CHAPTER 2 – WATER QUALITY CONDITIONS

This chapter describes the existing physical habitat, chemical, and biological conditions of the Belle River. In Appendix F, a data gap analysis summarizes additional information that should be collected depending on local and project-specific priorities.

The Belle River Watershed has a complex history of activities that have impacted water quality and the river's physical integrity, particularly over the past 100 years. These activities have included:

- Intense agricultural use,
- Uncontrolled tile drainage,
- Dredging and channelization,
- Historic mill dams,
- Mining of sand and gravel,
- Development and increased impervious cover,
- Road crossing installations,
- Silviculture,
- Clearing and snagging of large woody material,
- Riprapping of riverbanks,
- In-line irrigation ponds,
- Mining of oil and gas reserves,
- Pipelines and utility lines,
- Floodplain encroachment and fill, and
- Point source discharges from industrial and municipal wastewater plants.

Today, many of the pollution sources for the Belle River Watershed have changed. Point sources have been controlled. A point source is a discernible outlet from a man-made ditch, pipe, or other conveyance and has a specific legal definition for regulatory purposes. The impacts from many historical point discharges have been eliminated, such as impacts from mining of sand and gravel and mining of oil and gas reserves. Point source discharges from municipal wastewater facilities has decreased as significant improvements have been made in the function and design of these facilities. However, point source discharges still exist from municipal sources and from failing on-site sewage (septic) disposal systems in rural areas. Additionally, an ongoing point source is coal ash discharges to the air and river from the Detroit Edison power plant at King Road in East China Township.

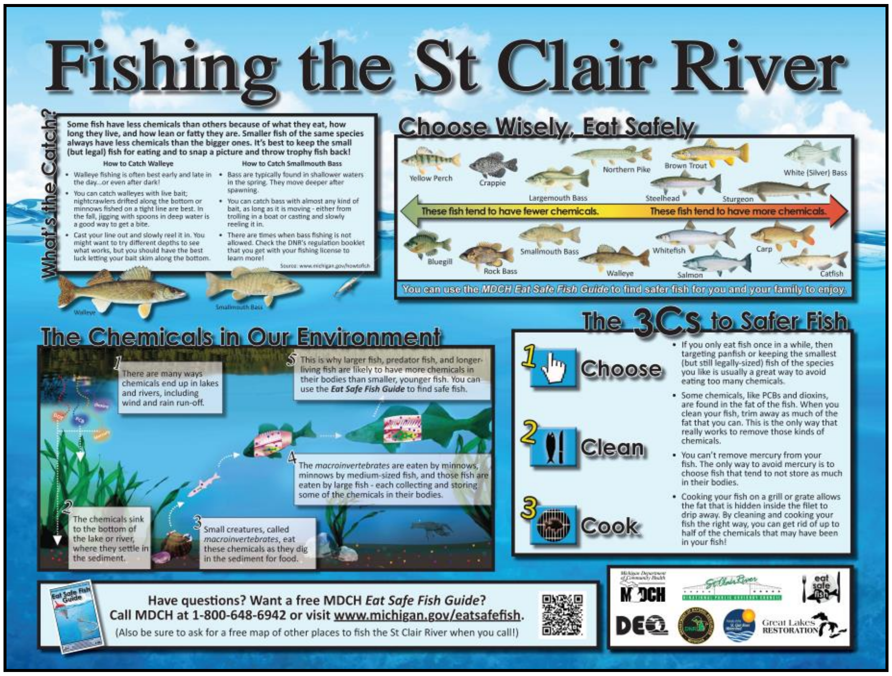
Nonpoint sources are sources of pollution that do not meet the legal definition of a point source and generally result from land runoff, precipitation, atmospheric deposition, drainage, seepage, or hydrologic modification. Although the percentage of agricultural use has fluctuated over the years, it still remains the dominant land use at 57.5%. Family farmers are some of the strongest conservationists in the watershed; however, outdated drainage and farm land management practices have had and continue to have considerable nonpoint source impacts on the river. Despite these impacts, the middle section of the Belle River remains one of the highest quality rivers in southeast Michigan.

2.1 Water Quality

The priority water quality concerns for the Belle River include the subwatersheds in the headwaters that have a TMDL for low dissolved oxygen and have high nutrient and fine sediment loads. Additional priority water quality concerns include the Belle River and tributaries that have been listed for TMDL development due to high levels of *E. coli* (subwatersheds 18, 19, 20, 21) and mercury in the water column (subwatersheds 22, 23, 24). These typical nonpoint source pollutants have long-term chronic impacts on river and human health. This plan focuses on these unregulated diffuse (nonpoint) sources of pollutants.

Dissolved oxygen levels in the headwaters of the watershed are often below the State's water quality standard. Phosphorus levels usually exceed regional reference conditions, but nitrogen levels are lower than reference conditions. Excessive sediment deposition is extensive through most of the county drains, whereas impacts due to sediment are isolated to localized problems along the main river. Chloride levels are higher than adjacent watersheds, such as the Clinton River Watershed and Black River Watershed, possibly due to poor road salt application practices or wastewater treatment plant discharges. The water in the Belle River is generally a calcium bicarbonate type (Knutilla, 1969); the local geology provides a high buffering capacity to the water which minimizes the impacts of acid rain.

Although toxic discharges in the St. Clair River Watershed have been reduced in the last 25 years, persistent contaminants in sediments continue to pose a potential risk to human health and the environment. The bioaccumulation of toxic contaminants in the food chain can also pose a risk to humans, wildlife, and aquatic organisms. As a result, advisories against consumption of fish are in place in the St. Clair River (Figure 2.1). As fish migrate or move into the Belle River Watershed from the St. Clair River, these organisms may pose human health and environmental risks.



Fishing the St Clair River

What's the Catch?

Some fish have less chemicals than others because of what they eat, how long they live, and how lean or fatty they are. Smaller fish of the same species always have less chemicals than the bigger ones. It's best to keep the small (but legal) fish for eating and to snap a picture and throw trophy fish back!

How to Catch Walleye

- Walleye fishing is often best early and late in the day...or even after dark!
- You can catch walleyes with live bait; nightcrawlers drifted along the bottom or minnows fished on a tight line are best. In the fall, jigging with spoons in deep water is a good way to get a bite.
- Cast your line out and slowly reel it in. You might want to try different depths to see what works, but you should have the best luck letting your bait skim along the bottom.

How to Catch Smallmouth Bass

- Bass are typically found in shallower waters in the spring. They move deeper after spawning.
- You can catch bass with almost any kind of bait, as long as it is moving - either from trolling in a boat or casting and slowly reeling it in.
- There are times when bass fishing is not allowed. Check the DNR's regulation booklet that you get with your fishing license to learn more!

Source: www.michigan.gov/howtofish

Choose Wisely, Eat Safely

These fish tend to have fewer chemicals. These fish tend to have more chemicals.

You can use the *MDCH Eat Safe Fish Guide* to find safer fish for you and your family to enjoy.

The Chemicals in Our Environment

1 There are many ways chemicals end up in lakes and rivers, including wind and rain run-off.

2 The chemicals sink to the bottom of the lake or river, where they settle in the sediment.

3 Small creatures, called *macroinvertebrates*, eat these chemicals as they dig in the sediment for food.

4 The *macroinvertebrates* are eaten by minnows, minnows by medium-sized fish, and those fish are eaten by large fish - each collecting and storing some of the chemicals in their bodies.

5 This is why larger fish, predator fish, and longer-living fish are likely to have more chemicals in their bodies than smaller, younger fish. You can use the ***Eat Safe Fish Guide*** to find safe fish.

The 3Cs to Safer Fish

1 Choose

2 Clean

3 Cook

- If you only eat fish once in a while, then targeting panfish or keeping the smallest (but still legally-sized) fish of the species you like is usually a great way to avoid eating too many chemicals.
- Some chemicals, like PCBs and dioxins, are found in the fat of the fish. When you clean your fish, trim away as much of the fat that you can. This is the only way that really works to remove those kinds of chemicals.
- You can't remove mercury from your fish. The only way to avoid mercury is to choose fish that tend to not store as much in their bodies.
- Cooking your fish on a grill or grate allows the fat that is hidden inside the filet to drip away. By cleaning and cooking your fish the right way, you can get rid of up to half of the chemicals that may have been in your fish!

Have questions? Want a free MDCH *Eat Safe Fish Guide*?
Call MDCH at 1-800-648-6942 or visit www.michigan.gov/eatsafefish.
(Also be sure to ask for a free map of other places to fish the St Clair River when you call!)

Figure 2.1 Fish consumption advisory sign for the St. Clair River Area of Concern (Source: Michigan Department of Community Health)

2.1.1 Total Maximum Daily Load (TMDL)

The Clean Water Act requires Michigan to report on the quality of its water resources to provide water quality information to the US EPA and the US Congress. The report lists Michigan waterbodies that are not attaining all of the designated uses for waters of the state and may require the establishment of Total Maximum Daily Loads (TMDLs) to meet and maintain Water Quality Standards (WQS). A TMDL is a value, typically in pounds per day, which reflects the allowable loading rate of a pollutant to a waterbody to assure that the WQS are met. A TMDL document is developed by the state to provide a basis for determining the pollutant reductions necessary from both point and nonpoint sources to restore and maintain the quality of the water resources.

A dissolved oxygen (DO) TMDL has been established for the Belle River Watershed (MDEQ, 2004) (Table 2.1). Intensive surveys conducted in the summers of 1973 and 1982 in the Belle and North Branch Belle Rivers near Imlay City revealed DO levels below the present warmwater DO standard of 5mg/L (DEQ, 2004). Additional surveys in 2002 showed that DO standard nonattainment continues to occur in the Belle and North Branch Belle Rivers near and below Imlay City. Subwatersheds 1, 2, 3 and parts of subwatersheds 4, 5, 6, 8, 13, and 16 are listed as source locations to the TMDL areas. Subwatersheds 4, 7, 8, 9, 10, 11, 12 and part of subwatersheds 13, 14, 15, and 16 were listed as impaired (Figure 2.2). Exhibit 12 in Appendix B provides a larger map of the TMDL areas.

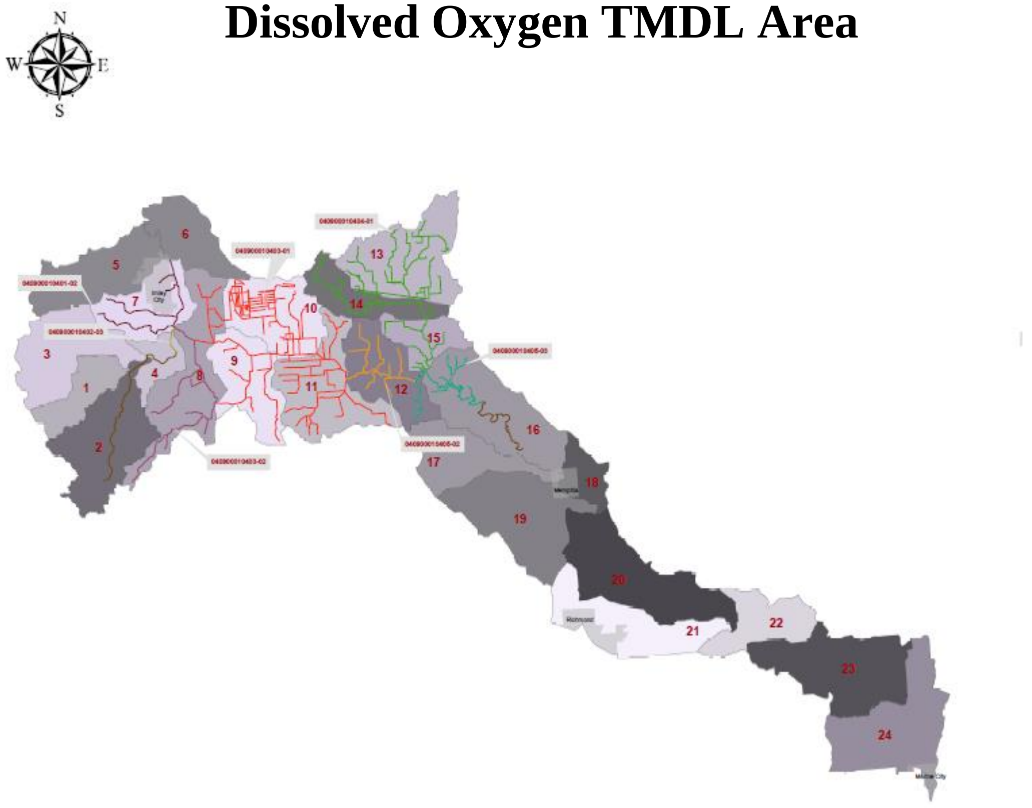


Figure 2.2 Dissolved Oxygen TMDL areas in the Belle River Watershed

Table 2.1 Belle and North Branch Belle Rivers DO TMDL reaches

River	Reach Start	Reach End	Distance (mi)
Belle River	Riley Center Road	Webster Road	17.1
North Branch Belle River	Belle River confluence	Blacks Corners Road	4.2

Monitoring oxygen levels in rivers is important because adequate dissolved oxygen is necessary for all forms of aquatic life. As dissolved oxygen levels drop below 5 mg/L, aquatic life is put under stress, and extremely low DO levels can result in fish kills. Rivers both produce and consume oxygen. Water can gain oxygen from the atmosphere and from plants as a result of photosynthesis. The turbulence of running water dissolves more oxygen than still water. Respiration by aquatic animals, decomposition, and various chemical reactions consume oxygen. Sources of oxygen-consuming waste include wastewater discharges and stormwater runoff from farmland or urban streets, feedlots, and failing septic systems (USEPA, 1997). DO levels fluctuate seasonally and diurnally (from day-to-night).

