State of Ohio
Environmental Protection Agency

Division of Surface Water

Total Maximum Daily Loads for the Beaver Creek and Grand Lake St. Marys Watershed

Chickasaw Creek at Botkins Road

Final Report
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Ted Strickland, Governor
Chris Korleski, Director

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1.0 INTRODUCTION

The Beaver Creek and Grand Lake St. Marys watershed drains approximately 171 square miles and includes two Assessment Units— Grand Lake St. Marys and tributaries, and Beaver Creek downstream of Grand Lake St. Marys to mouth. The watershed lies near the Ohio-Indiana border in west-central Ohio and consists of mostly agricultural land, as shown in Figure 2-1. The Ohio Environmental Protection Agency (Ohio EPA) has evaluated the biological health and water quality of the watershed and determined that most segments of the Beaver Creek and Grand Lake St. Marys watershed do not support designated aquatic life uses for Warm Water Habitat (WWH) and Exceptional Warm Water Habitat (EWH). Also, many segments do not support the Primary Contact Recreation use. Additional physical habitat impairments were determined using the Quality Habitat Evaluation Index (QHEI) scores (Rankin, 1989), which measure the overall habitat and ecosystem health. Table 1-1 summarizes the impairment causes and sources reported on Ohio's most recent Section 303(d) *Integrated Water Quality Monitoring and Assessment Report* (Ohio EPA, 2006a).

The Clean Water Act and U.S. Environmental Protection Agency (U.S. EPA) regulations require that states develop Total Maximum Daily Loads (TMDLs) for waters on the Section 303(d) lists. The TMDL and water quality restoration planning process involves several steps including watershed characterization, target identification, source assessment, and allocation of loads. The pollutant load is allocated among all sources within the watershed and voluntary (for nonpoint sources) and regulatory (for point sources) control measures are identified for attaining the source allocations. An implementation plan is also typically established to ensure that the control measures are effective at restoring water quality and all designated water uses.

The overall goals and objectives in developing the Beaver Creek and Grand Lake St. Marys TMDLs were to:

- Assess the water quality within the watershed and within Grand Lake St. Marys and identify key issues associated with the impairments and potential pollutant sources.

- Use the best available science and available data to determine water quality conditions that will result in all streams fully supporting their designated uses.

- Prepare a final TMDL report that meets the requirements of the Clean Water Act and provides information to the key stakeholders that can be used to facilitate implementation activities to improve water quality.

This report documents the results of the TMDL analysis. Section 2 briefly describes the watershed and applicable water quality standards, Section 3 describes the methodology used to estimate the current and allowable pollutant loads, and Section 4 presents the resulting TMDLs. The results of a modeling analysis to determine the potential effectiveness of various agricultural BMPs is presented in Section 5 and a modeling analysis of Grand Lake St. Marys is presented in Section 6. Appendix A presents the detailed results of the load duration curve analysis, Appendix B documents the assumptions and results of the model calibration process and Appendix C provides additional information on the allocated loads. Additional water quality information about the study area is contained in Appendix D. Appendix E contains a summary of responses to public comments (after public review in June-July 2007). "A memo about nutrient alternatives for west central Ohio" from the Ohio Department of Natural Resources is provided in Appendix F.

Table 1-1. Summary of Section 303(d) listings in the Beaver Creek and Grand Lake St. Marys watershed, Ohio.

Assessment Unit	Designated Uses	Pollutant	Sources of Impairment
AU 5120101 020 Grand Lake St. Marys and Tributaries Priority points = 2	Aquatic Life Use Support Recreational Use	Bacteria Nutrients	Non-irrigated crop production, animal feeding operations (AFOs) and confined animal feeding operations (CAFOs) (NPS), channelization, removal of riparian vegetation, stream bank destabilization, home sewage treatment systems
AU 5120101 030 Beaver Creek Downstream of Grand Lake St. Marys to Mouth Priority points = 5	Aquatic Life Use Support Recreational Use	Bacteria Nutrients	Non-irrigated crop production, AFOs and CAFOs (NPS), channelization, removal of riparian vegetation, stream bank destabilization, home sewage treatment systems

2.0 DESCRIPTION OF WATERBODIES, IMPAIRMENT STATUS AND WATER QUALITY STANDARDS

The purpose of this section of the report is to provide a brief background of Beaver Creek and Grand Lake St. Marys and its corresponding watershed. Extensive descriptions of the watershed are also available from the Grand Lake St. Marys Management Plan (Buck, n.d.).

