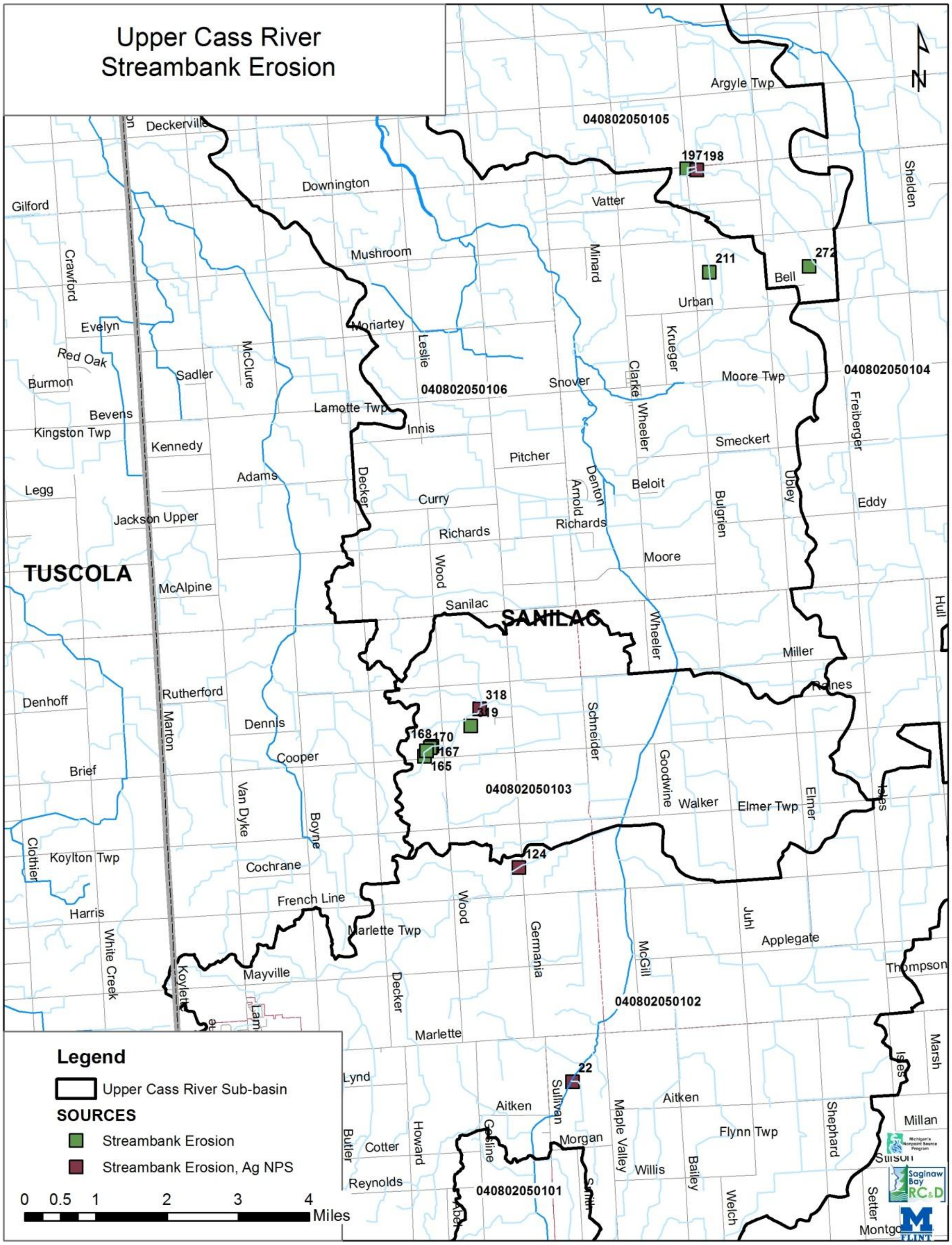
Summary Table

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	0	0	0
319	1000	8	NR	NR	NR	0	0	0
382	30	1	Bare bank w / rills	Top of bank	Storm water outfall	17	18.2	36.3

Summary Map

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.

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	040802050101	19,723	46	2,842	Table 7.10 Table 7.11 Table 7.12 Figure 7.6
Duff Creek	040802050102	31,528	64	3,873	Table 7.13 Table 7.14 Table 7.15 Figure 7.7
Stony Creek	040802050106	36,499	64	4,730	Table 7.16 Table 7.17 Table 7.18 Figure 7.8
Hartel Drain	040802050104	25,056	6	480	Table 7.19 not mapped
Middle Branch	040802050105		27		Low priority, not mapped

Sites that were identified in 2011 as having conventional tillage and 25% or less residue on the field were prioritized as the most likely to cause an impairment to water quality. 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. 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 a subwatershed cost-benefit comparison for three practices based on the assumption of the worst 5% and/or 10% total agricultural area be put into a mulch-till, no-till and 30-feet grass buffers.