The 2002 MDEQ study indicates that in order to decrease sediment oxygen demand and nutrient loads to the Belle River and its tributaries, the loading of suspended sediments to the rivers must be reduced. Reducing sediment loads would likely result in an increase in dissolved oxygen levels in the rivers. Non-commercial land uses in the townships of Almont, Attica, Berlin, Brockway, Dryden, Emmet, Goodland, Imlay, Mussey, and Riley are the major sources of total suspended sediment (TSS) in the TMDL area.

Other TMDLs have also been scheduled for development in the Belle River Watershed. In the MDEQ Integrated Report completed in March 2014, a new listing was created for the Jerome Creek subwatershed of the Belle River for not supporting the Designated Use of Total Body Contact Recreation as a result of elevated *E. coli* levels (MDEQ, 2014). A TMDL to address *E. coli* concentrations is scheduled to be developed in 2029.

Additionally, the Belle River in not supporting the Designated Use of Other Indigenous Aquatic Life and Wildlife and Fish consumption as a result of mercury in the water column. A TMDL was scheduled to be developed in 2014 to address mercury pollution. Mercury pollution in the region is largely a result of atmospheric deposition from industrial sources, thus specific projects and goals to decrease mercury levels will not be

Additionally, part of the North Branch of the Belle River has been found to be no supporting the designated use for Other Indigenous Aquatic Life and Wildlife due to direct habitat alterations and other flow regime alterations. This issue is addressed throughout the WMP, but the MDEQ will not be developing a TMDL because this impairment is not the result of a direct pollutant, thus an allowable pollutant level cannot be established.

2.1.2 Biological Oxygen Demand (BOD)

The decomposition of organic matter puts a demand on the dissolved oxygen in water bodies. Biochemical oxygen demand (BOD) is a measure of the amount of dissolved oxygen required to break down organic matter, in a waterway. BOD loading rates are higher in the winter months and correspond with streamflow (Figure 2.3). Neither the MDEQ nor the US EPA have set an ambient water quality criterion for BOD; criteria are set directly for dissolved oxygen (DO) concentrations. However, it is generally considered that if BOD concentrations are between 6 to 10 mg/L, conditions are poor and the water body is somewhat degraded. Data collected from 1947 to 2005 indicates the average BOD was less than 6mg/L for the Belle River; however, some individual samples were well above 10mg/L (USGS, 2007). This data indicates that BOD is not always a problem but is a concern and could be contributing to the low DO levels.

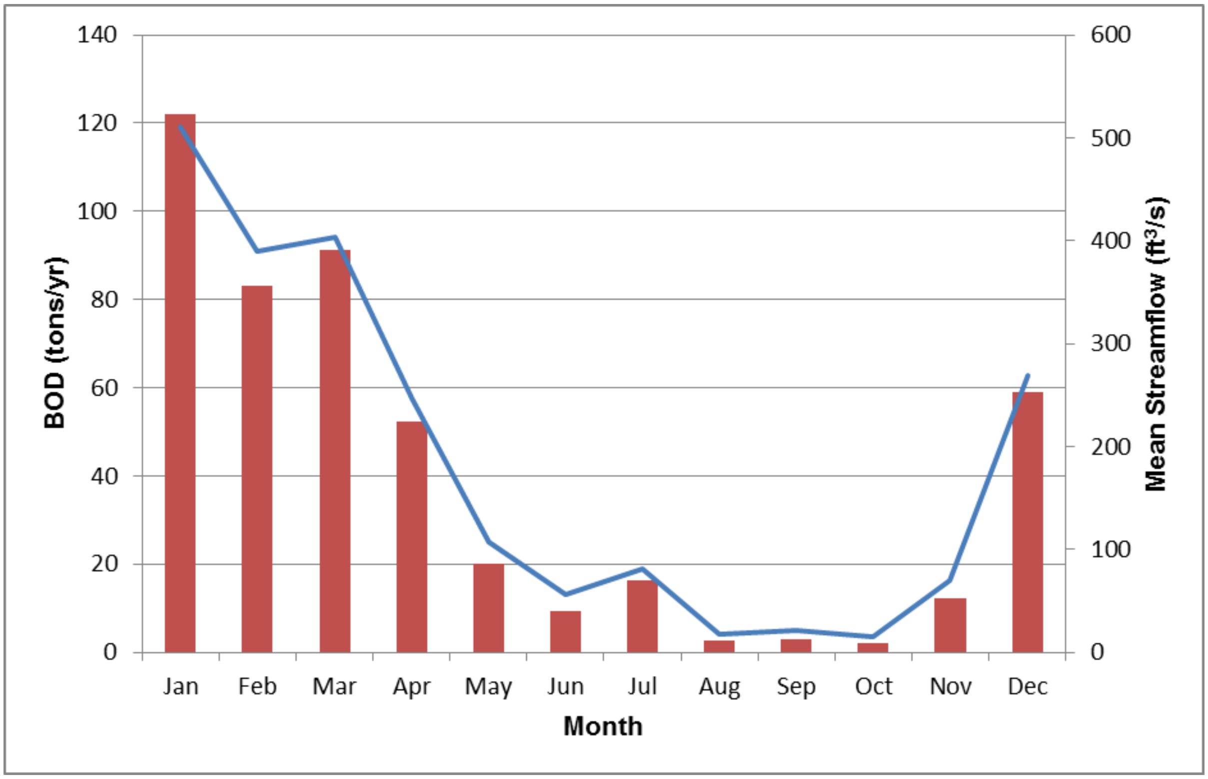


Figure 2.3 Estimated monthly biological oxygen demand loads near Marine City (USGS, 2007)

2.1.3 Turbidity and Suspended Solids

Erosion is the detachment of soil by wind or water and sedimentation is the settling out of suspended solids caused by erosion. Turbidity is the relative clarity of water as indicated by the extent which light penetration is reduced. Therefore, turbidity is an indirect measure of dissolved and suspended solids. High turbidity can inhibit photosynthesis production and affect fish development and growth. As the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macroinvertebrates (US EPA, 2000). Turbidity can be measured using a Secchi disk, an 8-inch diameter disk with alternating black and white quadrants, which is lowered into the water column. The point at which the disk can no longer be seen from the surface is a measure of lake turbidity.

Suspended sediment concentration (SSC) is a measure of suspended solid materials in surface waters. SSC measures the dry weight of all the sediment from a known volume of a water-sediment mixture (Gray et al., 2000). This measure produces reliable results for natural waters. Total suspended solids (TSS) measures the total dry weight of particles trapped by a filter per unit of water. Suspended solids can serve as carriers of nutrients and toxic pollutants by adsorption to particles. Higher levels of suspended solids can also clog irrigation devices. Excessive amounts of inorganic fine sediments have the greatest biological effects on the river.

The Michigan WQS states that waters of the state shall not have any of the following unnatural physical properties in quantities which are, or may become, injurious to any designated use: turbidity, color, oil films, floating solids, foam, settleable solids, suspended solids, and deposits. This kind of rule, which does not establish a numeric level, is known as a narrative standard. It is generally considered that water with a TSS concentration of less than 20 mg/L is clear. Water with TSS levels between 40 and 80 mg/L tends to appear cloudy, while water with concentrations over 150 mg/L usually appears muddy. The nature of the particles that make up the suspended solids may cause these numbers to vary as well (MDEQ, 2006).

The middle and lower reaches of the Belle River are negatively affected by suspended solids inputs from the Belle River Intercounty Drain and other tributary drains in the headwaters which tend to have high turbidity levels following rain events due to re-suspension of fine sediments. Based on the Lake St. Clair Regional Monitoring Program, 3 out of 28 samples at King Road in China Township and 1 out of 18 samples at M-19 in Memphis exceeded 40 mg/L TSS. Historical wetland loss has caused a 64% loss in the functional capacity of wetlands to retain sediments (Appendix E).

Cropland and ditches are the main sediment sources in the TMDL area of the headwaters. Construction sites, streambank erosion, hillslope failures, and road crossings are additional source areas in subwatersheds 17-24. The results of a field survey completed in 2013 of nonpoint source areas in subwatersheds 4, 6, 7, 10, 14, and 15 are provided in Appendix G and summarized in Table 2.2. During the survey, a total of 58 critical properties or parcels were identified in the field – 33 in Lapeer County and 25 in St. Clair County. A total of 108 source areas were identified because there was often more than one source on a property (e.g. a poor stream crossing and gully erosion on the same property). Priority source areas were identified after the results were ranked based on sediment volume, erosion severity, source size, or runoff characteristics. These priority areas are places where the greatest pollutant reductions will be achieved by treating the fewest sources at the least cost. More information about sediment and channel stability is provided in Section 2.3.

Table 2.2 Results of 2013 pollutant source identification surveys

Source Category	No. Sites	No. Priority Sites
1. Stream Crossings	24	6
2. Gully Erosion	8	4
3. Inadequate Riparian Buffer	20	10
4. Streambank Erosion	9	5
5. Livestock Access	1	0
6. Nonpoint Ag. Sources	44	8
7. Tile Outlet	2	1
TOTAL	108	34

2.1.4 Phosphorus

Phosphorus is an important nutrient for plant and algae growth. Although this nutrient is necessary, excessive amounts can lead to eutrophication or undesirable growth of excessive algae or aquatic plants. Indirectly, excess nutrients can affect dissolved oxygen, ammonia levels as well as odors, biological communities, and aesthetics. In most freshwater systems, phosphorus is considered a “limiting” nutrient. As phosphorus is in short supply, even a modest increase in the nutrient can often set off a chain of undesirable events in a stream including accelerated plant growth, algal blooms, low dissolved oxygen, and the death of certain fish, invertebrates, and other aquatic animals (EPA, 1997). Nonpoint sources of nutrients mostly enter the waterways from agricultural runoff, animal wastes, residential runoff from fertilizers and dumping of yard wastes, and commercial sites.

The US EPA recommends an ambient total phosphorus criterion of 0.033 mg/L for rivers and streams in this study area (US EPA, 2000). More than 93 percent of the phosphorus concentrations for the Belle River evaluated by USGS (Healy et al., 2007) were greater than this criterion. Phosphorus loading estimates were calculated for a site near Marine City (Figure 2.4). Total phosphorus loadings tend to vary seasonally with flow.

Excessive nutrients can originate from point and nonpoint sources. Urban and agricultural runoff is typically high in nitrogen and phosphorus compounds. Substantial loads of suspended sediment from urban and agricultural areas can results in substantial inputs of phosphorus. Wastewater treatment plants can be a prominent point source of nutrients, particularly phosphorus. There four individual National Pollutant Discharge Elimination System (NPDES) discharges, five non-storm water general permitted discharges, and 11 industrial stormwater permitted facilities in the Belle and North Belle Rivers near Imlay City. Of these facilities, the Imlay City WWTP and Pinnacle Foods-Imlay City are the greatest sources of phosphorus loading (MDEQ, 2004). However, agricultural runoff appears to be the major source of phosphorus, particularly in the headwaters. Failing septic sites can also be a nutrient source, and stakeholders in the watershed have expressed concerns about failing onsite sewage disposal systems. Historical wetland loss has caused a 68% loss in the functional capacity of wetlands to transform nutrients (Appendix E).

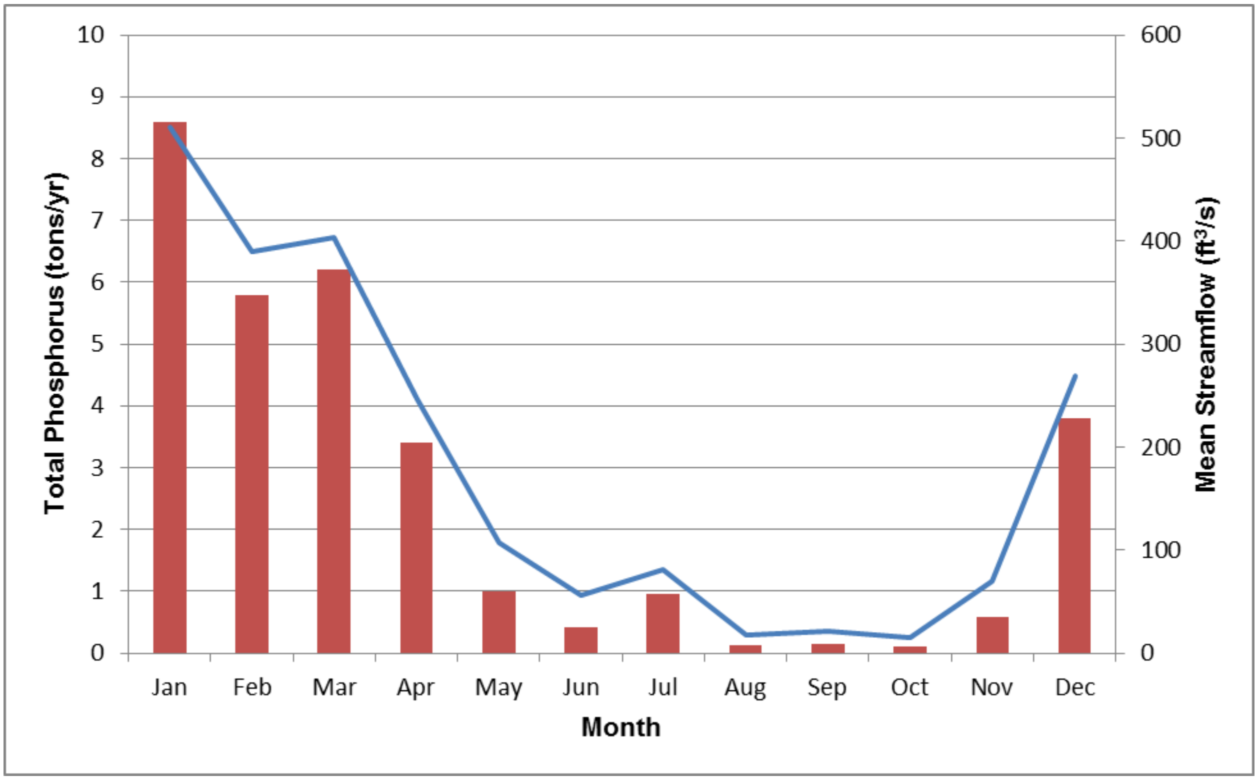


Figure 2.4 Estimated monthly phosphorus loads near Marine City (USGS, 2007)

2.1.5 Nitrogen

Nitrogen takes many forms in aquatic systems and the nitrogen cycle is more complex than the phosphorus cycle due to atmospheric sources. Various forms of nitrogen are important nutrients for aquatic life but can contribute to cultural eutrophication and are important to manage. Median concentrations of total nitrogen were well below the US EPA recommended maximum for total nitrogen ambient water-quality criterion of 0.54 mg N per L (Healy et al., 2007). Nitrogen concentrations are not a concern in the Belle River Watershed. Total nitrogen loadings also tend to vary seasonally with flow because aquatic organisms utilize nutrients more readily in the summer versus the winter (Figure 2.5).

