Chapter 4 – Identification and Prioritization of Pollutants, Sources, and Causes

4.0 IDENTIFICATION AND PRIORITIZATION OF POLLUTANTS, SOURCES, AND CAUSES

OBJECTIVES

- What are the sources/causes of the major pollutants in the Watershed?
- What areas contribute the most pollutants to the Watershed?
- In which areas would restoration have the greatest positive impact?
- Which areas are good candidates for protection?

4.1 IDENTIFYING SOURCES AND CAUSES

Once specific pollutants were identified, the focus of investigation turned to possible sources. In order to reduce the pollutants impairing the designated uses of the Watershed, it was necessary to determine where the pollutants originate as well as why the pollutant is impairing the Watershed. The sources and causes of pollutants were identified through review of Watershed inventories, studies, and reports, as previously discussed in Section 3.3, Watershed Inventory and Conditions. In addition, field investigations of Bass River and Deer Creek were conducted. The Steering Committee also provided input on the sources and causes of pollutants throughout the project. By identifying the cause of the pollutant source, implementation efforts can be directed to correct the condition that is generating the pollutant. This helps to ensure the most appropriate designs and successful control measures are implemented or installed.

4.2 NONPOINT SOURCES

To identify sources of nonpoint pollution, field investigations were conducted and existing Watershed inventories, studies, and reports were reviewed. Assessment focused on impairments identified in the State's 303(d) Integrated Report and the pollutants identified in Section 3.4, but any notable observations regarding other potential pollutants were also recorded. Several of the major sources of nonpoint source (NPS) pollution are discussed below.

Livestock

Beef cattle, dairy cows, hogs, and sheep are some of the livestock raised in the Watershed. Livestock operations range in size and include corporations as well as family-owned businesses. Livestock were identified as having an impact on water quality by being a source of nutrients and pathogens. Allegan, Ionia, and Ottawa Counties are ranked as the highest livestock producers in the State. The following statistics are from the 2007 USDA Census of Agriculture report (USDA, Agriculture Census, 2007); only areas with greater than 50% of area in Watershed are included.

County	Cattle	Hogs & Pigs
Allegan	44,971	195,695
Ionia	48,572	47,124
Ottawa	38,242	50,912
Barry	26,818	6,229
Kent	25,350	15,363
Eaton	10,141	6,809

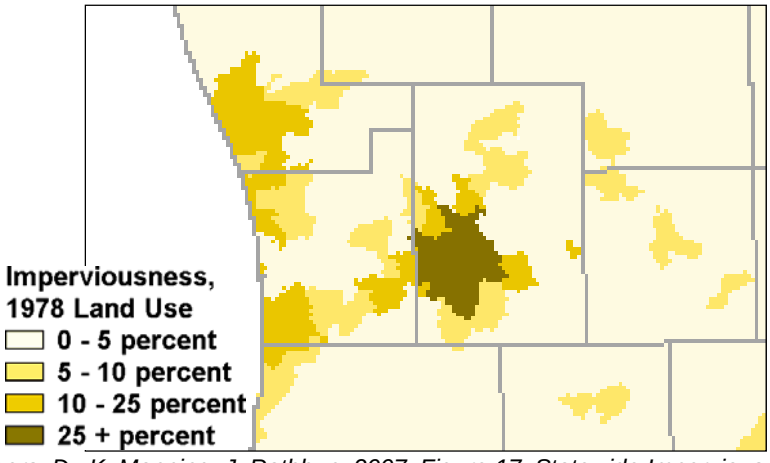
Cropland

Crops harvested in the Watershed include corn, hay, wheat, and soybeans. Croplands were identified as sources of pathogens, sediment, nutrients, chemicals, and herbicides. In addition, drainage of croplands impacts the Watershed's hydrology. A lack of stream buffers adjacent to croplands contributes to elevated stream temperatures. Specific information about cropland is the Watershed is below (USDA, Agriculture Census, 2007); only areas with greater than 50% of area in Watershed are included.

County	Total Acres of Cropland	Total Acres of Orchards	Number of Farms
Allegan	226,541	2,060	1,595
Ionia	193,376	772	1,183
Eaton	176,885	78	1,231
Kent	131,529	9,881	1,193
Ottawa	130,023	4,360	1,451
Barry	119,985	35	1,164

Impervious Surfaces

Urban runoff from impervious surfaces contributes excessive sediment and nutrients to surface waters of the Watershed and has been undeniably linked with increased flashiness (Fongers, 2008). Table 2.13 lists the urban land use as 12% of the Watershed, or 225,252 acres. Large volumes of storm water runoff impact the natural hydrology within several subwatershed management units. The MDNRE has conducted hydrologic studies in several subwatershed management units to relate the amount of imperviousness in a Watershed to the contribution of urban runoff to streams. A study was completed in Indian Mill Creek Watershed in 2010 to better understand the Watershed's hydrologic characteristics (Fongers, 2010).The percent of imperviousness in the urban areas of the Watershed ranged from 20% to 85%. A study was completed in Strawberry Creek (Mill Creek subwatershed management unit) to "better understand the watershed's hydrologic characteristics and reported continued channel instability subsequent to a streambank stabilization project." (Fongers, 2008). Strawberry Creek's percent of imperviousness in the urban areas ranges from 35% to 95%. The image below illustrates the percent imperviousness in the counties within the Lower Grand River Watershed. The Grand Rapids metropolitan area shows greater than 25% imperviousness. More information is given in Section 4.3.



(Source: Fongers, D., K. Manning. J. Rathbun. 2007. Figure 17–Statewide Imperviousness, 1978 Land Use)

Construction Sites

Soil exposed by vegetative disturbance of land clearing and grading, when not protected by proper soil erosion and sedimentation practices, makes its way into waterbodies through wind and water erosion. Municipal Separate Storm Sewer System (MS4) communities are addressing this issue as part of the National Pollutant Discharge Elimination System (NPDES) storm water permit, but construction practices in nonpermitted communities should have the same level of enforcement to minimize the impact to waterbodies

Illicit Connections to Storm Sewers

A connection to a storm sewer or other storm water conveyance system is considered "illicit" when it contains anything other than storm water, requires treatment before it is discharged, or if it should be routed to a sanitary sewer. MS4 communities have screened their storm sewer discharges for illicit connections, and all of those found in the initial screening have been addressed. Screening will occur again in the summer of 2011 in the MS4 communities.