Summary Tables and Maps

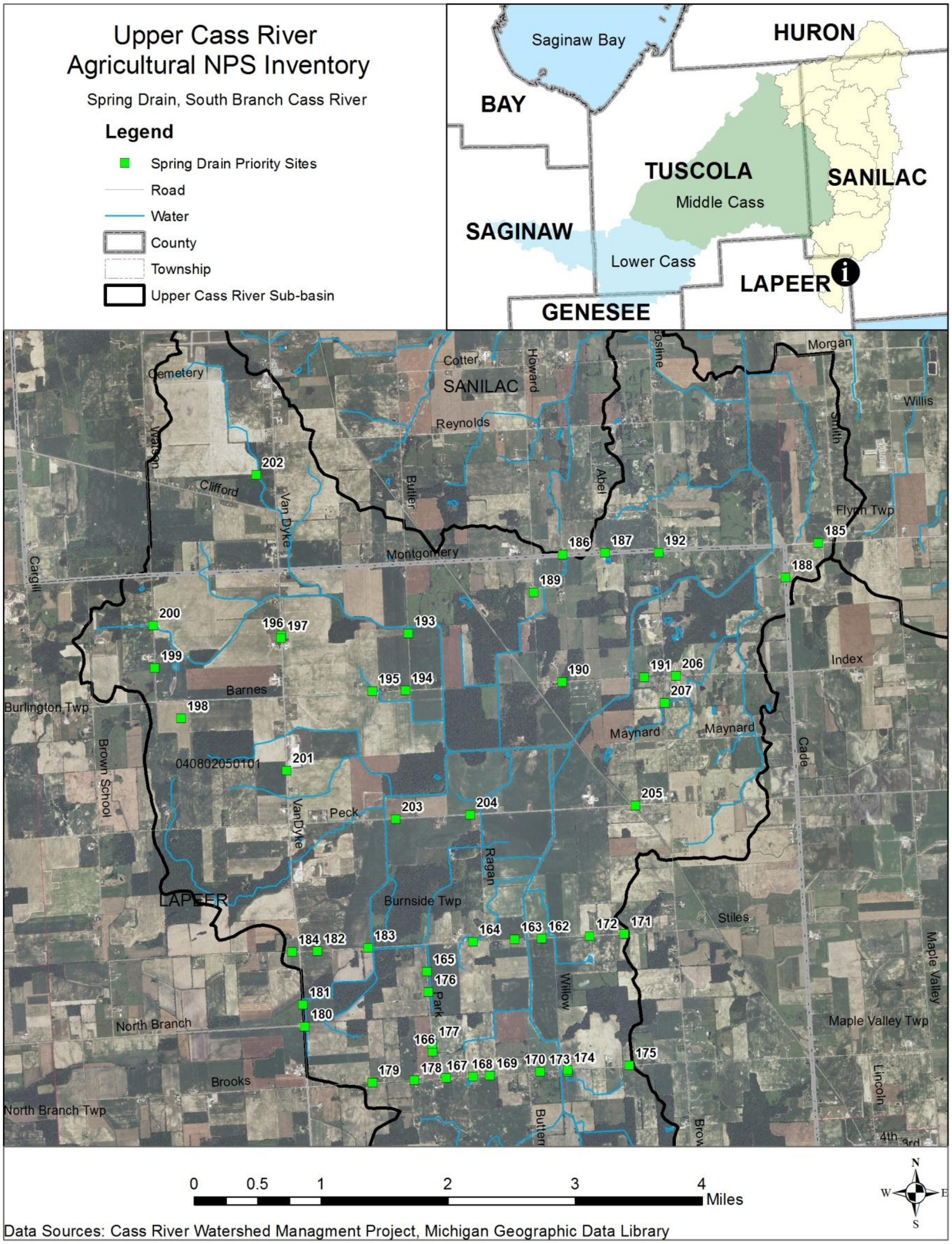
A series of tables and figures follows for each of the subwatersheds that were inventoried during the 2011 windshield survey. For the Spring Drain, Table 7.10 provides a list of field identified where practices can be installed; Table 7.11 provides pollutant loads estimates, Table 7.12 provides an estimation 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 for each site utilizing the STEPL Model, results are shown below in Table 7.11 for the Spring Drain subwatershed.

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)**
	9,281.5	2,363.9	19,123.5	1,236.3
	N Load (with BMP) (lb/yr)	**P Load (with BMP) (lb/yr)**	**BOD Load (with BMP) (lb/yr)**	**Sediment Load (with BMP) (t/yr)**
	2,322.3	595.5	12,500.9	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