2.1 Description of the Beaver Creek and Grand Lake St. Marys Watershed

Beaver Creek and Grand Lake St. Marys drain a 171 square mile watershed in west-central Ohio (Figure 2-1). The watershed lies within the glaciated Eastern Corn Belt Plains (ECBP) ecoregion. The ECBP ecoregion is characterized by rolling plains, local end moraines, extensive glacial deposits, and extensive corn, soybean, and livestock production. The watershed is divided between two counties; a majority lies within Mercer County and a small portion falls in Auglaize County. Cities within the watershed include Coldwater, St. Henry, Celina, Montezuma, Chickasaw, and St. Marys.

Grand Lake St. Marys is primarily fed by tributaries flowing from the south and it was once recognized as the largest man-made reservoir in the world. Grand Lake St. Marys remains Ohio's largest inland lake. A spillway on the western edge of the lake flows into Beaver Creek just south of the city of Celina. Beaver Creek flows west where it eventually reaches the Wabash River. The watershed is divided into two 11-digit assessment units (AUs):

- Grand Lake St. Marys and tributaries (05120101 020)
- Beaver Creek, downstream Grand Lake St. Marys to mouth (05120101 030)

Each of the 11-digit AUs is further subdivided into 14-digit hydrologic unit code (HUC) sub-watersheds as presented in Table 2-1.

Table 2-1. Assessment Unit (AU) and 14-Digit Hydrologic Unit Code (HUC) Designations for the Grand Lake St. Marys Watershed.

11-Digit AU	14-Digit HUC	Description	Drainage Area (mi^2)
05120101020		**Grand Lake St. Marys and tributaries**	**112.3**
	010	Barnes Creek, Little Chickasaw Creek, and Chickasaw Creek	29.0
	020	Prairie Creek, Beaver Creek tributary to Grand Lake, and Coldwater Creek	45.0
	030	Grand Lake St. Marys	38.3
05120101030		**Beaver Creek (downstream Grand Lake St. Marys to mouth)**	**58.6**
	010	Beaver Creek from Grand Lake to above Little Beaver Creek	19.3
	020	Little Beaver Creek	14.2
	030	Beaver Creek below Little Beaver Creek to the Wabash River	25.1