Septic Systems

Septic systems were identified as a source of pathogens and nutrients due to aging systems and improper maintenance. The density of septic systems within the Watershed is illustrated in Figure 3.3. The Barry-Eaton District Health Department (BEDHD) is the only agency in the Watershed to have developed regulations that govern the inspection of septic systems at time of sale or transfer (TOST). The 12-month report on the finding of the enforcement of the TOST program found that it has been an effective tool in identifying and correcting public health hazards. Prior to the enactment of the regulation, the Environmental Health Division forecasted a 10% failure rate based on inspections performed, upon request, by BEDHD. The overall incidence of failure realized in the first twelve months under the TOST program is 23%. The actual failure rate can be associated with the fact that "all transfers are now evaluated and that those evaluations are being performed by qualified people under established evaluation criteria with direct oversight by BEDHD." (BEDHD, 2008)

In late 2008, the Kent County Board of Commissioners established a Subcommittee to review septic issues. The Subcommittee's charge and purpose was to review ordinances around the state, benchmark best practices, and make a recommendation to the Legislative Committee regarding how the County should proceed on these issues. Over the past year, the Subcommittee has interviewed several stakeholders, reviewed ordinances across Michigan, spent several meetings discussing potential options, and attempted to quantify/compare the known data with other sources. As of August 2010, the Subcommittee is preparing a report to release this year with various recommendations. At this time, it is not known what those recommendations may be. The impacts of establishing some type of ordinance are under review. It is expected that the report and recommendations will be released in fall 2010. Exhibit 4.1 illustrates where septic systems were repaired between 2005 and 2010.

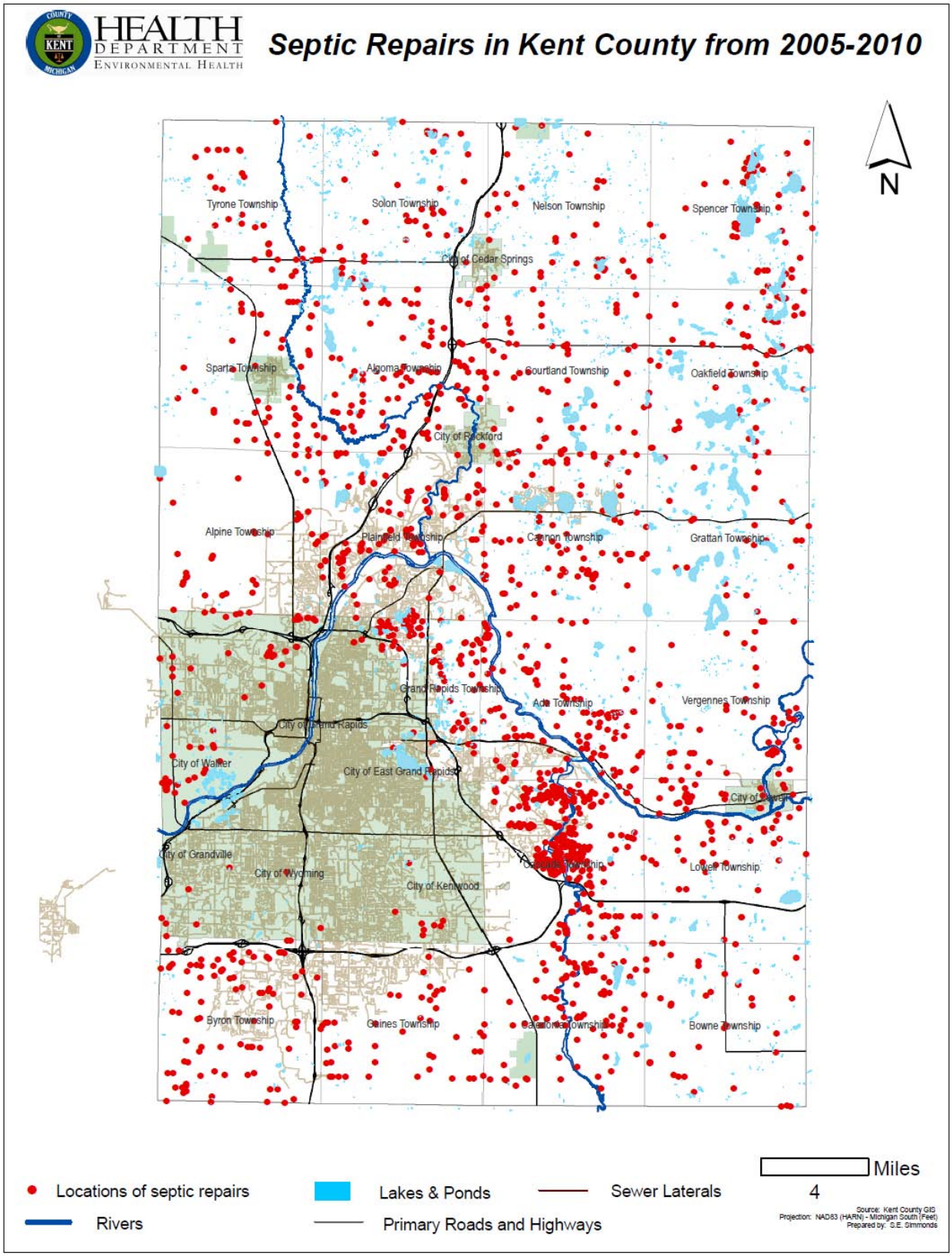


Exhibit 4.1 – Recent Septic System Repairs in Kent County

Channelization

Manmade alterations to drainage patterns, and land use changes resulting in a net loss of natural areas, affect a stream's natural hydrology. Hydrologic changes that increase a stream's flow cause channel instability, leading to increased erosion.

Streambank Erosion

Streambanks were identified as a source of excessive sediment due to unstable hydrology, livestock access, and removal of riparian vegetation. Excessive sediment can cover aquatic habitats, impacting the feeding and reproduction of fish and wildlife communities.

A comprehensive summary of pollutants identified throughout the Watershed can be found in Table 4.1. The status of impaired and threatened designated uses and the impacted subwatershed management units are listed. Table 4.1 also prioritizes pollutants of concern contributing to the degradation of the designated uses and their known or suspected sources and causes. The Watershed Management Plan (WMP) Review Committee evaluated each designated use and prioritized the pollutants based on the degree of impairment and the feasibility of reducing the pollutant to desirable levels. The pollutants, sources, and causes are identified as known (k) if they were documented in an existing Watershed inventory, study, or report. Pollutants, sources, and causes were identified as suspected (s) if indications or impacts were observed, but were not measured. Pollutants, sources, and causes were identified as potential (p) if conditions were typical for pollutants, sources, and causes to exist, but none were observed. Additional inventories should be conducted within 5 years to reassess the Watershed and determine if suspected or potential sources have become known.