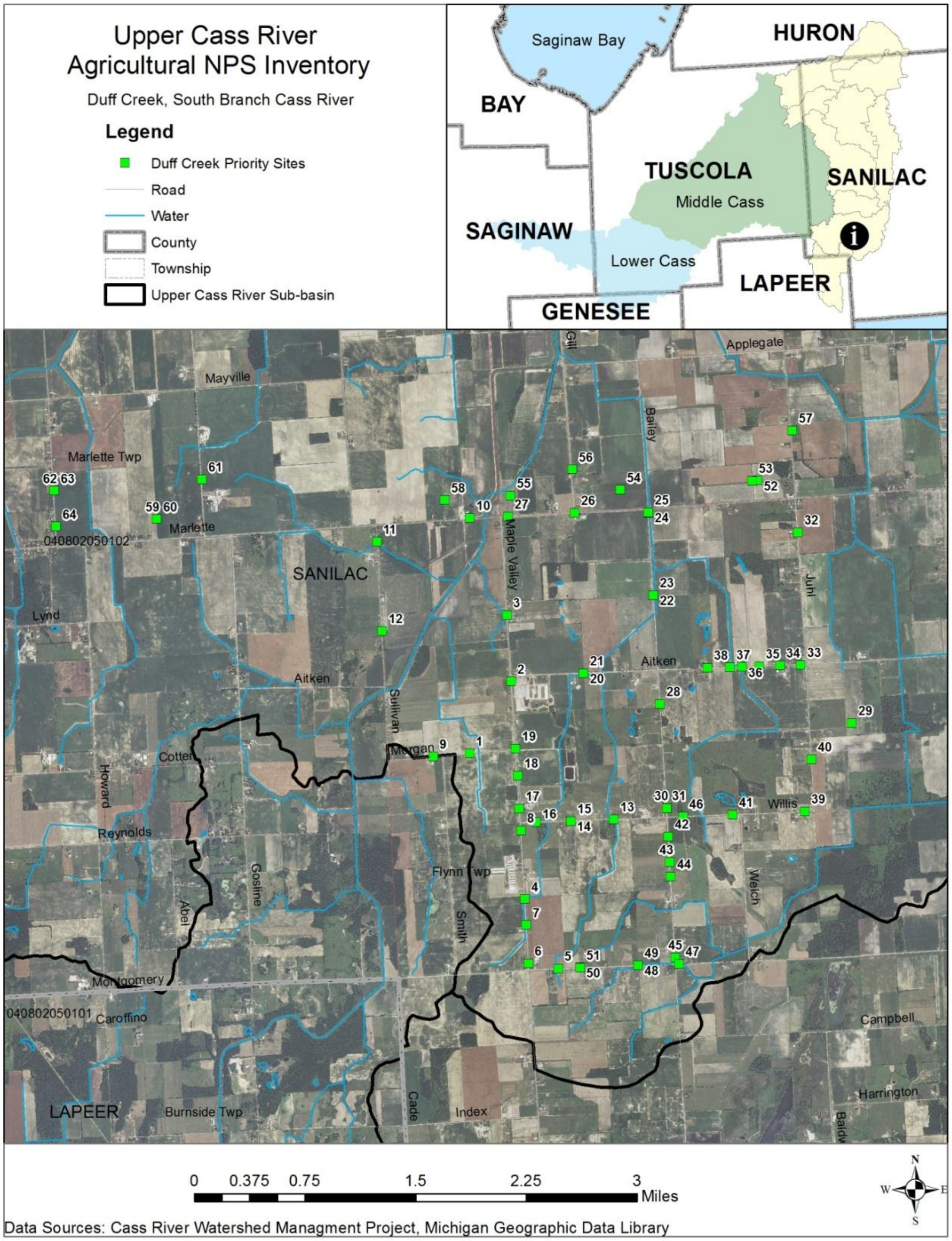
Label	Township	Section	Latitude	Longitude	Field Size (acres)	Field Orientation	Slope of Land	Residue Type
1	Flynn	7	43.306770	-82.989770	100	N/S	Flat	0
2	Flynn	6	43.313700	-82.983850	80	E/W	Flat	Corn
3	Flynn	6	43.320230	-82.984100	150	N/S	Moderate	0
4	Flynn	18	43.292280	-82.983060	40	E/W	Flat	0
5	Flynn	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

[1]Amish farm with mixed crops on 20 acres
[2]Amish farm: 10 acres corn, 30 acres pasture with mixed livestock
[3]Amish farm: 10 acres corn, 30 acres pasture with mixed livestock
[4]Clover cover crop
[5]Amish pasture with some oats planted
[6]Amish field of mixed crops: corn, oats, vegetables
[7]Amish field of mixed crops: corn, oats, vegetables
[8]Amish 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 for each site utilizing the STEPL Model, results are shown below in Table 7.14 for the Duff Creek subwatershed.