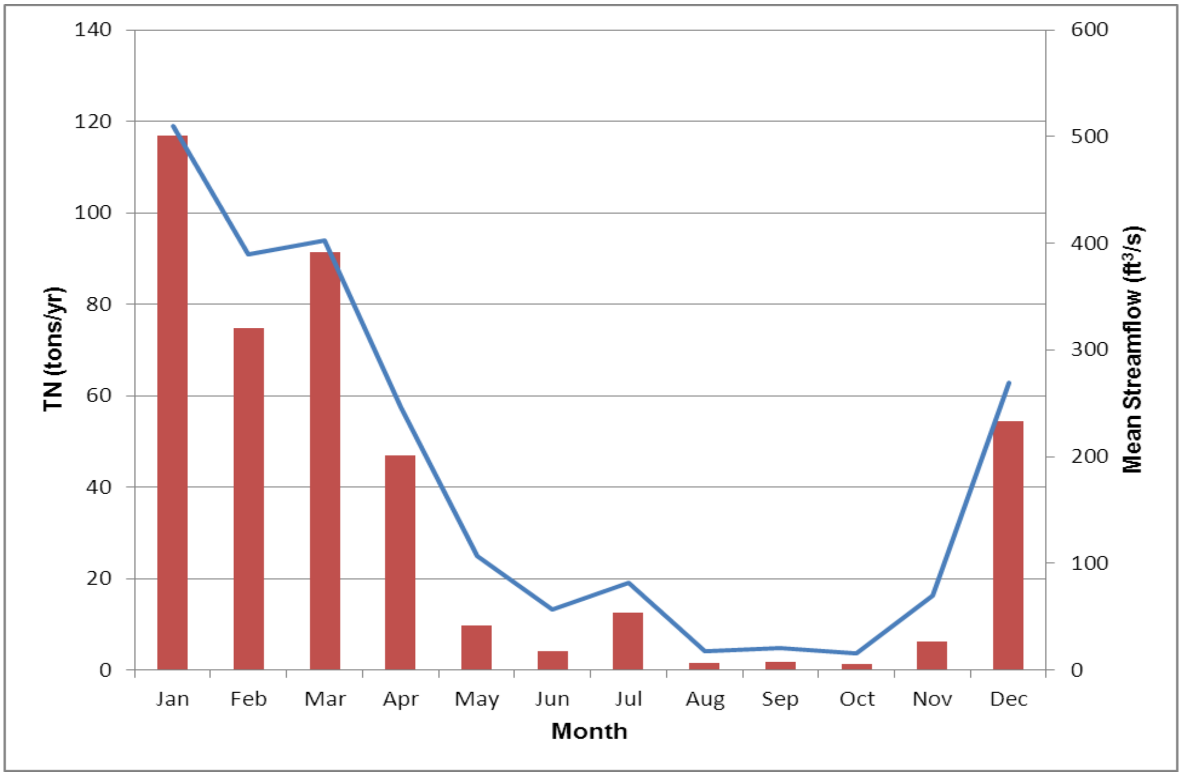


Figure 2.5 Estimated monthly total nitrogen loads near Marine City (USGS, 2007)

2.1.6 Chloride

Recent studies have shown that the thousands of tons of road salt applied each winter are mostly retained in our watersheds (U. of Minnesota, 2009). Long-term impacts of even moderate chloride levels will have a significant impact on aquatic life and species diversity. Major anthropogenic sources of chloride within the Belle River Watershed are agricultural and urban (road salt) runoff and municipal and industrial wastewater discharges.

The USEPA criterion maximum concentration (CMC) for chloride is 860 mg/L, and the criterion continuous concentration (CCC) is 230 mg/L (US EPA, 1988). For chloride, the CMC is the concentration that should not be exceeded for 1 hour once every 3 years; the CCC is the concentration that should not be exceeded for 4 days once every 3 years. As in many other areas of Michigan, chloride concentrations are increasing in streams throughout the Lake St. Clair basin (MCHD, 2007). During the Lake St. Clair Study, there were nine sites found to exceed the CMC chloride concentrations throughout the St. Clair River Watershed, with the six largest quantities being in the Belle River Watershed. Chloride loadings were highest in the winter and spring seasons because road salt is most heavily used during these seasons, leading to more non-point runoff of chloride (Figure 2.6).

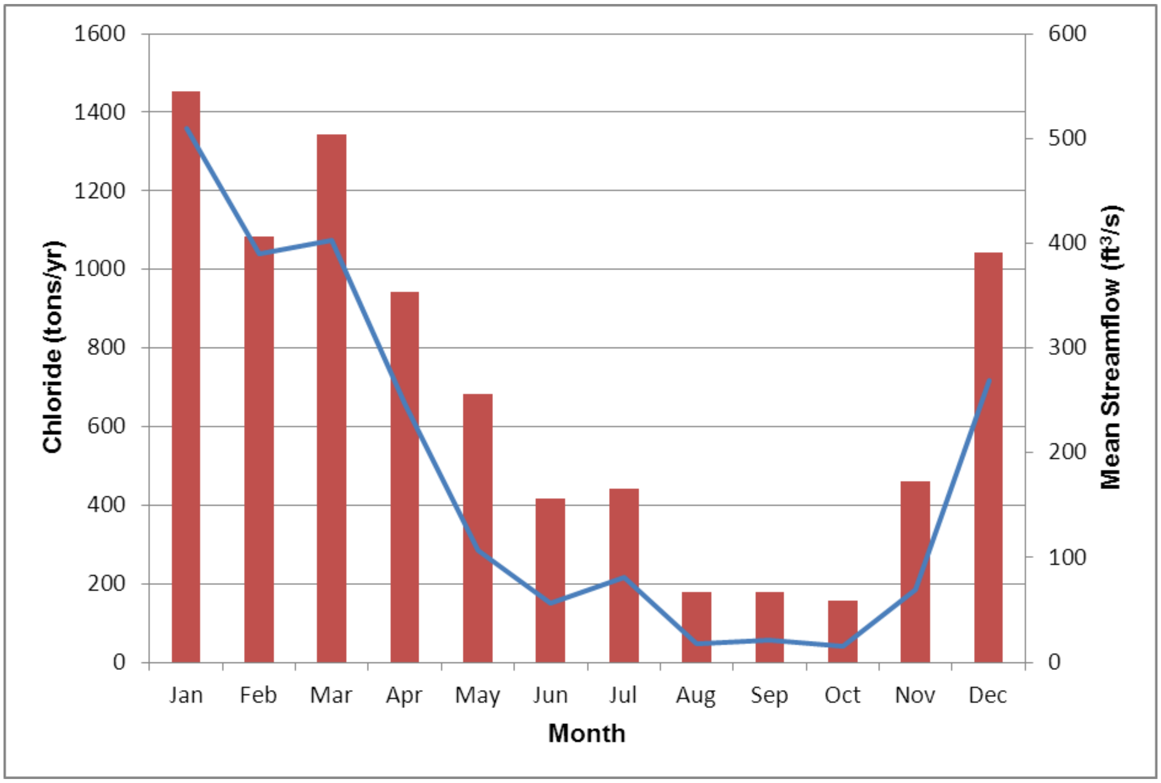


Figure 2.6 Estimated monthly chloride loads near Marine City (USGS, 2007)

2.1.7 Surface Water Temperature

Aquatic organisms from microbes to fish are dependent on certain temperature ranges for their optimal health (EPA, 1997). Temperature also drives rates of chemical processes and affects dissolved oxygen levels. Michigan's water quality standards dictate that warmwater fisheries shall not exceed a monthly maximum temperature of 84°F in June or 85°F in July-August. By comparison, coldwater fisheries shall not exceed 68°F in June through August.

Recent summer monitoring of the Belle River indicated water temperatures of over 75°F near M-19 (Healy et al., 2007). The Belle River is classified as a Type IV Trout Stream to support a migratory steelhead fishery. Although the Belle River is not a designated coldwater fishery, it could sustain a more healthy and diverse fishery if the summertime high temperatures were a few degrees cooler. Practices resulting in increased base flows and canopy shading along tributaries could reduce thermal impacts.

2.1.8 Pesticides

Pesticides, herbicides, insecticides, and fungicides, have been sampled in the watershed sporadically. A study by Heidelberg College (Richards, 1994) analyzed samples from a site near the mouth of the Belle River for 10 pesticides during the 1985 growing season and detected all 10 pesticides at least once. Atrazine was the most commonly detected pesticide. Lower pesticide concentrations were found in the Belle River compared to watersheds with similar agricultural land use. The MDEQ has collected minimal data on these parameters and not enough long-term data is available to fully characterize the impacts to the aquatic ecology.

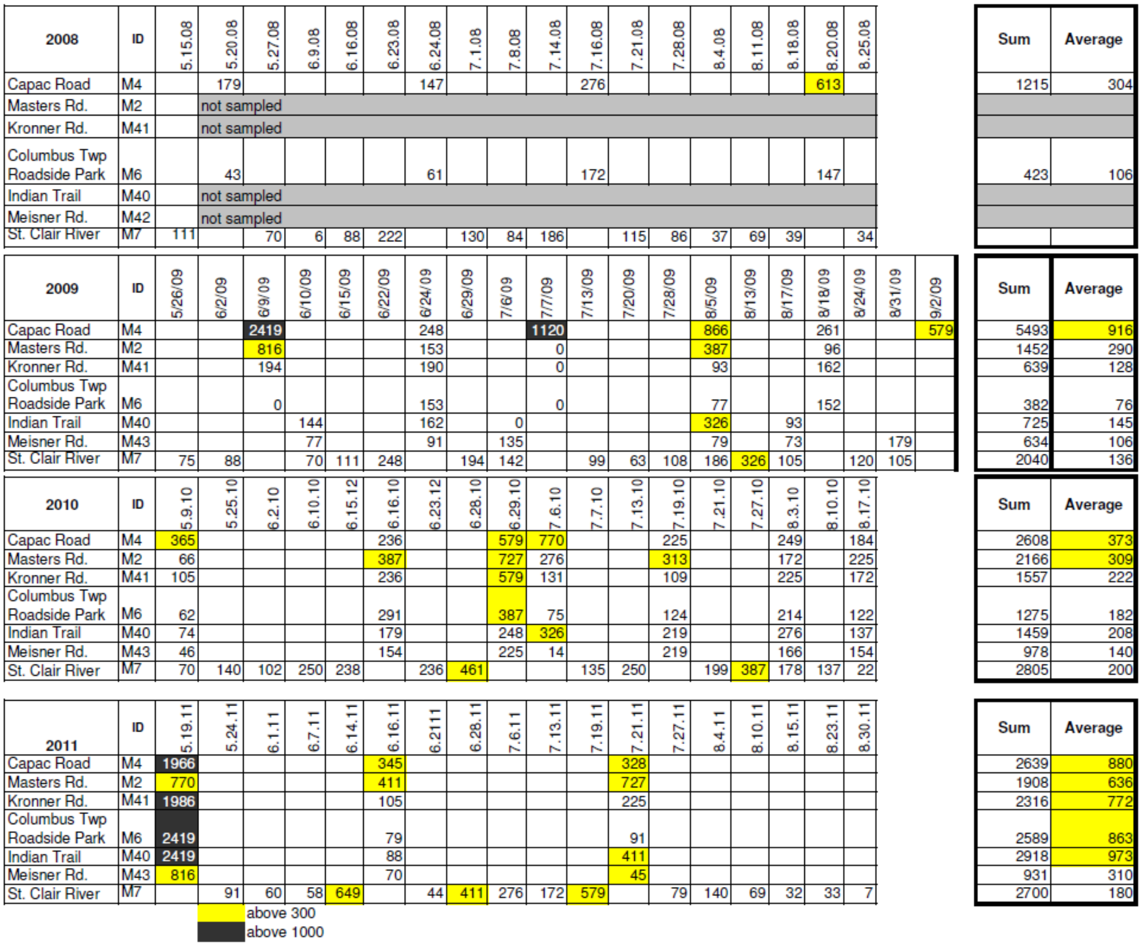
The USGS completed a survey of selected Michigan streams, including the Belle River, in 2005 to assess pesticide concentrations from March through November. Data was collected at the USGS stream gage near Marine City. Herbicides including atrazine, metolachlor, and simazine were commonly detected. Simazine concentrations were some of the highest in the Belle River (37ug/L); however, Michigan water quality criteria were not exceeded for any pesticide or herbicide in the Belle River Watershed.