Table 4.1 – Pollutant Sources and Causes of Impairments

Pollutant of Concern (by priority)	Designated Use	Subwatershed Management Unit Affected by Pollutant (bold = MS4 Community)	Source of Pollution (by priority)	Cause of Pollutants (by priority)	Documented Presence in Watershed
1. Pathogens and Bacteria (k)	Total Body Contact Recreation (I/T); Partial Body Contact Recreation (I/T)	*Impaired Uses:* **Bass River; Buck Creek; Direct Drainage to Lower Grand River; Plaster Creek;** Coldwater River; Coopers, Clear, and Black Creeks; Crockery Creek; Deer Creek *Threatened Uses:* Upper/Lower Rogue River; Spring Lake/Norris Creek; Sand Creek. Upper/Lower Thornapple	1. Cropland (k)	1. Over or improper application of manure (k)	951,791 acres of cropland in LGRW; 176 animal agriculture facilities in LGRW
			2. Livestock (k)	1. Uncontrolled access (k)	47 livestock access sites identified in NPS inventories
				2. Lack of buffer or setback at holding facilities adjacent channel (k)	47 livestock access sites identified in NPS inventories
			3. Septic tanks (k)	1. Aging systems (k)	86,694 septic systems in the LGRW, reported in 1990 census
				2. Lack of septic system regulation (k)	No septage ordinances in the LGRW. Septic system regulations exist only in Barry and Eaton Counties.
			4. Ducks and geese (k)	1. Maintained lawn to edge of water (k)	*1,203 miles of unvegetated riparian area in LGRW
				2. Overpopulation of waterfowl (k)	*1,203 miles of unvegetated riparian area in LGRW
			5. Sanitary sewer (s)	1. Aging/leaking sanitary sewer (s)	Miles of aging/leaking sanitary sewer to be determined
2. Sediment (k)	Warm Water Fishery (I/T); Other Indigenous Aquatic Life and Wildlife (I/T); Cold Water Fishery (I/T)	*Impaired Uses:* **Bass River; Direct Drainage to Lower Grand River (York Creek)**; **Mill Creek (Strawberry Creek); Plaster Creek;** Coldwater River; Indian Mill Creek; Mud Creek; Sand Creek *Threatened Uses:* Deer Creek; Buck Creek; Upper/Lower Rogue River; Spring Lake/Norris Creek	1. Cropland (k)	1. Tillage practices (k)	951,791 acres of cropland in LGRW
				2. Lack of buffers (k)	*1,203 miles of unvegetated riparian area in Watershed
				3. Dense drainage network (k)	4,457 miles of streams/drains in the LGRW
			2. Urban landscapes (k)	1. Impervious surfaces (k)	225,252 acres of urban land in the LGRW
				2. Dense drainage network (k)	4,457 miles of streams/drains in the LGRW

Table 4.1 – Pollutant Sources and Causes of Impairments

Pollutant of Concern (by priority)	Designated Use	Subwatershed Management Unit Affected by Pollutant (bold = MS4 Community)	Source of Pollution (by priority)	Cause of Pollutants (by priority)	Documented Presence in Watershed
				3. Construction sites (k)	13 construction sites identified during NPS inventories
			3. Streambanks (k)	1. Altered morphology and hydrology (k)	112 sites identified in NPS inventories
				2. Uncontrolled livestock access (k)	47 livestock access sites identified in NPS inventories
				3. Removal of vegetation (k)	*1,203 miles of unvegetated riparian area in LGRW
			4. Rill and gully erosion (k)	1. Agriculture practices (k)	951,791 acres of cropland in LGRW
				2. Concentrated flow from roadside ditch (k)	211 stream crossing sites identified in NPS inventories
			5. Lakeshore erosion (k)	1. Boat traffic/seawalls/wave action (k)	339,216 ft of lake shoreline in LGRW
3. Nutrients (k)	Warm Water Fishery (I/T); Other Indigenous Aquatic Life and Wildlife (I/T); Cold Water Fishery (T)	*Impaired Uses:* Lake Creek; Deer Creek; Upper Thornapple River (Low Dissolved Oxygen) *Threatened Uses:* Bass River; Buck Creek; Coldwater River; Plaster Creek; Upper/Lower Rogue River; Spring Lake/Norris Creek; Sand Creek	1. Livestock (k)	1. Over or improper application of manure (k)	176 animal agriculture facilities
				2. Uncontrolled access (k)	47 livestock access sites identified in NPS inventories
				3. Lack of buffer or setback at holding facilities adjacent channel (k)	47 livestock access sites identified in NPS inventories
			2. Septic tanks (k)	1. Aging systems (k)	86,694 septic systems in the LGRW, reported in 1990 census
				2. Lack of septic system regulation (k)	Barry and Eaton Counties have contract with MDNRE to conduct their own inspection and enforcement activities. All other Counties default to MDNRE for those services.

Table 4.1 – Pollutant Sources and Causes of Impairments

Pollutant of Concern (by priority)	Designated Use	Subwatershed Management Unit Affected by Pollutant (bold = MS4 Community)	Source of Pollution (by priority)	Cause of Pollutants (by priority)	Documented Presence in Watershed
			3. Cropland and urban landscapes (k)	1. Over or improper application of fertilizers (k)	951,791 acres of cropland in LGRW
				2. Lack of riparian buffer (k)	*1,203 miles of unvegetated riparian area in LGRW
			4. Ducks and geese (k)	1. Maintained lawn to edge of water (k)	*1,203 miles of unvegetated riparian area in LGRW
				2. Overpopulation of waterfowl (k)	*1,203 miles of unvegetated riparian area in LGRW
			5. Sanitary sewer (s)	1. Aging/leaking sanitary sewer (s)	Miles of aging/leaking sanitary sewer to be determined
4. Unstable Hydrology (k)	Coldwater Fishery (T); Other Indigenous Aquatic Life and Wildlife (T); Warm Water Fishery (T)	*Threatened Uses:* Coldwater River; Crockery Creek; Direct Drainage to Lower Grand River; Lower/Upper Thornapple River; Plaster Creek; Upper/Lower Rogue River; Rush Creek; Sand Creek	1. Wetland loss (k)	1. Drainage/filling for agriculture/development (k)	Approximately 170,000 acres of wetlands have been drained/lost since the 1800s
			2. Tiles and drainage networks (k)	1. Agriculture land use practices (k)	951,791 acres of cropland in LGRW
				2. Urban land use practices (k)	225,252 acres of urban land in the LGRW
			3. Filling of floodplains (k)	1. Filling for agriculture/development (k)	19,447 acres of floodplain in Kent County, data for the rest of LGRW is not available
			4. Channelization (k)	1. Agricultural practices (k)	951,791 acres of cropland in LGRW
5. Temperature (k)	Coldwater Fishery (T); Other Indigenous Aquatic Life & Wildlife (T); Warm Water Fishery (T)	*Threatened Uses:* Coldwater River; Plaster Creek; Sand Creek; Upper/Lower Rogue River	1. Lack of stream canopy (k)	1. Removal of riparian vegetation (k)	*1,203 miles of unvegetated riparian area in LGRW
			2. Excessive sediment (k)	1. See causes under sediment	See documented presence in watershed under sediment.