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

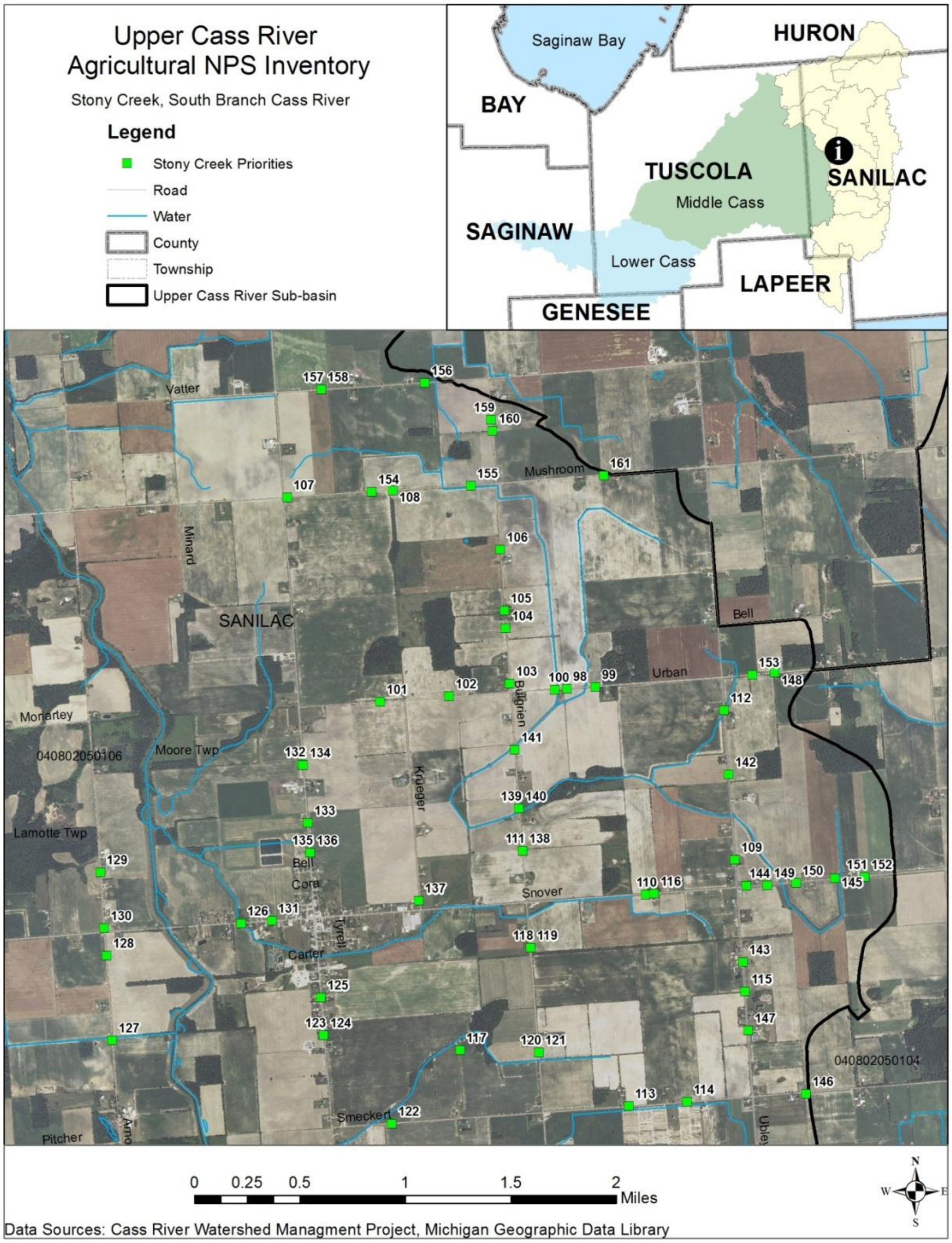
Label	Township	Section	Latitude	Longitude	Field Size (acres)	Field Orientation	Slope of Land	Residue Type
98	Moore	9	43.476290	-82.946124	200	N/S	Flat	Corn
99	Moore	9	43.476340	-82.943410	120	E/W	Flat	Sugar Beet
100	Moore	9	43.476250	-82.947230	40		Flat	Bean
101	Moore	8	43.475880	-82.963760	140	E/W	Moderate	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	

[1]Surface 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 for each site utilizing the STEPL Model, results are shown below in Table 7.17 for the Stony Creek subwatershed.

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	Sediment 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 for each site utilizing the STEPL Model, results are shown below in Table 7.20 for the Hartel Drain subwatershed.

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)
	1,204.6	249.6	2,508.6	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	2,071.0	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 7.21 and Figure 7.9.