2.1.9 Pathogenic Microorganisms

Escherichia coli (*E. coli*) concentration is used in Michigan as an indicator of possible sewage contamination because it is commonly found in human and animal feces. Although they are generally not harmful themselves, these bacteria indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems. Their presence in streams suggests that pathogenic microorganisms might also be present and that wading or swimming might be a health risk. *E. coli* is used as a surrogate for a range of possible pathogens to reduce sampling complexity, costs, and response time. Sources of fecal contamination to surface waters include wastewater treatment plants, failing septic systems, domestic and wild animal waste, waterfowl, mammals, and stormwater runoff. In addition to the possible health risks associated with the presence of elevated levels of fecal bacteria, they can also cause cloudy water, unpleasant odors, and an increased oxygen demand (US EPA, 1997).

According to the Michigan WQS, the full and partial body contact standard for *E. coli* is set at 300cfu/100mL and 1,000 cfu/100mL respectively. The 30-day geometric mean standard is 130cfu/100mL.Water quality data collected by the MDEQ from 2008 to 2011 shows that *E. coli* concentrations exceeded the WQS at multiple sites in all years (Table 2.3).

Table 2.3 Summary of E. coli monitoring results from 2008 to 2011 (cfu/mL)



2008	ID	5.15.08	5.20.08	5.27.08	6.9.08	6.16.08	6.23.08	6.24.08	7.1.08	7.8.08	7.14.08	7.16.08	7.21.08	7.28.08	8.4.08	8.11.08	8.18.08	8.20.08	8.25.08	Sum	Average
Capac Road	M4		179					147				276						613		1215	304
Masters Rd.	M2		not sampled																		
Kronner Rd.	M41		not sampled																		
Columbus Twp Roadside Park	M6		43					61				172						147		423	106
Indian Trail	M40		not sampled																		
Meisner Rd.	M42		not sampled																		
St. Clair River	M7	111		70	6	88	222		130	84	186		115	86	37	69	39		34		

2009	ID	5/26/09	6/2/09	6/9/09	6/10/09	6/15/09	6/22/09	6/24/09	6/29/09	7/6/09	7/7/09	7/13/09	7/20/09	7/28/09	8/5/09	8/13/09	8/17/09	8/18/09	8/24/09	8/31/09	9/2/09	Sum	Average
Capac Road	M4			2419				248			1120				866			261			579	5493	916
Masters Rd.	M2			816				153			0				387			96				1452	290
Kronner Rd.	M41			194				190			0				93			162				639	128
Columbus Twp Roadside Park	M6			0				153			0				77			152				382	76
Indian Trail	M40				144			162		0					326		93					725	145
Meisner Rd.	M43				77			91		135					79		73			179		634	106
St. Clair River	M7	75	88		70	111	248		194	142		99	63	108	186	326	105		120	105		2040	136

2010	ID	5.9.10	5.25.10	6.2.10	6.10.10	6.15.12	6.16.10	6.23.12	6.28.10	6.29.10	7.6.10	7.7.10	7.13.10	7.19.10	7.21.10	7.27.10	8.3.10	8.10.10	8.17.10	Sum	Average
Capac Road	M4	365					236			579	770			225			249		184	2608	373
Masters Rd.	M2	66					387			727	276			313			172		225	2166	309
Kronner Rd.	M41	105					236			579	131			109			225		172	1557	222
Columbus Twp Roadside Park	M6	62					291			387	75			124			214		122	1275	182
Indian Trail	M40	74					179			248	326			219			276		137	1459	208
Meisner Rd.	M43	46					154			225	14			219			166		154	978	140
St. Clair River	M7	70	140	102	250	238		236	461			135	250		199	387	178	137	22	2805	200

2011	ID	5.19.11	5.24.11	6.1.11	6.7.11	6.14.11	6.16.11	6.2111	6.28.11	7.6.11	7.13.11	7.19.11	7.21.11	7.27.11	8.4.11	8.10.11	8.15.11	8.23.11	8.30.11	Sum	Average
Capac Road	M4	1966					345						328							2639	880
Masters Rd.	M2	770					411						727							1908	636
Kronner Rd.	M41	1986					105						225							2316	772
Columbus Twp Roadside Park	M6	2419					79						91							2589	863
Indian Trail	M40	2419					88						411							2918	973
Meisner Rd.	M43	816					70						45							931	310
St. Clair River	M7		91	60	58	649		44	411	276	172	579		79	140	69	32	33	7	2700	180

🟨	above 300
⬛	above 1000

2.1.10 Dumping and Litter

Gross solids are defined as litter, trash, and large manmade materials in water courses. Yard wastes, such as leaves, grass clippings, and brush dumped along streambanks create excessive nutrient and BOD loads and impact riparian vegetation. Such organic materials should be composted outside of the riparian buffer zone.

Large-item trash collection and recycling has been eliminated in many municipalities due to budget cuts, and fees are often collected for disposal of large waste, such as tires. Incidents of dumping of large trash items such as tires and appliances in the Belle River appear to be increasing in recent years (Figure 2.7 and 2.8). Existing data is limited and is mostly based on Drain Office reports, County Park staff, and public input. For example, an estimated 50 tires were noted in the Belle River during field inventories between Kronner Road and Gratiot Ave in Columbus Township. Currently, no formal list exists for possible Belle River clean-up sites, but during the watershed inventory several sites were identified that could be used to start a prioritized list for clean-up events.

Figure 2.7 Debris in Currier Drain (Berlin Twp., Burt Rd.)

Figure 2.8 Trash in Hannah Drain (Berlin Twp., Burt Rd.)

2.1.11 Nonpoint Source Pollutants

A pollutant load is the mass or weight of pollutant transported per unit of time from a source area to a waterbody. Upland areas, particularly agricultural areas and areas without adequate riparian buffers, in the headwaters are the predominant source of pollutants in the TMDL areas (subwatersheds 1-16). Localized bank erosion and hillslope failures contribute most of the sediment to the river in the middle parts of the Belle River Watershed (subwatersheds 17-24).

As summarized in Table 2.2 in Section 2.1.2, field inventories were conducted to determine the sources of nonpoint source pollution in the TMDL areas. A total of seven pollutant source categories were evaluated: stream crossings, gully erosion, inadequate riparian buffers, streambank erosion, livestock access, nonpoint agricultural sources, and tile outlets. Tables 2.4 and 2.5 summarize the estimated annual loading rates (using Spreadsheet Tool for Estimating Pollutant Loads (STEPL) analysis; results available in the Appendix C) from inadequate riparian buffers and nonpoint agricultural sources, respectively.

Pollutant loads from non-point source areas with inadequate riparian buffers (Table 2.4) and areas with nonpoint agricultural sources (Table 2.5) contribute substantial sediment loads, phosphorus loads, nitrogen loads, and biological oxygen demand (BOD) loads to waterways in the Belle River Watershed. These pollutant loads can be decreased by implementing site-specific best management practices (Chapter 6).

Results for other categories—streambank erosion, gully erosion, and stream crossings—are included in Section 2.3.

Table 2.4 Upland nonpoint sources area loadings from inadequate riparian buffers

NPS Area	Sediment Load (tons/yr)	Phosphorus Load (lb/yr)	Nitrogen Load (lb/yr)	BOD Load (lb/yr)	Parcel Area (ac)
L6-06	33.1	48.4	154.5	314.1	26.0
L10-02	44.1	65.0	208.6	424.4	36.1
L10-04	60.6	90.1	291.5	593.2	52.0
S10-05	0.31	2.1	13.4	51.4	3.0*
S11-01	7.1	16.6	72.6	150.4	20.7
S14-02	29	75.4	343.9	714.2	104.0
S15-01	24.5	62.7	284.6	590.9	85.5
S15-03	15.5	38.4	171.9	356.7	50.7
S15-04	35.5	93.7	429.8	892.9	131
S15-09	2.1	4.7	19.7	40.7	5.3

*residential

Table 2.5 Upland nonpoint source area loadings from nonpoint agricultural sources

NPS Area	Sediment Load (tons/yr)	Phosphorus Load (lb/yr)	Nitrogen Load (lb/yr)	BOD Load (lb/yr)	Parcel Area (ac)
L6-07	162.1	247.1	818.5	1,668.7	160.0
L6-09	179.7	274.7	912.3	1,860.2	180.0
L6-14	39.2	57.7	184.7	375.6	31.6
L10-02	44.7	65.9	211.8	430.8	36.7
L10-08	70.1	104.6	339.4	691.0	61.4
S14-07	13.9	34.3	153.2	317.9	45.0
S15-03	15.5	38.4	171.9	356.7	50.7
S15-04	35.5	93.7	429.8	892.9	131.0

2.2 Biomonitoring

The condition of a river is not only a result of a watershed's physical and chemical characteristics, but also its biological characteristics. If a water quality sample is like a snapshot in time, then the use of biological monitoring (biomonitoring) is like a movie clip because it provides a long-term indication of water quality impacts. Monitoring a river's ecology also provides an educational tool to teach volunteers about pollution and stream ecology.

Aquatic insects (benthic macroinvertebrates) are the most common biomonitoring indicator because they typically drive the food chain in river systems and some macroinvertebrate taxa are sensitive to pollutants, thus they are indicators of good water quality. Diverse fish communities are important to have a complex and resilient ecosystem and gamefish provide recreational opportunities. The main source of existing biomonitoring data in the watershed is from periodic DNR and DEQ monitoring activities and more recent volunteer monitoring.

A qualitative biological protocol for wadeable streams was developed by the Great Lakes and Environmental Assessment Section (GLEAS) of the Michigan Department of Environmental Quality (MDEQ) called Procedure 51 (MDEQ, 2000b). This procedure has since been used to evaluate habitat, fish, and benthic macroinvertebrate data. The protocol evaluates 10 measures of the fish community to evaluate its overall health. Each metric was scored as +1, 0, or -1 and total scores of +5 or higher are classified as excellent, scores of -5 or lower are classified as poor and acceptable sites are those that scored +4 to -4. The State has used other monitoring procedures in the watershed since 1972 (Table 1 in Appendix F).

2.2.1 Aquatic Habitat

The four major ecological components of a stream system that determine productivity for aquatic animals are: (1) flow regime; (2) physical habitat structure; (3) water quality (including temperature); and (4) energy inputs from the watershed (nutrients and organic matter) (Karr and Dudley, 1981). Although physical habitat needs vary by species, "reference" stream conditions can be used to compare the river reach being studied to the best attainable conditions given the watershed geology and climate.

The GLEAS procedure takes into account a wide range of physical habitat characteristics in three principal categories: 1) substrate and instream cover; 2) channel morphology; and 3) riparian and bank structure. Habitat quality varies considerably throughout the watershed, with results of qualitative assessments varying from poor to excellent. In general, poor-to-marginal sites tend to be located in depositional areas near the river mouth in Zone 3 and in the headwaters in Zone 1 of the watershed. The

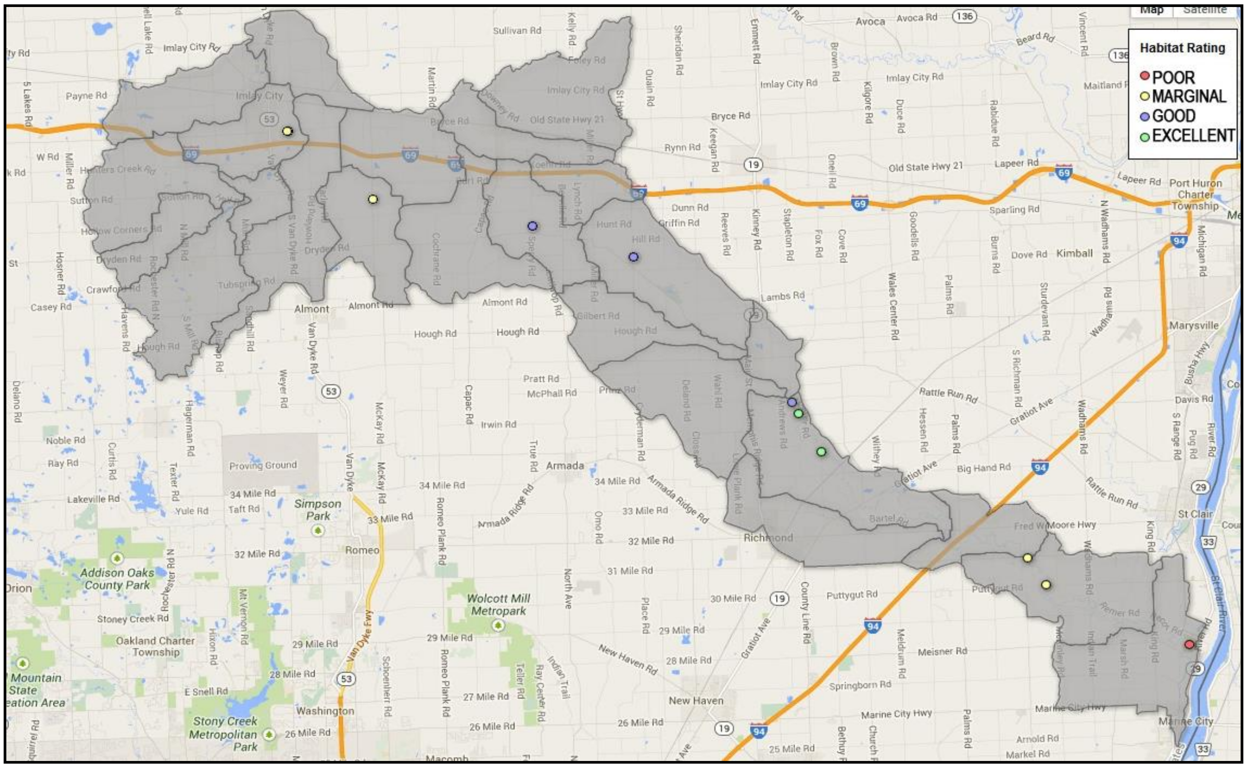


Figure 2.9 2012 Belle River GLEAS habitat scores

2012 GLEAS aquatic habitat monitoring data summarized in Figure 2.9 shows marginal-to-excellent habitat at 7 out of 10 sites (MDEQ, 2013). The middle section in Zone 2 of the Belle River rates good to excellent. Both sites on the North Branch Belle River with poor benthic macroinvertebrate ratings had marginal overall stream habitat scores (MDEQ, 2013). There is no long-term trend indicating that aquatic habitat quality is improving.