Table 4.1 – Pollutant Sources and Causes of Impairments

Pollutant of Concern (by priority)	Designated Use	Subwatershed Management Unit Affected by Pollutant (bold = MS4 Community)	Source of Pollution (by priority)	Cause of Pollutants (by priority)	Documented Presence in Watershed
6. Habitat Fragmentation (k)	Coldwater Fishery (I); Other Indigenous Aquatic Life & Wildlife (I/T); Warm Water Fishery (I/T)	*Impaired Uses:* Direct Drainage to Lower Grand River (York Creek) *Threatened Uses:* Entire Watershed	1. Destruction of habitat, including wetlands and floodplains (k)	1. Urban and agriculture development (k)	225,252 acres of urban land and 951,791 acres of agricultural land in the LGRW.
7. Chemicals (k)	Warm Water Fishery (T); Coldwater Fishery (T); Other Indigenous Aquatic Life and Wildlife (I/T)	*Impaired Uses:* Lower Thornapple *Threatened Uses:* Entire Watershed	1. Cropland (k)	1. Over or improper application of herbicides and pesticides (k)	951,791 acres of cropland in LGRW
			2. Industrial activity (k)	1. Industrial emissions and discharges (k)	10,555 acres of industrial land use in LGRW.
			3. Agriculture and urban areas (k)	1. Over or improper application of herbicides and pesticides (k)	951,791 acres of cropland in LGRW
			4. Pharmaceutical waste	1. Improper disposal of unused drugs	**80% of streams could contain trace levels of chemical compounds
8. Invasive Species	Warm Water Fishery (T); Coldwater Fishery (T); Other Indigenous Aquatic Life and Wildlife (T)	*Threatened Uses:* Entire Watershed	1. Accidental introduction	1. Man-made channels	Chicago shipping channel potential conduit for Asian Card to enter Lake Michigan and the Grand River
				2. Bait buckets and ballast water	Great Lakes shipping and boating industry
				3. Road fill	Garlic Mustard and phragmites prolific along road sides

*Miles of unbuffered channel assumes that 27% of stream length is unbuffered.
**A study by the US Geological Survey concluded that 80% of streams sampled contained detectable levels of compounds found in common medications (Yellow Jugs Old Drugs Project (http://www.greatlakescleanwater.org/)
I = Impaired
T = Threatened
k = Known
s = Suspected
p = Potential
MS4 Community = Municipal Separate Storm Sewer System permitees under National Pollutant Discharge Elimination System (NPDES) storm water regulations
High Priority = Designated Use is impaired due to the presence of a TMDL or pending TMDL (Total Maximum Daily Load)
Medium Priority = Designated use is threatened but TMDL has not been scheduled

4.3 POLLUTANT LOADING BY SUBWATERSHED

Pollutant loadings were calculated by subwatershed management unit. Pollutant loadings enable the Steering Committee to have a comprehensive understanding of which areas contribute the most pollutants into the Watershed to assist in developing corrective measures. Table 4.1a presents loadings from the NPS sites for sources of Streambank Erosion, Tile Outlet, Livestock Access Sites, Rill and Gully Erosion, and Road/Stream Crossing Sites. Pollutant loads for Bass River and Deer Creek were calculated with this project, since the inventories were completed with this current project. Loads for other SMUs were only presented in the table if they were available from previous studies or WMPs. Table 4.2 presents sediment, phosphorus, and nitrogen loadings from the NPS sites. The pollutant loadings from the NPS sites were calculated using the Michigan Department of Natural Resources and Environment (MDNRE) *Pollutant Controlled Calculations and Documentation for Section 319 Watersheds Training Manual*, June 1999.

Three different computer models were used to calculate watershed-wide pollutant loadings: High-Impact Targeting System (HIT), Soil and Water Assessment Tool (SWAT), and P-LOAD. HIT is a web-accessible tool that is designed to focus limited conservation resources on the most serious erosion and pollution problem. HIT relies on advanced geographical information systems technology and innovative applications of computer modeling. The HIT system provides data on sediment delivery and agricultural erosion based on soil types, slopes, proximity to water, and management practices. The HIT tool estimates the amount of sediment that deposits into waterways by each subwatershed annually and in tons per acre per year. The HIT model results were used to help prioritize the SMUs based on tons of sediment per acre per year. MSU performed the modeling, and published the results on AWRI's website (http://www.gvsu.edu/wri/isc/hit-model-home-page-317.htm). SWAT is a public domain model actively supported by the USDA Agricultural Research Service. SWAT is a river basin scale model developed to quantify the impact of land management practices on water, sediment, and agricultural chemical yield in large, complex watersheds. The SWAT model was performed by ACOE in 2006 (http://www.glc.org/tributary/models/grand.html). The results were used to help prioritize the SMUs based on tons of sediment per acre per year.

The P-LOAD model, which is a simplified, GIS-based model, was used to calculate pollutant loads for watersheds based on land use/cover, 30-year average annual precipitation, and Event Mean Concentration (EMC) values for each corresponding land use. Table 4.2 includes loadings as determined by the P-LOAD model. The P-LOAD model was run to estimate annual loads (lbs) of total suspended solids (TSS), total phosphorus (TP), and total nitrogen (TN). Land use for the Lower Grand River Watershed consisted of 1999-2001 IFMAP data for the entire Watershed. Sub-basin boundaries were used as provided by the MDNRE. The average annual precipitation for Muskegon was 32.56 inches and 36.04 for Grand Rapids, and was obtained from NOAA based on data from 1961–2000. The default value of 0.9 was used as the ratio of storms producing runoff. EMC values were obtained through a study done by the USGS in 2006 titled, *Estimation of Nonpoint-Source Loads of Total Nitrogen, Total Phosphorous, and Total Suspended Solids in the Black, Belle, and Pine River Basins, Michigan, by Use of the PLOAD Model*. The EMC and imperviousness percentage values are shown in Table 4.1b.