Loading Estimate Methodology

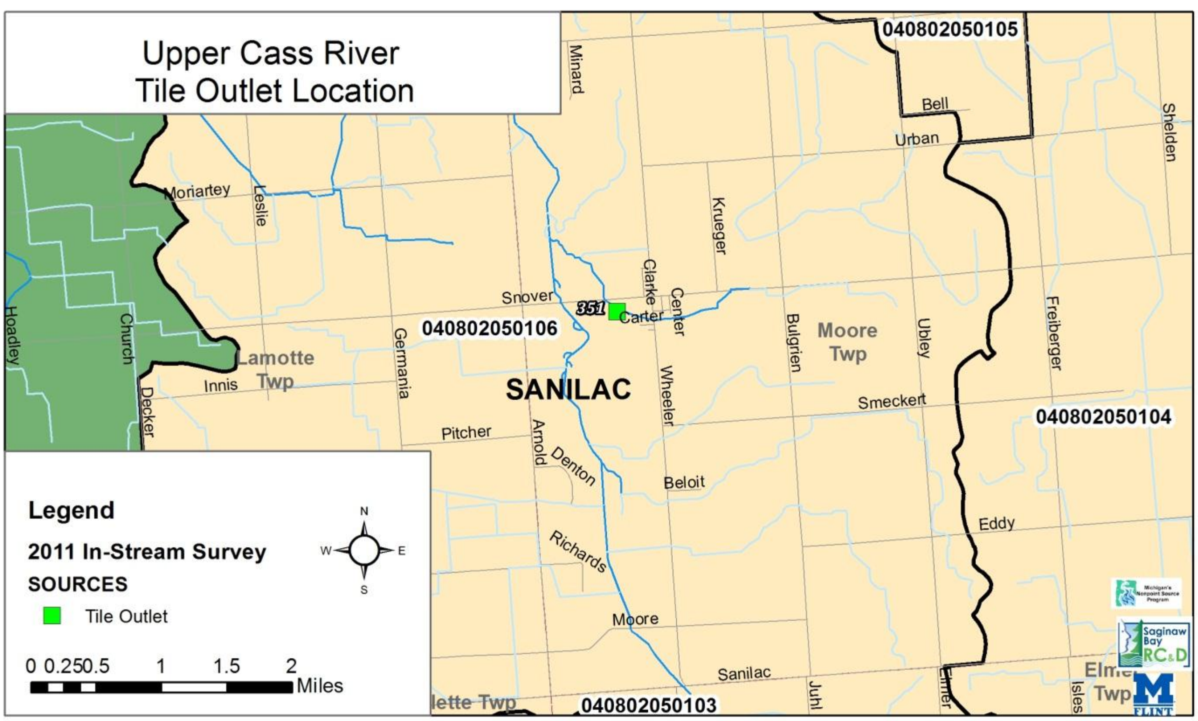
The loading reduction target for the tile outlet is 100% assuming that the outlet is stabilized to mitigate future erosion from occurring. For the loading calculations an identical calculation methods described for gully erosion sites; the soils in this area are well represented by a factor of 110 lbs/ft^3, when this is divided by 2000 lbs/Ton the conversion factor of 0.055 Tons/ft^3 is obtained.