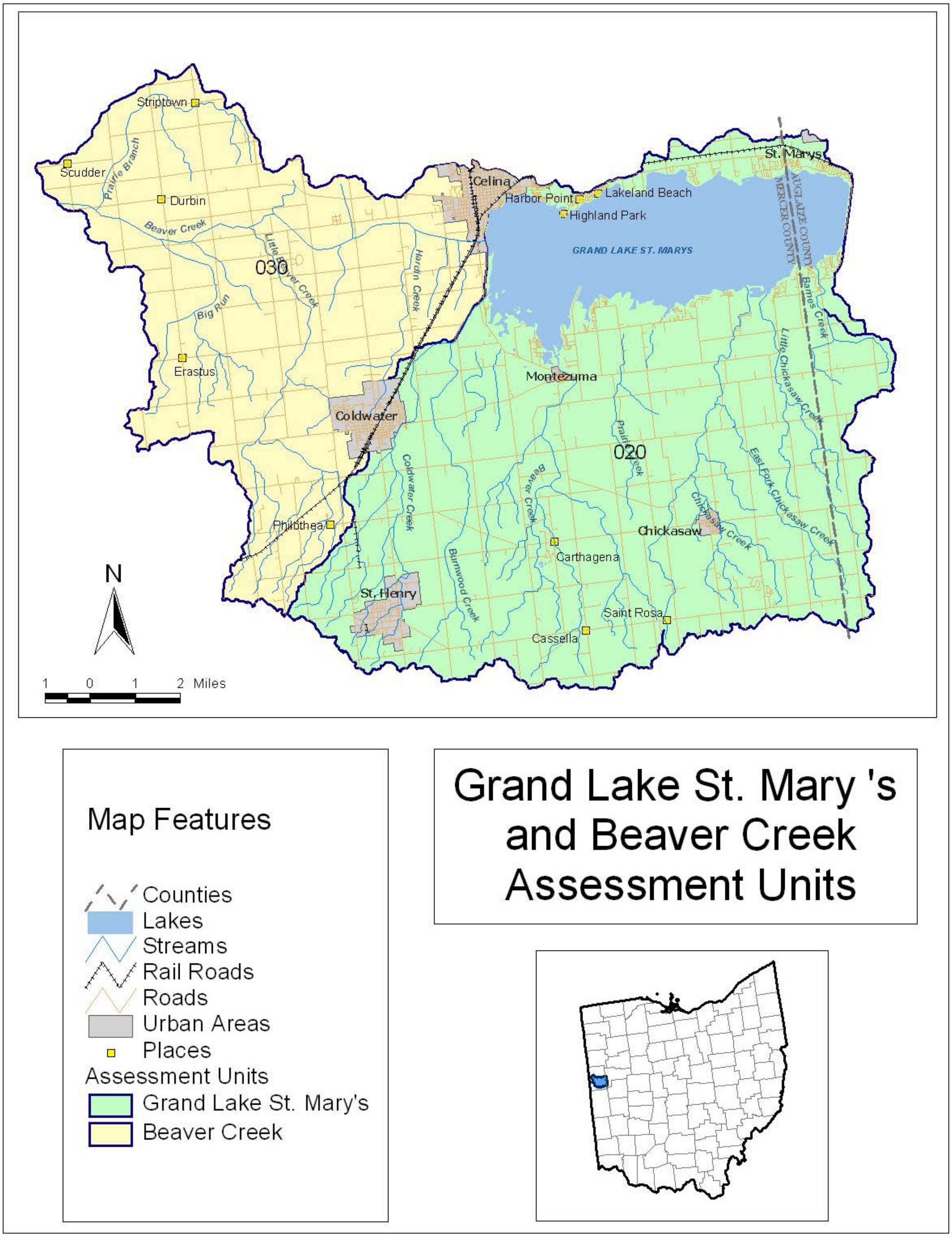

Figure 2-1. The Beaver Creek and Grand Lake St. Marys Watershed.

2.2 Land Use and Land Cover within the Beaver Creek and Grand Lake St. Marys Watershed

The land use/land cover for the Beaver Creek and Grand Lake St. Marys watershed was extracted from the Ohio Statewide Land Cover Classification. This spatial database was derived from satellite imagery collected from 1999 to 2003 and is the most current detailed land use/land cover data known to be available for the watershed. Each 98-foot by 98-foot pixel contained within the satellite image was classified according to its reflective characteristics and the resulting land use and land cover characteristics of the Grand Lake St. Marys watershed are presented in Figure 2-2 and summarized in Table 2-2. The figure and the table show that row crop agriculture is by far the dominant land cover in the watershed as it accounts for approximately 73 percent of the total area. Open water (e.g., Grand Lake St. Marys) accounts for nearly 12 percent of the watershed area and pasture/hay land cover represents 8 percent of the total watershed area.

Table 2-2. Land Use and Land Cover Characteristics of the Beaver Creek and Grand Lake St. Marys Watershed.

Land Cover / Land Use	Area (acres)	Area (Sq. Miles)	Percent of Watershed
Open Water	12,891.73	20.14	11.8%
Low Intensity Residential	1,832.85	2.86	1.7%
High Intensity Residential	376.57	0.59	0.3%
Commercial/Industrial/Transportation	882.04	1.38	0.8%
Quarries/Strip Mines/Gravel Pits	136.65	0.21	0.1%
Transitional	74.66	0.12	0.1%
Deciduous Forest	4,417.70	6.90	4.0%
Evergreen Forest	21.54	0.03	0.0%
Mixed Forest	4.80	0.01	0.0%
Pasture/Hay	8,783.34	13.72	8.0%
Row Crops	79,249.09	123.83	72.5%
Urban/Recreational/Grasses	207.22	0.32	0.2%
Woody Wetlands	193.30	0.30	0.2%
Emergent Herbaceous Wetlands	269.04	0.42	0.2%
Total	**109,340.53**	**170.84**	100.0%

Figure 2-2. Land use and land cover within the Beaver Creek and Grand Lake St. Marys watershed.

2.3 Water Quality Standards

The purpose of developing a TMDL is to identify the pollutant loading that a waterbody can receive and still achieve water quality standards. Under the Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the Clean Water Act's goal of "swimmable/fishable" waters. Water quality standards consist of three components: designated uses, numeric or narrative criteria, and an antidegradation policy. Ohio's water quality standards are summarized in Table 2-3 and explained in greater detail below.