Table 4.1a – Sediment and Nutrient Loadings by Source - NPS Sites

Subwatershed	Sediment Loading (tons/yr)						Phosphorus Content (lbs/yr)	Nitrogen Content (lbs/yr)
	Streambank Erosion	Gully Erosion	Tile Outlet	Road/Stream Crossing	Livestock Access	Total (tons/yr)		
Rogue River (Lower & Upper Rogue)	556			1,491	99	2,146	1,826	3,652
Coldwater River	453				30	483	427	854
Plaster Creek	13.5	1.1	0.2	15.8		31	27	54
Buck Creek	18	0.3			6.6	25	21	36
Bass River			0.1	0.6		0.7	0.6	1
Indian Mill Creek	110.9	2.1			0.3	113	95	189
Deer Creek	0.1		1	0.1	6	7	6	13
TOTAL	**1,151.5**	**3.5**	**1.3**	**1507.5**	**141.9**	**2,806**	**2,396**	**4,798**

Table 4.1b – EMC and Imperviousness Percentage Values used in P-LOAD Model

Land Use/Cover	Imperviousness %	TN	TP	TSS
Residential	25	2.25	0.50	25
Commercial	80	1.92	0.34	35
Industrial	80	1.92	0.34	35
Other Developed Areas	80	1.92	0.34	35
Cropland	2	2.50	0.40	27
Orchards/Vineyards/Other	25	1.92	0.37	17
Confined Feeding/Permanent Pasture	2	2.50	0.40	27
Other Agricultural Land	2	2.31	0.39	25
Open Field	2	0.94	0.15	19
Forest	2	0.94	0.15	16
Water	100	0.65	0.08	3
Wetlands	2	0.75	0.11	8
Barren/Sand Dune	50	0.65	0.08	30
Transitional Land	50	0.65	0.08	30

Table 4.2 – Sediment and Nutrient Loading - NPS Sites & P-LOAD

Subwatershed Management Unit	Sediment			Phosphorus			Nitrogen		
	Sediment Loading NPS (tons/yr)	Sediment Loading P-LOAD Model (tons/yr)	Total Sediment Loading (NPS + P-LOAD) (tons/yr)	Phosphorus Content NPS Sites (lbs/yr)	Phosphorus Content P-LOAD (lbs/yr)	Total Phosphorus Loading (NPS + P-LOAD) (lbs/yr)	Nitrogen Content NPS Sites (lbs/yr)	Nitrogen Content P-LOAD (lbs/yr)	Total Nitrogen Content Loading (NPS + P-LOAD) (lbs/yr)
Direct Drainage to Lower Grand River		4,676	4,676		118,380	118,380		686,410	686,410
Rogue River (Lower & Upper Rogue)	2,146	1,901	4,049	1,826	49,110	50,936	3,652	287,600	291,252
Coldwater River	483	1,137	1,620	427	21,419	21,846	854	128,520	129,374
Upper Thornapple River		1,584	1,584		32,689	32,689		198,190	198,190
Lower Thornapple River		1,452	1,452		22,890	22,890		133,690	133,690
Plaster Creek	31	1,315	1,347	27	16,050	16,077	54	89,100	89,154
Upper Flat River		1,239	1,239		29,150	29,150		174,000	174,000
Buck Creek	25	1,000	1,025	21	28,040	28,061	36	153,400	153,436
Crockery Creek		850	850		18,340	18,340		107,730	107,730
Lower Flat River		833	833		24,920	24,920		144,320	144,320
Rush Creek		742	742		18,330	18,330		103,000	103,000
Coopers, Clear, and Black Creeks		637	637		16,680	16,680		100,640	100,640
Prairie Creek		600	600		23,430	23,430		143,660	143,660
Sand Creek		457	457		12,620	12,620		75,200	75,200
Dickerson Creek		422	422		16,800	16,800		101,300	101,300
Spring Lake/Norris Creek		371	371		8,930	8,930		52,600	52,600
Mud Creek		350	350		6,384	6,384		38,765	38,765
Libhart Creek		339	339		9,280	9,280		55,440	55,440
Bass River	1	302	303	0	6,380	6,380	1	38,800	38,801
Wabasis and Beaver Dam Creek		294	294		6,230	6,230		36,500	36,500
Indian Mill Creek	113	282	395	95	7,450	7,545	189	42,500	42,689
Deer Creek	7	244	251	6	3,600	3,600	13	20,900	20,913
Cedar Creek		238	238		9,690	9,690		57,600	57,600

Table 4.2 – Sediment and Nutrient Loading - NPS Sites & P-LOAD

	Sediment			Phosphorus			Nitrogen		
Subwatershed Management Unit	Sediment Loading NPS (tons/yr)	Sediment Loading P-LOAD Model (tons/yr)	Total Sediment Loading (NPS + P-LOAD) (tons/yr)	Phosphorus Content NPS Sites (lbs/yr)	Phosphorus Content P-LOAD (lbs/yr)	Total Phosphorus Loading (NPS + P-LOAD) (lbs/yr)	Nitrogen Content NPS Sites (lbs/yr)	Nitrogen Content P-LOAD (lbs/yr)	Total Nitrogen Content Loading (NPS + P-LOAD) (lbs/yr)
Bear Creek		209	209		3,690	3,690		21,600	21,600
Lake Creek		202	202		3,330	3,330		19,200	19,200
Mill Creek		200	200		7,420	7,420		43,300	43,300
Bellemy Creek		191	191		3,640	3,640		22,040	22,040
High Bank Creek		184	184		4,270	4,270		26,400	26,400
Glass Creek		168	168		1,030	1,030		6,340	6,340
Fall Creek		160	160		3,520	3,520		20,900	20,900
Total:	**2,806**	**22,579**	**25,388**	**2,396**	**533,692**	**536,088**	**4,798**	**3,129,645**	**3,134,443**

Total Maximum Daily Load (TMDL) reports are completed by the MDNRE according to the schedule in the Integrated Report to address the water bodies currently listed as impaired. Total daily loads are estimated using the L-THIA or the P-LOAD model. The TMDL process establishes the allowable loadings of pollutants for a water body, based on the relationship between pollution sources and in-stream water quality conditions. A summary of the reports for all scheduled TMDLs are included in Appendix 3.2. Specific loadings listed in the TMDL reports calculated for certain waterbodies are listed in Table 4.2a.