Summary Table & Map

Table 7.21 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

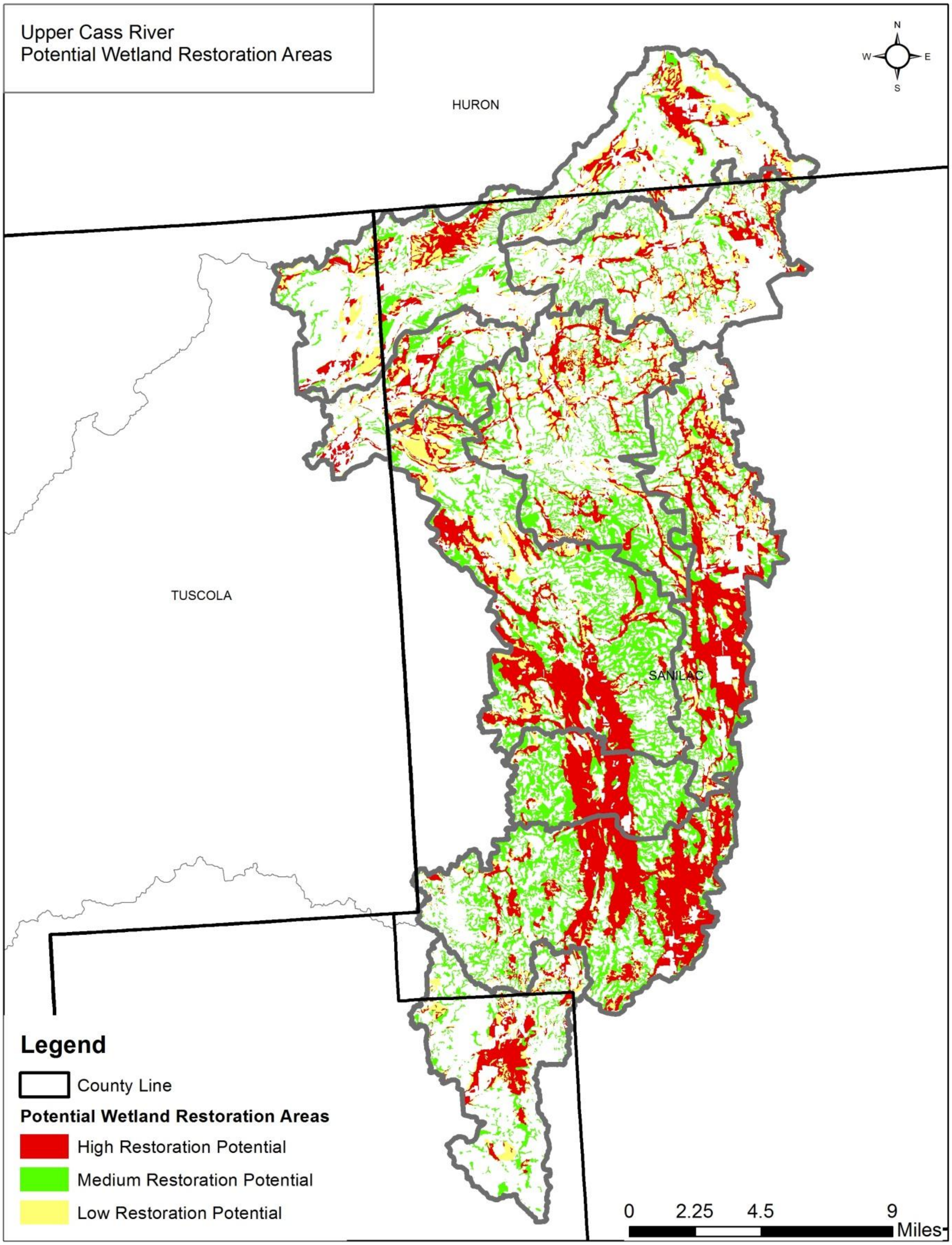
Figure 7.9 Tile Outlet, Stony Creek



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 nutrient (phosphorous and nitrogen) and BOD 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 7.22.

Table 7.22 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%

The annual nutrient reduction loads for livestock in the watershed were calculated assuming the following BMPs are installed:

- Filter Strips along water course (Table 7.23)
- Waste Management Systems (Table 7.24)
- Waste Storage (Table 7.25)

Method used for determination of these nutrient loadings was the *Pollutant Controlled Calculation and Documentation for Section 319 Watersheds Training Manual, June, 1999.*
Table 7.23 shows reductions in annual loadings if vegetated filter strips are used to protect waterways. Table 7.24 shows reductions in annual loadings if waste management systems are used to on high priority sites. Table 7.25 shows reductions in annual loadings if a waste storage facility is used on high priority sites.

Table 7.23 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 7.24 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 7.25 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, 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