Table 2-3. Ohio water quality standards.

Component	Description
Designated Use	Designated use reflects how the water can potentially be used by humans and how well it supports a biological community. Every water in Ohio has a designated use or uses; however, not all uses apply to all waters (i.e., they are waterbody specific).*
Numeric Criteria	Chemical criteria represent the concentration of a pollutant that can be in the water and still protect the designated use of the waterbody. Biological criteria indicate the health of the in-stream biological community by using one of three indices: • Index of Biotic Integrity (IBI) (measures fish health). • Modified Index of well being (MIwb) (measures fish health). • Invertebrate Community Index (ICI) (measures benthic macroinvertebrate health).
Narrative Criteria	These are the general water quality criteria that apply to all surface waters. These criteria state that all waters must be free from sludge; floating debris; oil and scum; color- and odor-producing materials; substances that are harmful to human, animal or aquatic life; and nutrients in concentrations that may cause algal blooms.
Antidegradation Policy	This policy establishes situations under which Ohio EPA may allow new or increased discharges of pollutants, and requires those seeking to discharge additional pollutants to demonstrate an important social or economic need. Refer to <http://www.epa.state.oh.us/dsw/wqs/wqs.html> for more information.

* According to OAC 3745-1-07(A)(1) each waterbody is assigned a designated use. Any streams in Ohio that are undesignated still must attain the chemical criteria associated with the Warm Water Habitat designation. There is no similar protection for recreational use.

2.3.1 Designated Uses

Beaver Creek and its tributaries and the tributaries to Grand Lake St. Marys are designated by Ohio EPA as warmwater habitat. Grand Lake St. Marys itself is assigned the exceptional warmwater habitat designated use because all public lakes and reservoirs in the state of Ohio are automatically given this aquatic life designation. The lake is also listed as a source of public, agricultural, and industrial water supply. All of the streams in the Beaver Creek and Grand Lake St. Marys watershed, as well as the lake itself, are designated for Primary Contact Recreation (OAC 3745-1-22).

2.3.2 Numeric Criteria

Numeric criteria exist in Ohio to protect contact recreation designated uses. However, interpreting Ohio's water quality standards for fecal coliform and *E. coli* is somewhat complex and the state is currently considering changing the standard. Standards have been established to protect three different designated uses:

> <u>Bathing waters</u>: these are waters that, during the recreation season, are suitable for swimming where a lifeguard and/or bathhouse facilities are present, and include any additional such areas where the water quality is approved by the director.

> Primary contact: these are waters that, during the recreation season, are suitable for full-body contact recreation such as, but not limited to, swimming, canoeing, and scuba diving with minimal threat to public health as a result of water quality.
>
> Secondary contact: these are waters that, during the recreation season, are suitable for partial body contact recreation such as, but not limited to, wading with minimal threat to public health as a result of water quality.

Table 2-4 shows that the primary contact *E. coli* criterion of 126 cfu/100 mL is identical to the bathing water *E. coli* criterion as a geometric mean. However, this is not the case for fecal coliforms. While the primary contact fecal coliform criterion is 1,000 cfu/100 mL, the bathing water fecal coliform criterion is 200/100 mL. For this reason, *E. coli* is not used by itself to determine if there is a violation of the primary contact recreation criteria because Ohio EPA's regulations state that:

"For each designation at least one of the two bacteriological standards (fecal coliform or E. coli*) must be met (OAC 3745-1-07, Table 7-13)."*

Therefore, when both fecal coliform and *E. coli* data are available from the same sample, if at least one of the two standards is met, there is not a human health violation. If only one of the two bacteria groups are available to determine violations of recreational standards, then fecal coliform should be used, not *E. coli*, because it is very rare that a fecal coliform count of 1,000/100 mL would violate the criteria and *E. coli* would not violate the 126/100 mL criteria. For this reason, the TMDLs for the Beaver Creek and Grand Lake St. Marys watershed are based on meeting the primary contact fecal coliform standard. Note that the standard only applies during the recreation season (May 1 to October 15).

Table 2-4. Fecal coliform and *E. coli* standards for Ohio. Standards only apply for the period May 1 through October 15.