Table 4.2a –Pollutant Loadings Reported in TMDL Report in Stream Reaches With Approved TMDLs

Subwatershed Management Units	HUC Codes	Waterbody	Impacted Miles/ Acres	Total Phosphorus (lbs/year)	Biota, TSS Load (tons/yr)	*E. coli* – Range of concentration, 30-Day Geometric Mean (count/100 mL)	*E. coli* – Dry Weather Sampling Results, Range of Concentration, 30-Day Geometric Mean (count/100 mL)
Bass River	04050006 0706-01	Bass Creek	45.3 M		1,357	2 - 10,389 (2005 TMDL)	
	04050006 0707-01	Bass Creek, Bass River, Bear Creek and Little Bass Creek	55.6 M				
Buck Creek	04050006 0510-02	Buck Creek and Pine Hill Creek	11.4 M			40 - 5,846 (2006 TMDL)	75 - 2,420 (Table 3.3a Buck Creek WMP Addendum 8/2007)
Coldwater River	4050007 0302-01	Little Thornapple River and Woodland Creek	24.6 M	UNKNOWN – 2016 TMDL			
	04050007 0306-01	Tyler/Bear Creek	18.5 M			25 – 814 (2005 TMDL)	
	04050007 0307-03	Coldwater River	39.3 M			56 – 547 (2005 TMDL)	11 - >2,420 (Table 4 Coldwater River WMP, 4/2009)
Coopers, Clear, and Black Creeks	04050006 0107-02	Lincoln Lake Pine Resort Beach- NW of Greenville	0.2 M			20 - 2,141 (2006 TMDL)	
Crockery Creek	04050006 0603-02	Rio Grande Creek	31.8 M			68 - 1.076 (2003 TMDL)	

Table 4.2a –Pollutant Loadings Reported in TMDL Report in Stream Reaches With Approved TMDLs

Subwatershed Management Units	HUC Codes	Waterbody	Impacted Miles/ Acres	Total Phosphorus (lbs/year)	Biota, TSS Load (tons/yr)	*E. coli* – Range of concentration, 30-Day Geometric Mean (count/100 mL)	*E. coli* – Dry Weather Sampling Results, Range of Concentration, 30-Day Geometric Mean (count/100 mL)
Direct Drainage to Lower Grand River	04050006 0507-02	York Creek	5.9 M		170		
	04050006 0507-06	Grand River	4.0 M			31 - 1,261 (2006 TMDL)	
	04050006 0512-03	Grand River	3.0 M			31 - 1,261 (2006 TMDL)	
	04050006 0705-02	Maplewood Lake Park Beach	0.2 M				
	04050006 0705-03	Ottawa Creek	7.7 M				
	04050006 0712-01	Grand River Grand Haven Boaters Park Beach	1.0 M				
Lake Creek	04050006 0311-03	Morrison Lake - S. of Rt. 96 Due S. of Saranac	294.5 A	919			
Mill Creek	04050006 0503-02	Strawberry Creek	3.6 M		103.6		
Plaster Creek	04050006 0505-02	Plaster Creek	42.6 M		1,676	216 - 6,903 (2002 TMDL)	96 - >24,200 (Table 3.1 Plaster Creek WMP, 10/2008)
	04050006 0506-02	Little Plaster Creek, Plaster Creek and Whisky Creek	32.5 M				
Sand Creek	04050006 0701-01	East Fork Sand Creek and Unnamed Tributaries to East Fork Sand Creek	22.41 M		1,733		<33 - >6000 (Table 13, Sand Creek WMP 2004)
	04050006 0702-01	Sand Creek	38.0 M				
	04050006 0703-01	Sand Creek	24.3 M				

4.4 IDENTIFICATION OF CRITICAL AREAS FOR RESTORATION

4.4.1 SUBWATERSHED MANAGEMENT UNIT PRIORITIZATION

Critical areas for restoration are those subwatershed management units that have the most potential of contributing the greatest amounts of NPS pollution which impair or threaten water quality in the Watershed. The Steering Committee ranked the subwatershed management units by their critical areas for restoration based on five categories:

1. Sediment loadings – estimated sediment loads (via streambank erosion and sedimentation) by subwatershed management unit using the average of the P-LOAD, SWAT, and HIT model results (data normalized by subwatershed management unit area).

2. Nutrient loadings – estimated nutrient loads by subwatershed management unit using the P-LOAD model (data normalized by subwatershed management unit area).

3. TMDL nonattainment reaches – subwatershed management units received one point per completed TMDL report, two points per scheduled TMDL report, and one point per pending TMDL report, thereby ranking subwatershed management units by implementation status level.

4. Wetland restoration areas (%) – wetland restoration areas based on hydric soils and presettlement land use, as determined through the Landscape Level Wetland Functional Assessment analysis.

5. NPS sites – number of known NPS sites as determined by field inventories, thereby ranking subwatershed management units by implementation status level.

Each subwatershed management unit was given a ranking under each of the five categories: 1 being the worst condition (e.g., highest number of NPS sites). All five category rankings were then averaged by subwatershed management unit to determine the final ranking. Table 4.3 shows the prioritization of subwatershed management units for restoration based on results of the five assessments listed above. The following highest priority subwatershed management units (listed alphabetically) are the most imperative for restoration due primarily to the high pollutant loadings and total number of known NPS sites.

- Buck Creek
- Direct Drainage to the Grand River
- Indian Mill Creek
- Mud Creek
- Plaster Creek
- Rush Creek
- Sand Creek
- Upper and Lower Rogue River
- Upper Thornapple River

The priorities for high, medium, and low were determined based on the results of the ranking, and are to be considered in their groupings and not according to the individual rankings. All high priorities have a total ranking of 1-10, medium priorities have a total ranking 11-20, and low priorities have rankings 21-31. Figure 4.1 depicts the critical areas for restoration.