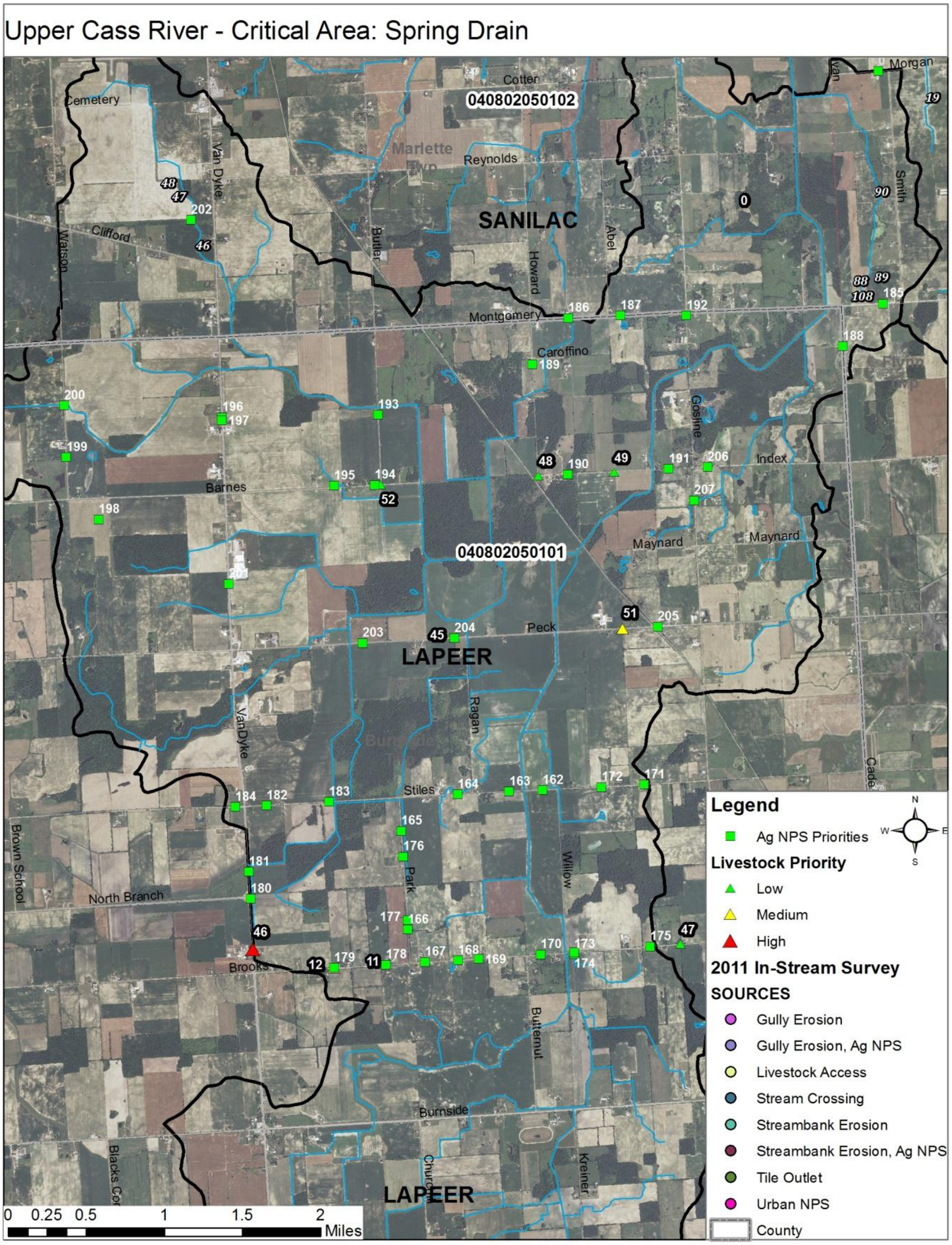


Figure 7.12 Duff Creek Impairments

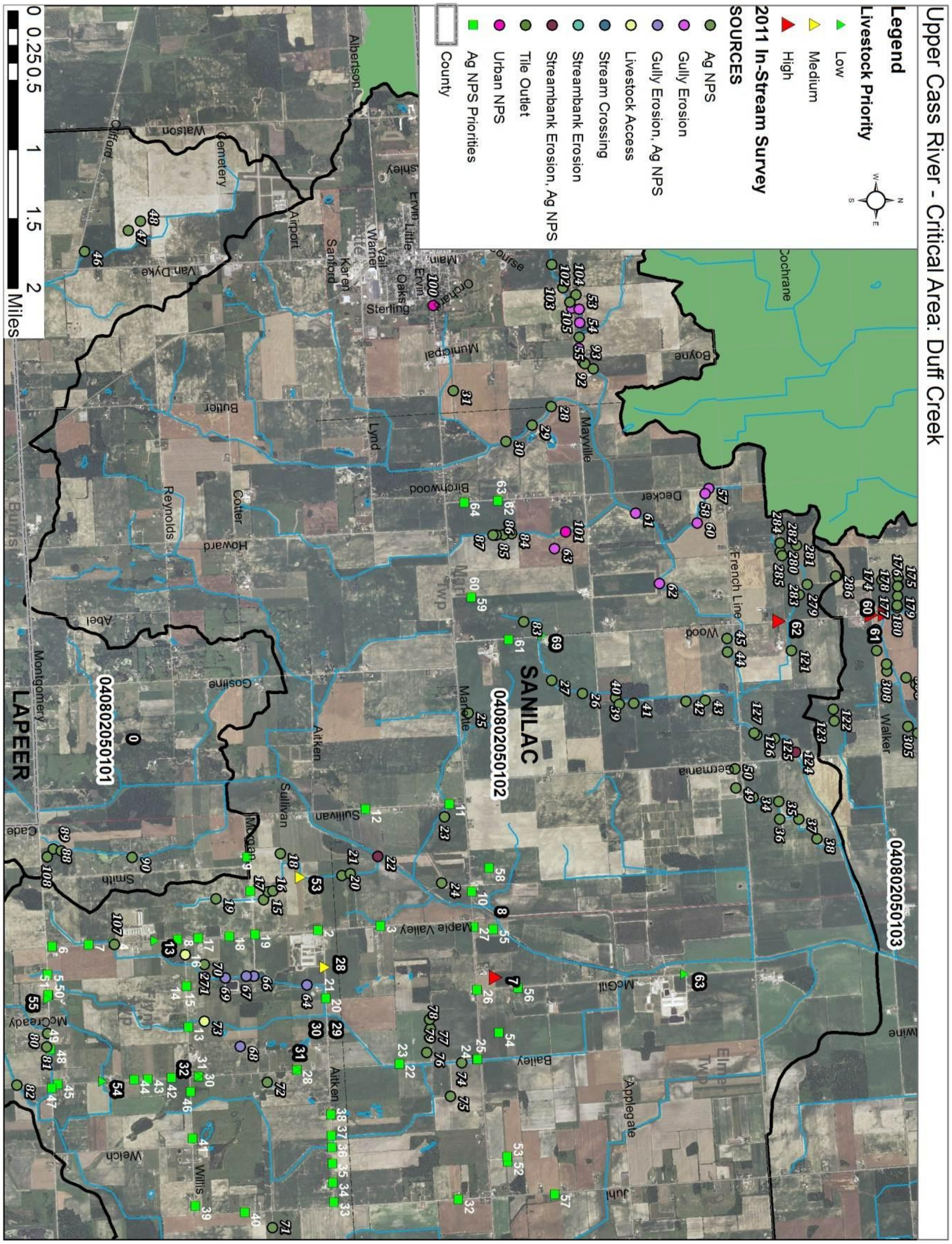
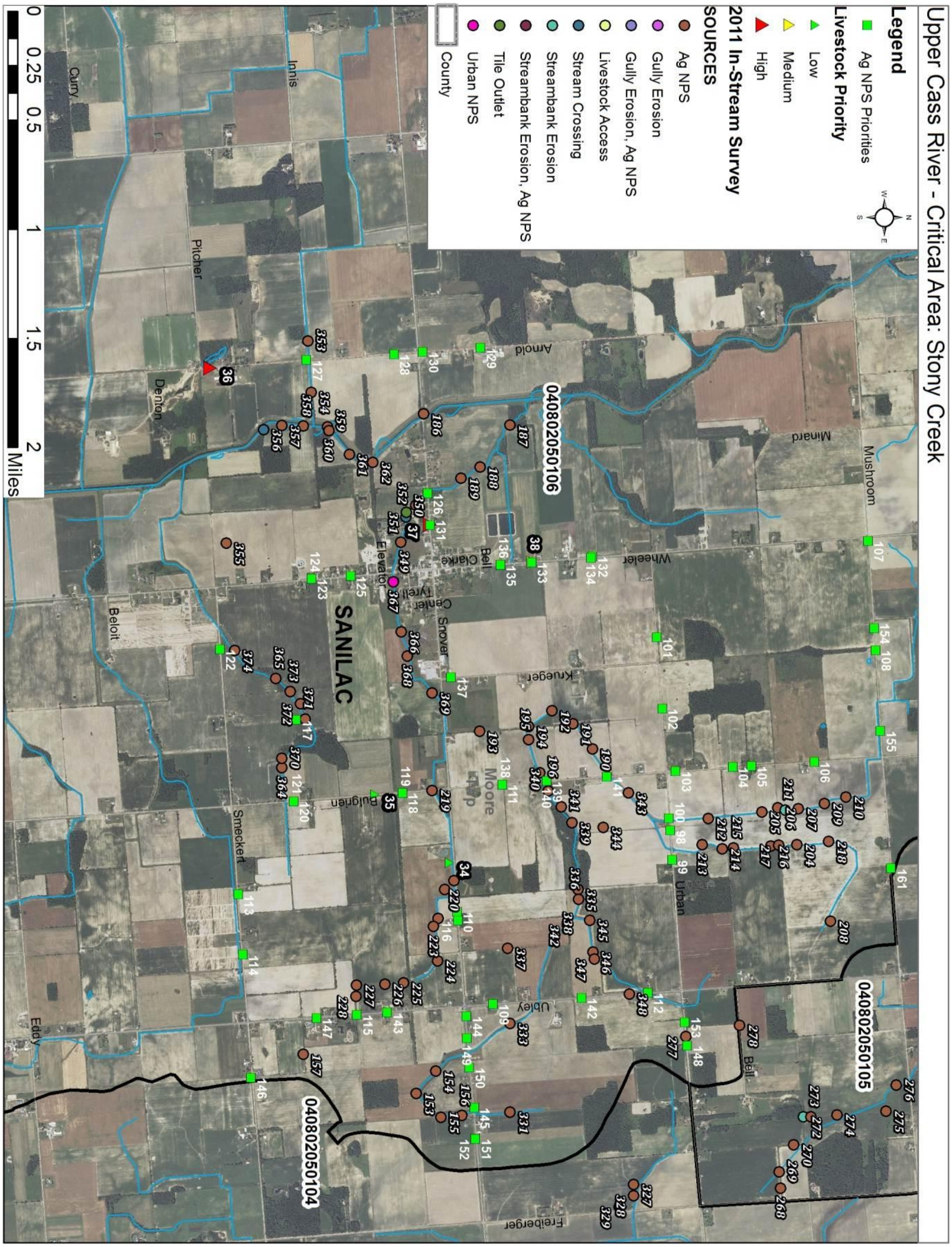


Figure 7.13 Stony Creek Impairments



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 7.26

Table 7.26 Implementation Priorities and Management

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
4 **Duff Creek**	Streambank Erosion Stabilization	Engineering and construction for grading,	Saginaw Bay RC&D Staff time	*Saginaw Bay RC&D, Sanilac Conservation District	12 priority sites totaling 2,364 linear	est $20 per linear foot = $47,280	$47,280 Coastal Zone Management, Great Lakes	Drain Office, 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
		stabilization structures, and vegetation			feet		Commission	
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
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

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
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
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
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	10 subwatershed sites	N/A	$15,000 MiCorps, MDEQ, Local match	MDEQ, EPA
	1MDA, Michigan Department of Agriculture – oversees the Michigan Right to Farm Act							

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
	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 7.27 Implementation schedule 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)		

Priority	Sub-shed	Management Measure	Implementation Schedule	Interim Measurable Milestones	Evaluation Dates
10	Upper Cass River	Wetland Restoration	Long term (5-10 years)		
n/a	Upper 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)

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 tiled 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.

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. None of these nine sites are located in the Upper Cass River. 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.

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