Parameter	Bathing Waters		Primary Contact		Secondary Contact
	Geometric Mean[1]	Instantaneous[2]	Geometric Mean[1]	Instantaneous[2]	Instantaneous[2]
Fecal Coliform	200/100 mL	400/100 mL	1,000/100 mL	2,000/100 mL	5,000/100 mL
E. coli	126/100 mL	235/100 mL	126/100 mL	298/100 mL	576/100 mL

[1] Geometric mean fecal coliform content should not exceed this standard based on not less than five samples within a thirty-day period.
[2] Fecal coliform content should not exceed this standard in more than ten percent of the samples taken in any thirty-day period.

2.3.3 Narrative Criteria

Only narrative criteria are available for nutrient-related causes of impairment. TMDL targets are therefore needed to compare existing water quality conditions to desired water quality conditions and to derive "maximum daily loads." Ohio EPA (Ohio EPA, 1999) has established water quality targets for nutrients and these were applied for TMDL development purposes in the Beaver Creek and Grand Lake St. Marys watersheds (Table 2-5). The total phosphorus and nitrate targets are Ohio EPA suggested concentrations that are protective of aquatic life. These proposed values have been derived from a state-wide dataset and are categorized by drainage area.

Table 2-5. Nutrient TMDL Target Values for the Beaver Creek and Grand Lake St. Marys Watersheds.

Water Quality Parameter	Drainage Area	Target Value (mg/L)
Total Phosphorus	Headwaters (< 20 square miles)	0.08
	Wadeable (20 < 200 square miles)	0.10
	Small Rivers (200 < 1000 square miles)	0.17
Nitrate Nitrogen	Headwaters (< 20 square miles)	1.0
	Wadeable (20 < 200 square miles)	1.0
	Small Rivers (200 < 1000 square miles)	1.5

The Index of Biotic Integrity (IBI) and the Invertebrate Community Index (ICI) scores are measures of fish and macroinvertebrate community health, respectively. These indices have been found to display an inverse relationship with nutrient concentrations in Ohio streams and rivers (Ohio EPA, 1999). Maintaining nutrient concentrations based on water quality targets should therefore result in improved aquatic communities and meeting the WWH designated use.

3.0 TECHNICAL APPROACH

This section of the report presents the technical approach used to estimate current and allowable loading to Grand Lake St. Marys, Beaver Creek, and their tributary streams. As discussed below, a load duration approach was used to make these estimates.

3.1 Load Duration Curves

Load reductions were determined through the use of load duration curves. This approach involves calculating the allowable loadings over the range of flow conditions expected to occur in the impaired stream by taking the following steps:

1. A flow duration curve for the stream is developed by generating a flow frequency table and plotting the data points to form a curve. The data reflect a range of natural occurrences from extremely high flows to extremely low flows.

2. The flow curve is translated into a load duration (or TMDL) curve by multiplying each flow value by the water quality standard/target for a particular contaminant, then multiplying by a conversion factor. The resulting points are plotted to create a load duration curve (LDC).

3. Each water quality sample is converted to a load by multiplying the water quality sample concentration by the average daily flow on the day the sample was collected. Then, the individual loads are plotted as points on the TMDL graph and can be compared to the water quality standard/target, or LDC.

4. Points plotting above the curve represent deviations from the water quality standard/target and the daily allowable load. Those plotting below the curve represent compliance with standards and the daily allowable load. Further, it can be determined which locations contribute loads above or below the water quality standard/target.

5. The area beneath the TMDL curve is interpreted as the loading capacity of the stream. The difference between this area and the area representing the current loading conditions is the load that must be reduced to meet water quality standards/targets.

6. The final step is to determine where reductions need to occur. Those exceedences at the right side of the graph occur during low flow conditions, such as septic systems and illicit sewer connections; exceedences on the left side of the graph occur during higher flow events, such as runoff. The example shown in Figure 3-1 shows that the exceedences occur at the left side of the graph, or high flow conditions. Using the LDC approach allows Ohio EPA to determine which implementation practices are most effective for reducing loads based on flow regime. If loads are significant during wet weather events (including snowmelt), implementation efforts can target those BMPs that will most effectively reduce storm water run-off.