Table 4.3 – Critical Areas for Restoration*

Subwatershed Management Unit	Sediment Load (average based on P-LOAD, SWAT, HIT)	Nutrient Load (based on P-LOAD)	TMDL Nonattainment Reaches (report status)	Wetland Restoration Areas (%)	Known NPS Sites (no.)	Average Ranking Score	Priority		Watershed Organization	MS4 Communities
Buck Creek	2	1	8	17	2	6.0	1	High		Grandville, Wyoming, Kentwood, Kent County Drain Commission, Kent County Road Commission
Upper Rogue River	4	2	16	7	7	7.2	2	High	Rogue River Watershed Council	
Upper Thornapple River	7	7	5	8	10	7.4	3	High	Thornapple River Watershed Council	
Direct Drainage to Lower Grand River	9	8	1	14	10	8.4	4	High		Allendale Township, Georgetown Township, Ferrysburg, Grand Haven, Spring Lake, Cascade Township, Plainfield Township, East Grand Rapids, Grand Rapids, Grand Rapids Township, Walker, Grandville, Wyoming, Kentwood, Kent County Drain Commission, Kent County Road Commission, Ottawa County Drain Commission, Ottawa County Road Commission

Table 4.3 – Critical Areas for Restoration*

Subwatershed Management Unit	Sediment Load (average based on P-LOAD, SWAT, HIT)	Nutrient Load (based on P-LOAD)	TMDL Nonattainment Reaches (report status)	Wetland Restoration Areas (%)	Known NPS Sites (no.)	Average Ranking Score	Priority		Watershed Organization	MS4 Communities
Plaster Creek	1	9	3	27	4	8.8	5	High	Plaster Creek Stewards	Cascade Township, East Grand Rapids, Grand Rapids, Grand Rapids Township, Wyoming, Kentwood, Kent County Drain Commission, Kent County Road Commission
Rush Creek	8	6	15	5	10	8.8	5	High		Georgetown Township, Hudsonville, Grandville, Wyoming, Kent County Drain Commission, Kent County Road Commission, Ottawa County Drain Commission, Ottawa County Road Commission
Sand Creek	12	10	8	11	3	8.8	5	High	Sand Creek Watershed Partners	Walker, Kent County Drain Commission, Kent County Road Commission
Indian Mill Creek	5	4	13	22	1	9.0	8	High	Friends of Indian Mill Creek	Grand Rapids, Walker, Kent County Drain Commission, Kent County Road Commission

Table 4.3 – Critical Areas for Restoration*

Subwatershed Management Unit	Sediment Load (average based on P-LOAD, SWAT, HIT)	Nutrient Load (based on P-LOAD)	TMDL Nonattainment Reaches (report status)	Wetland Restoration Areas (%)	Known NPS Sites (no.)	Average Ranking Score	Priority		Watershed Organization	MS4 Communities
Mud Creek	6	5	15	10	10	9.2	9	High	Thornapple River Watershed Council	
Lower Rogue River	3	2	16	20	7	9.6	10	High	Rogue River Watershed Council	Plainfield Township, Rockford, Sparta, Kent County Drain Commission, Kent County Road Commission
Prairie Creek	10	3	16	12	10	10.2	11	Medium		
Bass River	22	20	3	1	6	10.4	12	Medium		Allendale Township, Georgetown Township, Hudsonville, Ottawa County Drain Commission, Ottawa County Road Commission
Spring Lake/Norris Creek	15	14	16	2	10	11.4	13	Medium	Spring Lake-Lake Board, Rein in the Runoff Committee	Ferrysburg, Spring Lake, Ottawa County Drain Commission, Ottawa County Road Commission
Libhart Creek	19	15	16	3	10	12.6	14	Medium		
Lake Creek	13	25	8	9	10	13.0	15	Medium		
Coldwater River	23	24	2	13	5	13.4	16	Medium	Coldwater River Watershed Council, Thornapple River Watershed Council	
Coopers, Clear, and Black Creeks	20	16	8	15	10	13.8	17	Medium		
Bellemy Creek	21	23	16	4	10	14.8	18	Medium		

Table 4.3 – Critical Areas for Restoration*

Subwatershed Management Unit	Sediment Load (average based on P-LOAD, SWAT, HIT)	Nutrient Load (based on P-LOAD)	TMDL Nonattainment Reaches (report status)	Wetland Restoration Areas (%)	Known NPS Sites (no.)	Average Ranking Score	Priority		Watershed Organization	MS4 Communities
Crockery Creek	27	26	8	6	10	15.4	19	Medium		
Deer Creek	14	27	6	21	9	15.4	19	Medium		
Lower Thornapple River	11	17	13	28	10	15.8	21	Low	Thornapple River Watershed Council	Cascade Township, Kent County Drain Commission, Kent County Road Commission
Dickerson Creek	26	11	16	18	10	16.2	22	Low		
Lower Flat River	18	13	16	25	10	16.4	23	Low		
Bear Creek	17	22	16	23	10	17.6	24	Low		Kent County Drain Commission, Kent County Road Commission, Plainfield Township
Mill Creek	30	28	6	16	10	18.0	25	Low		Plainfield Township, Kent County Drain Commission, Kent County Road Commission
Fall Creek	16	18	16	31	10	18.2	26	Low	Thornapple River Watershed Council	
Upper Flat River	25	19	16	24	10	18.8	27	Low		
Cedar Creek	28	12	16	29	10	19.0	28	Low	Thornapple River Watershed Council	
High Bank Creek	24	21	16	26	10	19.4	29	Low	Thornapple River Watershed Council	
Wabasis and Beaver Dam Creek	31	30	16	19	10	21.2	30	Low		
Glass Creek	29	29	16	30	10	22.8	31	Low	Thornapple River Watershed Council	

*The process for ranking the 31 subwatershed management units by these 7 categories is explained in the narrative.

4.4.2 CRITICAL RESTORATION SITES

The identification of critical sites within the critical areas defines the sites to implement Best Management Practices (BMPs). Critical sites were identified during the field investigations conducted in the Watershed. These NPS sites are illustrated on the Subwatershed Management Unit Summary Sheets (Appendix 4.1). Assessments will be needed in the future to identify additional critical sites in subwatershed management units that have not yet been inventoried (Figure 3.2)

4.5 IDENTIFICATION OF PRIORITY AREAS FOR PRESERVATION AND PROTECTION

Priority areas for preservation and protection include subwatershed management units that have the high-quality features necessary for healthy ecosystems. The identification of critical sites within the priority areas is to target ecologically significant parcels to protect.

4.5.1 SUBWATERSHED MANAGEMENT UNIT PRIORITIZATION

The Steering Committee ranked the subwatershed management units by their priority areas for preservation and protection based on four categories:

1. Permanently protected lands (%) – lands permanently protected by the government (e.g., parkland, state game areas);
2. Existing wetlands (%) - wetland areas identified by the National Wetland Inventory;
3. Occurrence of endangered, threatened, or special concern species or rare plant communities (%) – status of species and plant communities was determined by the Michigan Natural Features Inventory (MNFI); and
4. Trout streams (%) – stream reaches designated as suitable for trout by the MDNRE.

Each subwatershed management unit was given a ranking under each of the four categories: 1 being the best condition (e.g., highest percentage of existing wetlands). All four category rankings were then averaged by subwatershed management unit to determine the final ranking. Table 4.4 shows the priority subcatchments for preservation and protection based on their existing high-quality features. Overall, the Glass Creek subwatershed management unit is the most imperative for protection and preservation due primarily to high percentage of permanently protected lands and MNFI occurrences. Figure 4.2 depicts the priority areas for preservation and protection.