2.2.2 Fisheries

Fish surveys were conducted by the MDNR at various sites in the Belle River Watershed in late August-early September of 2008 (Figure 2.10). Ten sites were sampled on the main branch and three on tributary streams. A total of 3,814 fish were captured represented by 52 species. The most common and abundant species included suckers (white sucker, golden redhorse, and northern hog sucker), common shiner, rock bass, and Johnny darter. A total of 26 northern pike were captured ranging from 5 to 24 inches. Other species that were common among sites, but were less abundant included green sunfish, blackside darter, smallmouth bass, and creek chub.

Figure 2.10 MDNR fish shocking in the Belle River, Kronner Road, Columbus Township

In general, poor-to-marginal sites tend to be located in depositional areas near the river mouth and in the headwaters of the watershed (Zones 1 & 3). The middle stretch (Zone 2) of the Belle River rates good to excellent. Figure 2.11 summarizes the most recent GLEAS fisheries data.

There was a noticeable shift in the fish community from the upstream sites progressing downstream. Although the catch rate was good at Bishop Road in Dryden Township (81 fish/100 feet), 95% of the catch was composed of species that are tolerant of a wide range of conditions, indicating degraded conditions; this site had the lowest GLEAS score of -4. Although the catch rate was reduced at Schultz Road in Berlin Township (17.4 fish/100 feet), the fish community had a lower percentage of tolerant species and an increase in the number of intolerant species; these changes are reflected in the improved

GLEAS score of +2 for this site. In general, there was an improvement in catch rates and GLEAS scores from Riley Center Road in Riley Township downstream to Indian Trail Road in China Township.

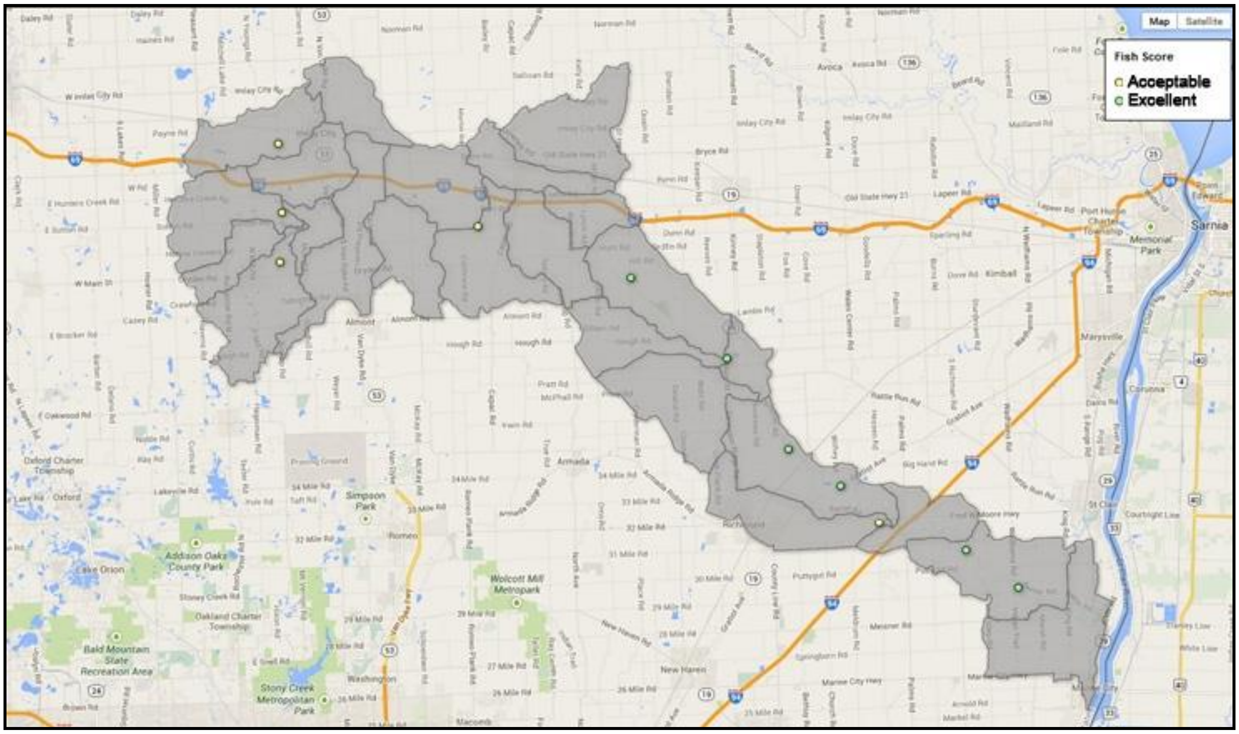


Figure 2.11 2008 Belle River GLEAS fish scores

The increased catch rates and fish diversity in the middle sites reflect improvements in habitat conditions. Beginning at Riley Center Road in Riley Township, the substrate transitions to a combination of sand and cobble compared to the upstream sites that were predominantly silt. The sites from Memphis to Westrick Road (Zone 2) also contain varied habitat including pools, riffles, and runs. These sites with diverse habitat and substrate support a more diverse and balanced fish community. A significant portion of the river upstream of Riley Center Rd. has been dredged which has resulted in a simplified habitat in the channel, altered the hydrology of the river and degraded the fish community. These changes are reflected in lower GLEAS fish scores. The DNR recommends that dredging should be restricted in the Belle River.

The two most downstream sites at King Road and Meisner Road in China Township had reduced catch rates and species diversity. These results are partly due to changes in sampling gear. These sites were wide and deep, so sampling was completed with a boat electrofishing unit compared to the other sites which were sampled while wading. The GLEAS Procedure 51 was designed for wadable streams, so GLEAS scores were not calculated for these last two sites. Several new species were caught at the more downstream locations, including emerald shiner, brook silverside, and round goby. These species are more commonly found in the connecting St. Clair River and indicate movement of fish between these two systems.

Eastern sand darter was found at two sites—near the Westrick Drain in Casco Township and at Indian Trail Road in China Township. This species is on the State Threatened list, with southeast Michigan being the northern edge of its range (Scott and Crossman, 1973). The eastern sand darter is found in streams and rivers with sandy substrates and lakes with sandy shoals. These fish are reliant on unstable, shifting sand bar habitats which can dramatically change in location, quantity, and quality from year to year depending on river flows. As this habitat is so variable, modifications to riparian areas, channel or flow alterations, nutrient enrichment, or other habitat modifications can completely change the amount, quality, and locations of these shifting sand bars to the detriment of the eastern sand darter (Simon, 1993).

The Michigan Department of Natural Resources (MDNR) annually stocks fish into the Belle River. Walleye fry were planted in 1973 with hopes of developing a spawning population in the river. It is unclear what evaluation took place, but a historical file indicates the plant failed and the stocking program did not continue. There was also discussion of developing a Coho and Chinook salmon program in the Belle River in the 1970s, but this management direction was not supported by local stakeholders and was not pursued further. Steelhead were stocked in 1973, but reports indicate the population failed. Steelhead were stocked again in 1981 and have been stocked annually since. Stocking numbers have ranged from 7,000 to 20,000 yearling steelhead annually, and the current management plan recommends 7,000 annually.

The steelhead stocking program has created a seasonal fishery for this cold-water species. The Belle River Watershed has one designated trout stream (Figure 2.12). Trout streams are associated with high quality waters and a good supply of groundwater-fed baseflow, which helps keep stream flows and temperatures steady. Much of the Belle River is classified as a Type IV trout fishery which limits catch size restrictions. The yearling steelhead are stocked in early spring (Figure 2.13) and are only in the stream a short time before they migrate to the St. Clair River. It is unclear whether the fish ultimately end up in Lake Erie or Lake Huron, but the fish return to the Belle River, typically a year or two later, to spawn. The steelhead begin returning as early as November, with the number of returning fish increasing in March and April when spawning occurs. This pattern creates a seasonal fishery from November to mid-May. After hatching, juvenile steelhead spend their first year or two in the stream before migrating to the Great Lakes. The Belle River is a warm-water stream, reaching temperatures of 80^{o} F in the summer, so juvenile steelhead cannot survive. Thus, the steelhead fishery would not be possible without annual stocking.

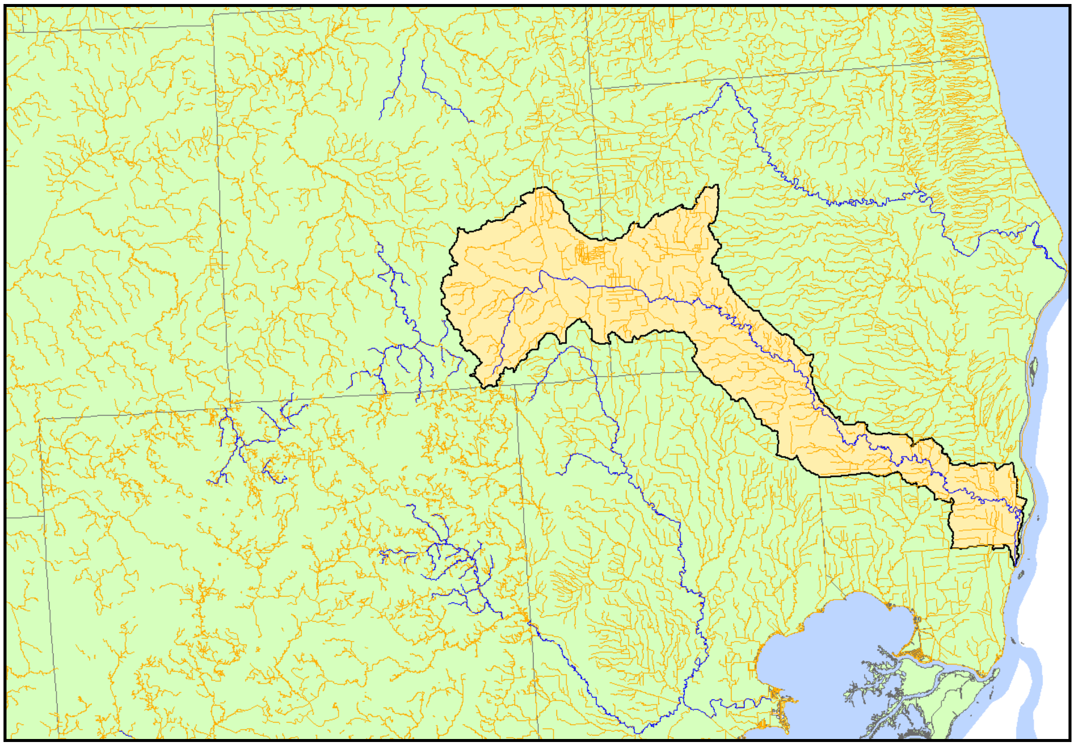


Figure 2.12 Belle River Watershed trout streams shown in purple (Appendix D)

Figure 2.13 Steelhead stocking in the Belle River

2.2.3 Macroinvertebrates

In August 1997, a biological survey of the Belle River Watershed found excellent macroinvertebrate communities at one location, acceptable communities at eight locations, and poor communities at three locations. Seven of the ten wadeable sites surveyed had acceptable macroinvertebrate communities with scores ranging from 0 to 4; one exception was the Belle River upstream of Glover Road which had an unacceptable score of -4 (DEQ, 2013). The scores were considerably lower in the Belle River Intercounty Drain and the North Branch Belle River. A non-wadeable site in the lower Belle River Watershed at East China Township Park had a macroinvertebrate community rated as poor, indicative of not meeting the designated use for other indigenous aquatic life. Long-term trends do not indicate improvements in these parts of the watershed.