Table 4.4 – Priority Areas for Preservation and Protection*

Subwatershed Management Unit	Permanently Protected Lands (%)	Existing Wetlands (%)	Michigan Natural Features Inventory (occurrences by %)	Trout Streams (%)	Average Ranking Score	Priority		Watershed Organization	MS4 Communities
Glass Creek	1	7	1	9	4.5	1	High		
Bear Creek	10	15	2	2	7.3	2	High	Bear Creek Watershed Council	Kent County Drain Commission, Kent County Road Commission, Plainfield Township
Spring Lake/Norris Creek	7	2	9	11	7.3	3	High	Spring Lake-Lake Board, Rein in the Runoff Committee	Ferrysburg, Spring Lake, Ottawa County Drain Commission, Ottawa County Road Commission
Dickerson Creek	2	1	14	15	8.0	4	High		
Mill Creek	17	12	7	3	9.8	5	High		Plainfield Township, Kent County Drain Commission, Kent County Road Commission
Upper Rogue River	3	14	11	12	10.0	6	High	Rogue River Watershed Council	
Wabasis and Beaver Dam Creek	6	13	5	26	12.5	7	High		
Cedar Creek	24	6	8	12	12.5	8	High		
Sand Creek	8	25	15	1	12.3	9	High	Sand Creek Watershed Partners	Walker, Kent County Drain Commission, Kent County Road Commission
Lower Flat River	12	8	12	20	13.0	10	High		
Lower Thornapple River	4	21	6	21	13.0	11	Medium	Thornapple River Watershed Council	Cascade Township, Kent County Drain Commission, Kent County Road Commission

Table 4.4 – Priority Areas for Preservation and Protection*

Subwatershed Management Unit	Permanently Protected Lands (%)	Existing Wetlands (%)	Michigan Natural Features Inventory (occurrences by %)	Trout Streams (%)	Average Ranking Score	Priority		Watershed Organization	MS4 Communities
Direct Drainage to Lower Grand River	5	19	13	17	13.5	12	Medium		Allendale Township, Georgetown Township, Ferrysburg, Grand Haven, Spring Lake, Cascade Township, Plainfield Township, East Grand Rapids, Grand Rapids, Grand Rapids Township, Walker, Grandville, Wyoming, Kentwood, Kent County Drain Commission, Kent County Road Commission, Ottawa County Drain Commission, Ottawa County Road Commission
Indian Mill Creek	13	31	4	6	13.5	13	Medium	Friends of Indian Mill Creek	Grand Rapids, Walker, Kent County Drain Commission, Kent County Road Commission
Lower Rogue River	11	18	20	10	14.8	14	Medium	Rogue River Watershed Council	Plainfield Township, Rockford, Sparta, Kent County Drain Commission, Kent County Road Commission
Fall Creek	20	4	10	26	15.0	15	Medium		
Coopers, Clear, and Black Creeks	19	3	17	24	15.8	16	Medium		
Buck Creek	14	29	16	7	16.5	17	Medium		Grandville, Wyoming, Kentwood, Kent County Drain Commission, Kent County Road Commission
High Bank Creek	26	5	19	18	17.0	18	Medium		
Lake Creek	23	23	18	4	17.0	19	Medium		

Table 4.4 – Priority Areas for Preservation and Protection*

Subwatershed Management Unit	Permanently Protected Lands (%)	Existing Wetlands (%)	Michigan Natural Features Inventory (occurrences by %)	Trout Streams (%)	Average Ranking Score	Priority		Watershed Organization	MS4 Communities
Upper Flat River	9	9	26	25	17.3	20	Medium		
Prairie Creek	30	11	22	8	17.8	21	Medium		
Plaster Creek	15	27	3	26	17.8	22	Medium	Plaster Creek Stewards	Cascade Township, East Grand Rapids, Grand Rapids, Grand Rapids Township, Wyoming, Kentwood, Kent County Drain Commission, Kent County Road Commission
Crockery Creek	16	17	28	16	19.3	23	Low		
Bass River	21	10	25	23	19.8	24	Low		Allendale Township, Georgetown Township, Hudsonville, Ottawa County Drain Commission, Ottawa County Road Commission
Coldwater River	18	26	23	14	20.3	25	Low	Coldwater River Watershed Council	
Bellemy Creek	25	24	31	5	21.3	26	Low		
Upper Thornapple River	27	22	21	22	23.0	27	Low	Thornapple River Watershed Council	
Deer Creek	29	20	29	19	24.3	28	Low		
Mud Creek	28	16	30	26	25.0	29	Low		
Rush Creek	22	30	24	26	25.5	30	Low		Georgetown Township, Hudsonville, Grandville, Wyoming, Kent County Drain Commission, Kent County Road Commission, Ottawa County Drain Commission, Ottawa County Road Commission
Libhart Creek	31	28	27	26	28.0	31	Low		

*The process for ranking the 31 subwatershed management units by these 6 categories is explained in the narrative.

4.5.2 PRIORITY PRESERVATION AND PROTECTION SITES

Other areas in the Watershed have protection strategies but not necessarily based on natural features or water quality.

Prime farmland soils are identified as soils that have the capacity to produce high yields. These areas are important to communities not only economically, but also for retaining the rural character desired by many. Land to preserve for farming has been identified in many communities in the Watershed and ranked as a high priority in their Master Plans. However, ensuring that the agricultural operations on these lands are not impairing water quality should also be a priority.

The MNFI conducted a Potential Conservation Areas (PCAs) study for Barry County in 2007 and Eaton County in 2008. The PCAs are defined as places on the landscape dominated by native vegetation that have various levels of potential for harboring high quality natural areas and unique natural features. These studies were not used to prioritize the Priority Areas for Presentation in the LGRW, since other counties do not have this information; however, a study completed in the other Watersheds is recommended. The PCAs in Barry County and Eaton County are identified in the Subwatershed Management Unit Summary Sheets in Appendix 4.1.

Riparian areas should be kept intact and provide connections to other areas of high quality habitat. Figure 2.13 illustrates the natural connections recommended for the Watershed. These areas correspond to the priority areas for preservation in Figure 4.2, but provide a greater level of detail as to specific sites for preservation.

When the MDNRE Fisheries Assessment for the Grand River is released to the public, a review will be conducted to identify high priority areas for fish habitat preservation. Initially, the Prairie Creek Subwatershed Management Unit has been identified as one of those areas to preserve.