Figure 2.14 Representative photographs taken in the Belle River Watershed in July/August 2012: Top Left) Belle River at St. Clair Hwy (Station 28), Top Right) Belle River at Kronner Road (Station 29), Bottom Left) N. Br. Belle River at Newark Road d/s of Pinnacle (Vlasic) Foods outfall (Station 32), and Bottom Right) N. Br. Belle River at Newark Road u/s of Pinnacle (Vlasic) Foods outfall (Station 33) (MDEQ, 2013)

Additional macroinvertebrate sampling was completed in 2012 in the Belle River Watershed (Figure 2.14). Two sites in the North Branch Belle River rated as poor, indicative of not meeting the designated use for other indigenous aquatic life (Figure 2.15). In 2007, the North Branch Belle River sites had acceptable and poor benthic communities (Schmitt, 2008). Factors likely contributing to the poor scores in the North Branch Belle River sites include historical stream corridor modifications (e.g., channel dredging, riparian vegetation disturbance), poor shading, and agricultural and urban drainage from upstream watershed areas (MDEQ, 2013).

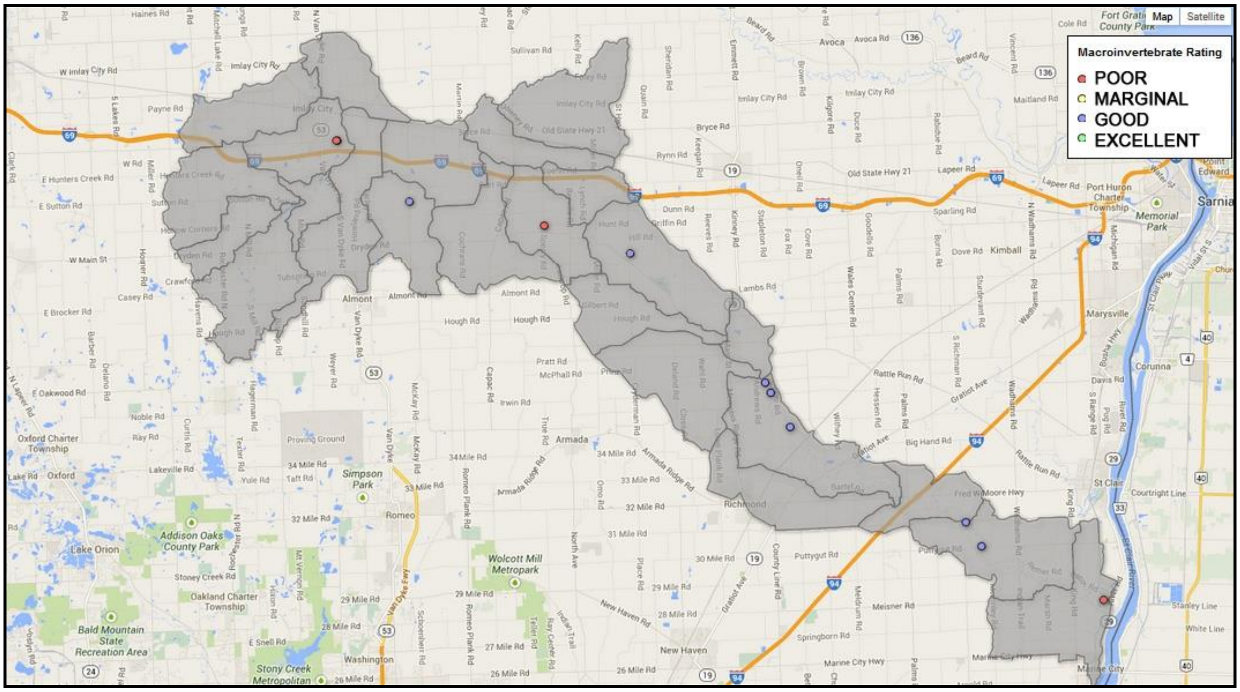


Figure 2.15 2012 Belle River GLEAS macroinvertebrate scores

Friends of the St. Clair River Watershed (Friends) conducted Michigan Clean Water Corps (MiCorps) macroinvertebrate monitoring with volunteers on the main branch of the Belle River from September 2009 through May 2014 (Figure 2.16-2.18) to qualitatively characterize the biotic integrity of the macroinvertebrate communities. Macroinvertebrate collection followed MiCorps protocol in which 300 feet of wadeable river was searched for 30 minutes working downstream to upstream. All organisms were identified to the order or sub-order level at the St. Clair County Community College biology laboratory.

The macroinvertebrate communities were scored with metrics that rate water bodies from excellent (>48) to poor (<19) based on the abundance of each taxon. The three monitoring sites in the middle stretch of the river at Riley Township Hall, Memphis City Park, and Columbus Township Roadside Park consistently rated the highest with ‘excellent’ and ‘good’ scores. Common organisms found include sensitive species such as caddisfly larvae (*Tricohptera*), mayfly (*Ephemeroptera*), water pennies (*Coleoptera*), and dragonflies and damselflies (*Odonata*). The most downriver site at China Township Hall had lower scores consistent with a more urbanized watershed.

Overall, the middle section of the river has a high quality macroinvertebrate population unlike other MiCorps sites that are sampled throughout St. Clair County.

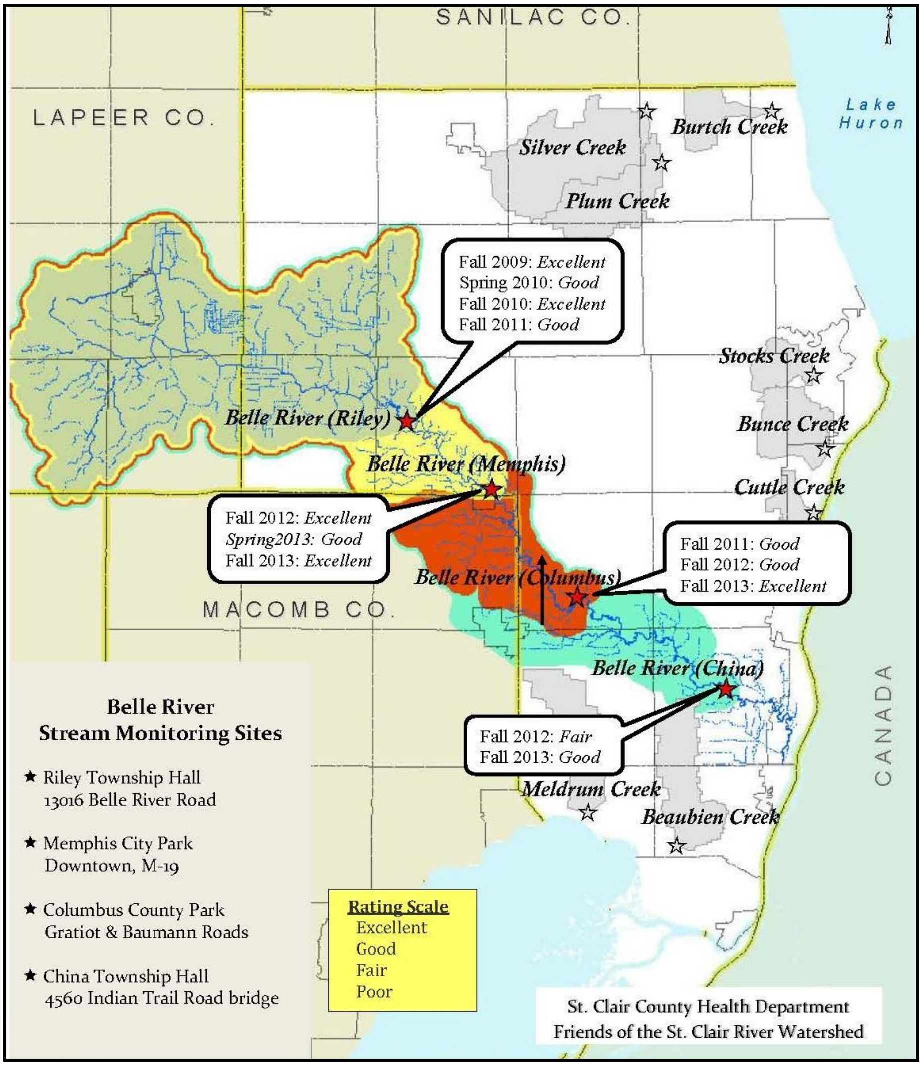


Figure 2.16 Belle Rive report card for the MiCorps volunteer stream monitoring program

Figure 2.17 Volunteers monitoring the Belle River, China Township

Figure 2.18 Volunteers monitoring the Belle River, Memphis

2.2.4 Mussels

Freshwater mussels are one of the most imperiled groups of animals in the world and, prior to invasion by the zebra mussel (*Dreissena polymorpha*), the tributary streams to Lake St. Clair and Western Lake Erie were home to the richest mussel fauna in the St. Lawrence River drainage area (Hoeh and Trdan, 1985). Historically, 24 of Michigan’s 45 mussel species were found in the Belle River (Sherman-Mulcrone, 2012), including seven state or federally listed species.

The Belle River is currently home to one of the most diverse populations of mussels remaining in southeast Michigan. Zebra mussels have not been found in the Belle River, making it a regional refuge for native mussels. However, based on field observations in 2012 and discussions with experienced mussel biologists who have sampled the watershed repeatedly over the last 19 years, mussel populations throughout the watershed are threatened by several issues related to stream stability: hydrologic flashiness, channel incision and/or widening, excessive sedimentation, and channelization of tributary streams.

Mussel surveys were completed by the MDNR in 2011 at four sampling points (Point 1: 3 miles north of Marine City and 4 miles upstream of the confluence with the St. Clair River; Point 2: 0.25 miles downstream of the bridge between Indian Trail Rd. and Belle River Rd.; Point 3: 0.125 miles upstream of the same bridge from Point 2; Point 4: 3 miles north and 1 mile west of Marine City) in the Lower Belle River (Figure 2.19). Two federally endangered mussel species were found during this study: rayed bean and snuffbox. Additionally, a total of 20 mussel species were found. Seven endangered, threatened, or special concern species were documented. Table 2.6 includes a list of the mussel species found during surveys at the four sampling points.

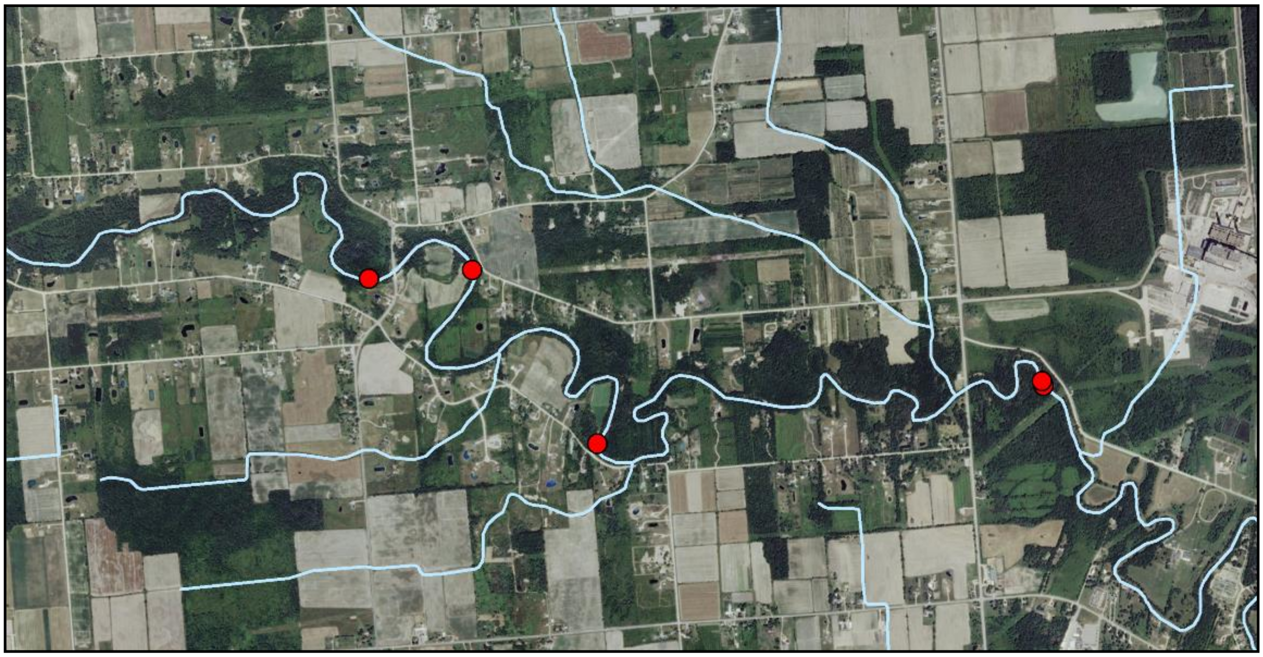


Figure 2.19 Sampling locations on the Belle River from 2011 MDNR studies

Table 2.6 Mussel species found during MDNR surveys at four sampling locations. State and federal status are indicated with the following abbreviations: E=endangered; T= threatened; SC=species of special concern.

Species	Common Name	State Status	Federal Status
Alasmidonta marginata	Elktoe	SC	
Amblema plicata	Threeridge		
Epioblasma triquetra	Snuffbox	E	E
Fusconaia flava	Wabash pigtoe		
Lampsilis siliquoidea	Fatmucket		
Lampsilis ventricosa	Pocketbook		
Lasmigona complanata	White heelsplitter		
Lasmigona compressa	Creek heelsplitter		
Lasmigona costata	Fluted-shell		
Leptodea fragilis	Fragile papershell		
Ligumia recta	Black sandshell	E	
Obovaria subrotunda	Round hickorynut	E	
Pleurobema sintoxia	Round pigtoe	SC	
Potamilus alatus	Pink heelsplitter		
Ptychobranchus fasciolaris	Kidney-shell	SC	
Pyganodon grandis	Giant floater		
Quadrula pustulosa	Pimpleback		
Quadrula quadrula	Mapleleaf		
Strophitus undulatus	Strange floater		
Villosa fabalis	Rayed bean	E	E

MDEQ conducted mussel inventories in eight rivers in the summer of 2002 (Badra and Goforth, 2003). On the Belle River, they surveyed 11 sites with glass bottom buckets and found 23 species of live mussels plus 4 additional species identified by shell only. This was the highest number of species of any river studied, including the Au Sable River. The Belle River also had a high density of mussels, second only to the Grand River.

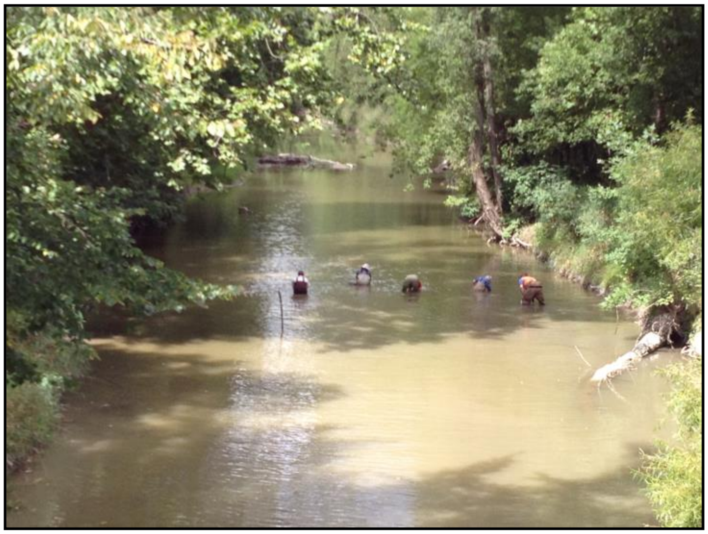


Figure 2.20 Belle River mussel surveys, St. Clair Township

Surveys were performed at seven locations in the summer and fall of 2012 by staff from the SCCHD, consultants, DEQ, and volunteers to fill in geographic gaps in the historic record (Figure 2.20). Surveys were performed as per the Michigan Natural Features Inventory (MNFI) protocol, in which 128 m^2 of streambed are searched visually and by hand, and all mussels are identified to species. Good numbers of mussels (> 30 individuals) and species (≥ 8) were found at half the surveyed locations on the main branch of the Belle River, while tributaries to the Belle River usually had low numbers of mussels and species. Four uncommon species were found: the round hickorynut, *Obovaria subrotunda* (state endangered), slippershell (state threatened), and the kidneyshell and rainbow (state species of special concern).

2.3 Sediment Loading & Channel Stability

Sediment loading is impacting water quality and aquatic habitat conditions in Belle River Watershed. The aim is not to eliminate sediment from a river, but to manage and balance the relative quantities of fine sediments and coarse sediments. Fine sediments (silts and clays) require control at their source. Whereas for coarse sediments (cobble, gravel, coarse sand), the river channel dimensions, pattern, and profile need to be restored in order to effectively transport these types of sediments.

Fine sediment loading tends to be a localized problem in the Belle River Watershed and requires source controls to reduce upland and bank erosion. Inorganic fine sediments that tend to have the greatest water quality impacts to rivers (Waters, 1995). Suspended sediment and excessive deposition of fine sediments is primarily a problem in county drains and immediately downstream of major riverbank erosion sites and hillslope failures.

The coarse sediment regime of the Belle River affects river habitat and stability. Changes in the quantity of coarse sediment, either significant increases or decreases, can impact aquatic habitat and the physical integrity of the river. If the energy greatly exceeds the ability to move the incoming sediment load, then the river will downcut or become incised (e.g. river straightening). Excessive deposition will occur if the sediment size or load (volume over time) exceeds the river's ability to move it.

Instream habitat is most often impacted by direct human modifications such as straightening, dredging, armoring, and/or clearing and snagging. More subtle, chronic impacts occur when streams begin to become unstable – usually because one of the controlling variables has been altered. Leopold (1964) identified eight major variables that affect channel stability: channel width, channel depth, flow velocity, discharge, channel slope, roughness of channel materials, sediment load, and particle size distribution. When one of these controlling variables is altered, it affects the ability to dissipate energy and the stream starts to become "unstable". For example, pools may start to fill with sediment, transverse bars form, and the stream widens with a corresponding decrease in sinuosity and increase in slope. Once the processes of instability begin, they can progress until long-term habitat conditions become degraded.

Natural stream channel stability is defined as the ability of a stream, over time, in the present climate, to transport the sediment and flows produced by its watershed in such a manner that the stream maintains its dimension, pattern, and profile without either aggrading or degrading (Rosgen, 1996).

The sediment load, stability, and habitat of the Belle River have been impacted by several factors:

- Channelization – straightening, over-widening, deepening, and near-bank levees;
- In-line ponds and historic dams;
- Floodplain fill and encroachment;
- Excess sediment supply from upland, hillslope, and riverbank sources;
- Modified riparian vegetation (e.g. mowed turf grass);

- Inability to transport sediment within over-widened drains, upstream of concrete fords, areas of natural channel widening, and under-sized culverts;
- Clearing and snagging of wood has reduced channel roughness, sediment storage, and energy dissipation;
- Manmade channel blockages as well as excessive logjams in over-wide reaches;
- Channel bed lowering at road crossings has caused headcutting and bank erosion;
- Under-sized, twin, or misaligned road culverts have caused localized instability;
- Over-wide bridge crossings have created mid-channel bars and bank erosion; and
- Lack of bedload below former dams, dredging areas, and stormwater discharges.

Many conceptual models predict that increased runoff will cause bank erosion and channel succession leading to different stream types. Flow-related sediment increases were not as common in the Belle River Watershed as the impacts of direct channel modifications such as straightening, dredging, road crossings, and armoring.

2.3.1 Stable Reference Reach Areas

Areas of the Belle River and tributaries that were relatively stable and in good functional condition were identified during the Level III Watershed Assessment of River Stability and Sediment Supply (WARSSS). Although not pristine, these areas are considered stable because they have good floodplain connectivity, low width-to-depth ratios, and stable banks. These stable "reference" sites were surveyed so that the data can be compared to unstable, degraded areas. The amount of physical departure from these reference conditions provides a way of quantifying channel instability and physical habitat degradation. The following sites were identified and surveyed as stable reference reaches:

I. **Long Lake Drain:** south of Hunters Creek Rd. in Attica Township in Lapeer County
II. **Pickerel Drain:** west of M-53 in Imlay Township in Lapeer County
III. **Belle River:** upstream of Ashery Creek to Kronner Rd. in Richmond and Columbus Townships in St. Clair County (Figure 2.21)
IV. **Jerome Creek:** 1,800 ft. west of Hessen Rd. in Richmond Township in St. Clair County
V. **Unnamed tributary to the Belle River:** North of St. Clair Hwy; East of Allington Rd. in China Township in St. Clair County (Figure 2.22)
VI. **Unnamed tributary to the Belle River:** South of Fred Moore Hwy; West of Allington Rd. in China Township in St. Clair County

Figure 2.21 Reference Reach III on the Belle River upstream of Ashery Creek to Konner Rd.

Figure 2.22 Reference Reach V on an unnamed tributary of the Belle River N. of St. Clair Hwy.

The reference reach data was also used to develop localized regional reference curves for determining bankfull discharge, width, and cross-sectional area. These curves are important because they show relationships for stable, relatively un-impacted reaches in the Belle River Watershed. For example, the curve below could be used to quickly determine preliminary channel dimensions for two-stage ditches or river restoration, but should be verified based on local channel slope and roughness. Bankfull discharge can be approximated using the relationship in Figure 2.23.

Other hydraulic geometry curves are available in the WARSSS report in Appendix H.

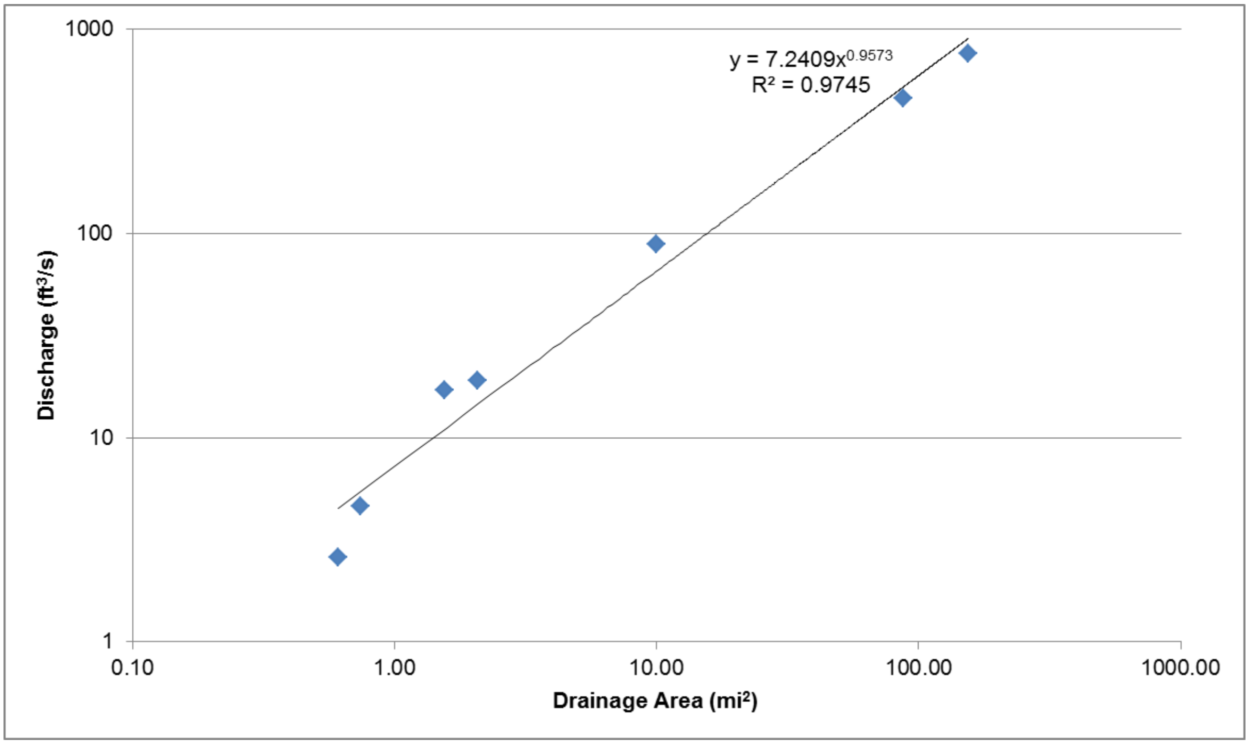


Figure 2.23 Localized regional curve of drainage area vs. bankfull discharge

2.3.2 Bed Erosion

Erosion is a natural process in alluvial rivers. However, accelerated erosion rates can create localized or system-wide problems. In addition to habitat and ecological impacts, excessive erosion and sedimentation can cause:

- Property loss and possibly lower property values;
- Lower aesthetic quality;
- Increased channel width;
- Deposition resulting in loss of hydraulic capacity which can increase flooding; and
- Lower dissolved oxygen and increased algae and nuisance weeds from associated organic matter and nutrient loadings.

Aggradation is the deposition of sediment that results in raising the channel bottom elevation. Excessive sedimentation was noted in most of the channelized county drains and the Belle River Intercounty Drain due to a reduced slope or over-widening during construction (Figure 2.24). Although none of these areas would be classified as aggrading, the channel bottom materials are much finer (silt and muck) than the reference reaches. Sediment deposition tends to cause channel widening due to bank erosion which creates even more sediment.

Degradation or incision is the erosion of the channel bottom that results in lowering its elevation (channel down-cutting). It was often difficult to determine where degradation was occurring due to changes in watershed conditions rather than due to dredging. A good measure of channel incision is the Bank Height Ratio (BHR) which is the existing bank height / bankfull maximum depth. The streambank erosion risk becomes moderate when the bank height is 1.2 times the bankfull depth or more. In the Belle River, there are five water courses that are actively down-cutting (Table 2.7). Many channelized drains have a high bank height ratio, but are not actively downcutting because they are too wide. Common causes of degradation include:

1. Lack of bedload downstream of in-line ponds,
2. Channel straightening,
3. Channelization of upstream tributaries,
4. Headcutting due to channel lowering during road crossing construction (Figure 2.25), and
5. Channel constriction due to riprap bank armoring.

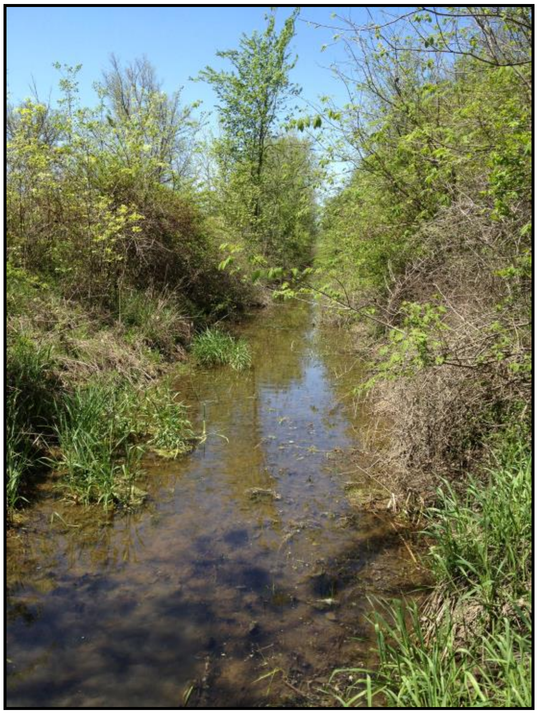


Figure 2.24 Example of excessive deposition in Currier Drain (Berlin Twp.)

Figure 2.25 Example of channel downcutting in Schneider-China Drain (China Twp.)

Table 2.7 Actively downcutting water courses in the Belle River Watershed

Water Course	**Location**	**BHR**	**Cause**
Belle River	downstream of Main St in Memphis to Bordman Rd.	1.2	2, 5
Sharrad-Burgess Drain	Burwood Rd. downstream to Belle R.	>2	3
Ashery Creek	downstream of Smith Drain	>2	2, 3
Jerome Creek	confluence 1,450 ft upstream of Church Rd. to Belle R.	>1.5	2, 3
Schneider-China Drain	upstream of Belle River Rd.	>2	4

2.3.3 Streambank Erosion

The BANCS model, which combines the Bank Erosion Hazard Index (BEHI) and Near-Bank Stress (NBS) ratings, was used to quantify sediment loadings from bank erosion for the Level III WARSSS areas (Exhibit 11 in Appendix B). The exception was the Belle River downstream of I-94 which was inventoried by the SCCHD using a more qualitative modified BEHI procedure (Exhibit 14 in Appendix B). The methods are discussed in more detail in Appendix H.

Sediment loadings from streambank erosion using the BANCS method (BEHI/NBS) are summarized in Table 2.8. The Schneider-China Drain upstream of Belle River Rd. to the Belle River has the highest bank erosion rate (0.423 tons/ft./year). Sediment loadings from non-point source areas from streambank erosion and gully erosion are summarized in Tables 2.9 and 2.10. Based on the BANCS modeling, Site S15-04 and Site S15-06, both at the Cox-Doty Drain in St. Clair County, are ranked the highest for sediment loading. More details are provided for all of the upland nonpoint source sites in Appendix J.

Streambank erosion rates are generally low in the middle and upper areas of the Belle River. Hillslope failures contribute the most in-stream sediment in these areas. Localized erosion areas are associated with channel straightening, modified riparian vegetation (turf grass), logjams, and the former Memphis Dam. Downstream of Kronner Road in Columbus Township, the Bank Height Ratio begins to increase and active erosion is common around outer banks. Downstream of I-94, Bank Height Ratios exceed 1.5 and erosion is almost continuous, but tends to alternate from right bank to left. The lateral instability in this lower area appears to be a cumulative effect of many historic impacts: the former dam at Indian Trail, dredging at road crossings and near-bank levees, excess sediment supply from agriculture, and flashiness due to channelization of tributaries.

Increased flashiness due to channelized headwater tributaries may contribute to bank and gully erosion but is difficult to verify. On Jerome Creek upstream of Hessen Road, an old concrete ford has provided enough grade control to reduce the Bank Height Ratio and provide floodplain connectivity. As a result, there are several acres of riparian wetland and a few hundred feet of stable channel before the bank heights increase again. Therefore, lack of floodplain connectivity (high Bank Height Ratio) seems to be a more significant determinant of bank stability than altered hydrology. All of the Belle River tributaries have been highly modified over the past 150 years and the cumulative impacts (causes of bank erosion) are complex.

Table 2.8 In-stream nonpoint source loadings from streambank erosion

Water Course	Location	Length (mi)	Bank Erosion Rate (tons/ft/yr)
Belle River	Braidwood Rd. to Bordman Rd.	3.500	0.0210
Belle River	Bordman Rd. to Weber Rd.	2.700	0.0096
Belle River	Kronner Rd. to Gratiot Ave.	3.100	0.0590
Jerome Creek	Meldrum Rd. half way to Hessen Rd.	0.950	0.0590
Eschenburg Drain	Rattle Run Golf Course to Belle R.	0.520	0.0020
Schneider-China Drain	upstream of Belle River Rd. to Belle R.	0.114	0.4230

Table 2.9 Upland nonpoint sources area loadings from streambank erosion

NPS Area	Sediment Load (cyd/yr)
L10-03	5.19
S15-02	4.44
S15-04	185.19
S15-05	3.33
S15-06	37.04

Table 2.10 Upland nonpoint source area loadings from gully erosion

NPS Area	Sediment Load (cyd/yr)
L7-08	5.15
L10-04	0.54
S14-02	0.46
S15-06	3.78

2.3.4 Channel Enlargement

Several water courses in the Belle River Watershed appear to have a much larger cross-sectional area than the bankfull area and are actively enlarging. Enlargement of channels can be caused by combined processes of incision, bank erosion, and direct modification by human activities. The results of enlargement are increased sediment supply from the bed and banks, increased deposition due to decreased shear stress and stream power, loss of habitat, increased water temperatures, and a shift in morphological stream types. Channel enlargement is actively occurring in the following areas:

- The lower portions of the Sharrard-Burgess Drain in subwatershed 17, Ashery Creek in subwatershed 19, and Jerome Creek in subwatershed 21 due to dredging and channel lowering at road crossings.
- Belle River at Columbus County Park due to clearing and snagging of logjams that had been storing sediment.
- Belle River at the Columbus Township Roadside Park (on Gratiot Ave.) due to historic dredging.
- Belle River from I-94 in Casco Township to the mouth at the St. Clair River in Marine City.

2.3.5 Hillslope Failures

Erosion inventories were conducted in the Level III WARSSS assessment areas in subwatersheds 17-24 which are located in Zones 2 and 3 of the Belle River (Exhibit 11 in Appendix B). In-stream source areas were separated into two categories: 1) hillslope failures that create mass wasting of sediments into the river and 2) actively eroding streambanks that are contributing sediment (minor sediment sources were not documented). Sediment loadings from hillslope failures are summarized in Table 2.11. The results show that the bank erosion hazard rating is very high to extreme for sites along the Belle River and the Schneider-China Drain.

These hillslope failures occur where the Belle River flows against large morainal features along the margins of the river valley (Figures 2.26 and 2.27) upstream and downstream from the Memphis gage station on the Belle River. Hydraulic scour typically creates accelerated erosion of 3-5 feet high riverbanks along the Belle. By comparison, hillslope failures can cause mass wasting of sediment due to a combination of hydraulics, seepage, freeze and thaw, geotechnical processes, and other factors. These hillslopes are typically 8 to 30 feet high or more along the Belle River and the Schneider-China Drain. The till from these morainal features can be a source of important boulders, cobble, and spawning gravel.

However, failure of the upper hillslopes can cause river embeddedness and widening due to high loadings of fine sediments.

Exhibit 15 in Appendix B illustrates the areas with the highest in-stream erosion rates with hillslopes shown as dashed lines.

Table 2.11 In-stream nonpoint source loadings from hillslope failures

ID	Water Course	Bank Side	Bank Height (ft)	Bank Length (ft)	BEHI_NBS Ratings	Erosion Rate (ft/yr)	Erosion Volume (cyd/yr)	Erosion Volume (tons/yr)	Total Erosion (tons/ft/yr)
24	Belle River	Right	12	30	EX/L	0.4	5.3	9	0.28
34	Belle River	Right	20	100	H/L	0.25	18.5	30	0.30
42	Belle River	Right	20	100	H/L	0.25	18.5	30	0.30
51	Belle River	Left	50	100	EX/L	0.4	74.1	119	1.19
64	Belle River	Right	20	100	H/L	0.25	18.5	30	0.30
70	Belle River	Right	20	250	H/VL	0.165	30.6	49	0.20
71	Beaver Creek	Right	50	100	VH/L	0.25	46.3	74	0.74
80	Schneider-China Drain	Right	8	25	VH/M	0.375	2.8	4	0.18
81	Schneider-China Drain	Right	8	88	EX/H	2.75	71.7	115	1.30
82	Schneider-China Drain	Right	8	338	VH/H	0.575	57.6	92	0.27
84	Schneider-China Drain	Left	8	25	VH/M	0.375	2.8	4	0.18
88	Belle River	Left	25	250	EX/M	1	231.5	370	1.48
89	Belle River	Left	25	200	EX/M	1	185.2	296	1.48
90	Belle River	Right	10	160	EX/M	1	59.3	95	0.59
91	Belle River	Right	10	120	EX/M	1	44.4	71	0.59
92	Belle River	Right	40	150	EX/M	1	222.2	356	2.37
93	Belle River	Right	25	100	EX/M	1	92.6	148	1.48
94	Belle River	Right	20	200	EX/M	1	148.1	237	1.19
95	Belle River	Right	35	100	EX/M	1	129.6	207	2.07
96	Belle River	Right	15	100	EX/M	1	55.6	89	0.89
97	Belle River	Right	25	170	EX/M	1	157.4	252	1.48
113	Belle River	Right	25	176	VH/M	0.375	61.1	98	0.56
129	Belle River	Right	20	100	EX/L	0.4	29.6	47	0.47
133	Belle River	Right	10	180	EX/L	0.4	26.7	43	0.24
134	Belle River	Right	12	60	EX/L	0.4	10.7	17	0.28
137	Belle River	Left	20	180	EX/L	0.4	53.3	85	0.47

Figure 2.26 Hillslope failures on Belle River upstream of the Memphis gauge station

Figure 2.27 Hillslope failure on Belle River downstream of Memphis gauge station

2.3.6 Channel Blockages

Manmade barriers, logjams, and cross-spanning logs were inventoried during the streambank erosion inventories. The inventory procedures and the complete inventory results and recommended priority management areas are provided in the "Belle River Management Plan for Large Woody Material" (Appendix I). Excessive logjams are a localized problem in the middle portion of the Belle River and some of its tributaries such as Jerome Creek and Ashery Creek (Figure 2.28). Logjams tend to be more extensive downstream of I-94 due to channel instability problems. Excessive wood is usually a symptom of wider-scale river instability problems. Some increase in wood loading is expected following ice storms, wind storms, or disease and pests such as Emerald ash borer. The amount of wood was excessive when channel enlargement, chute cutoffs, and river downcutting were present.

Figure 2.28 Extensive logjam on the Belle River, Columbus Township

2.3.7 Road Stream Crossings

The St. Clair County Road Commission has a Roadsoft database of over 850 road crossings in the Belle River Watershed. Some are older culverts that have exceeded their design life. Other crossings are perched or severely under-sized. Some gravel road ditch outlets need to be stabilized. Such unmaintained crossings can create several problems:

- Contribute to sediment loadings
- Cause severe bank erosion or vertical instability problems
- Prone to debris blockages
- Cause localized flooding
- Barriers to the migration of aquatic organisms

Sediment loadings from several road crossings in the upland areas were quantified based on the surveys explained in Section 2.10. Table 2.12 shows the sediment loads from six non-point source areas in the headwaters. Further information for each site is provided in Appendix J.

Table 2.12 Upland nonpoint source area loadings from stream crossings

NPS Area	Sediment Load (cyds/yr)
L6-01	4.24
L6-05	0.42
L7-02	0.45
L10-03	0.035
L10-09	0.124
S10-02	0.067

A detailed inventory of all of the road-stream crossings in the watershed was beyond the scope of the project. However, an example of two specific crossings is provided below. Recommendations for a detailed road/stream crossing inventory are provided in the Data Gap Analysis in Appendix F.

Road Stream Crossing: Jerome Creek at Church Road

The road crossing on Jerome Creek at Church Road in Casco Township is an example of a perched culvert that blocks fish migration (Figure 2.29). The under-sized culverts also cause channel deposition upstream and widening downstream. There is evidence of blockages and erosion due to road over-topping. Jerome Creek is deeply incised (downcutting) in this area. A single, wider bottomless arch culvert sized to the bankfull width (14-15 feet based on the localized regional curve) would be a better option. Grade controls are necessary downstream of the crossing to restore longitudinal connectivity. Two abandoned concrete cattle crossings upstream of Church Road are also contributing to localized channel instability problems.

Figure 2.29 Jerome Creek at Church Road crossing (facing upstream)

<u>Road Stream Crossing: Belle River at Palms Road Bridge</u>

The bridge crossing of the Belle River at Palms Road in Casco Township is an example of an over-wide channel crossing (Figure 2.30). The bridge opening was constructed much larger than the channel and the river was likely dragged under the road to increase flood capacity. This provides short-term flood stage reduction but causes channel instability due to several factors: 1) the increased channel width causes excessive deposition and mid-channel bars, 2) dredging increases bank heights which can cause erosion and increased logjams due to the inability to pass debris, 3) river straightening can increase scour and vertical instability. The flow should be directed through the central cell of the bridge with a low bench constructed within each of the side cells up to the bankfull elevation to improve channel stability, reduce flooding, and maintenance. River crossings should typically be constructed as riffles to improve sediment and wood transport to reduce maintenance and loss of flood capacity.

Figure 2.30 Belle River at Palms Road crossing (facing upstream)