An example load duration curve is presented in Figure 3-1 and illustrates that observed nitrate loads exceed allowable loads during high flows zones and are below allowable loads during low flow zones. The figure also indicates that excessive loads primarily occur during the critical winter months (October to March) and when surface flows exceeds subsurface flows. The proportion of surface versus subsurface flows was determined using the sliding-interval method for streamflow hydrograph separation contained in the USGS HYSEP program (Sloto and Crouse, 1996). Algorithms from HYSEP were incorporated into the load duration analysis to determine the proportion of daily mean discharge that was overland runoff (surface) or groundwater discharge (subsurface) components. A surface flow threshold value of 50 percent was used to identify water quality samples that were collected during primarily surface runoff events.

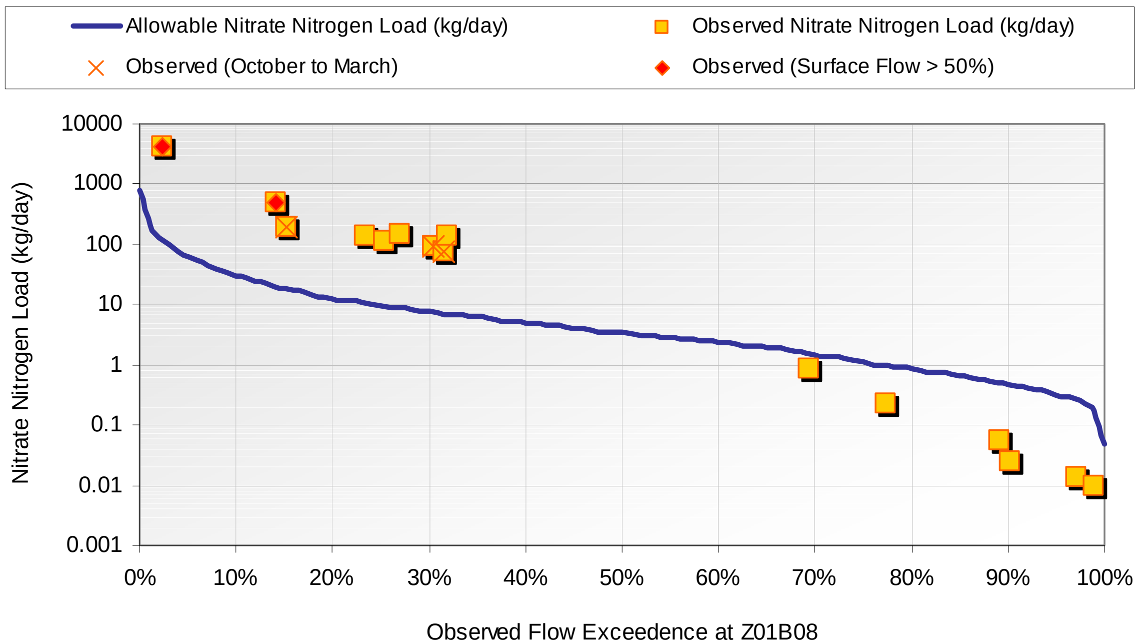

Figure 3-1. Nitrate load duration curve example for monitoring station Z01B08 located on Burntwood Creek.

The stream flows displayed on a load duration curve may be grouped into various flow regimes to aid with interpretation of the load duration curves. The flow regimes are typically divided into 10 groups which can be further categorized into the following five "hydrologic zones" (Cleland, 2005):

- High flow zone: stream flows that plot in the 0 to 10 percentile range, related to flood flows.
- Moist zone: flows in the 10 to 40 percentile range, related to wet weather conditions.
- Mid-range zone: flows in the 40 to 60 percentile range, median stream flow conditions.
- Dry zone: flows in the 60 to 90 percentile range, related to dry weather flows.
- Low flow zone: flows in the 90 to 100 percentile range, related to drought conditions.

Because the load duration approach determines loads based on various flow regimes, it helps to identify the issues surrounding the impairment and to roughly differentiate between sources. Table 3-1 summarizes the relationship between the five hydrologic zones and potentially contributing source areas (Cleland, 2005).

The load reduction approach also considers critical conditions and seasonal variation in the TMDL development as required by the Clean Water Act and EPA's implementing regulations. Because the approach establishes loads based on a representative flow regime, it inherently considers seasonal variations and critical conditions attributed to flow conditions.

Table 3-1. Relationship Between Load Duration Curve Zones and Contributing Sources.

Contributing Source Area	Duration Curve Zone				
	High	Moist	Mid-Range	Dry	Low
Point source				M	H
Livestock direct access to streams				M	H
On-site wastewater systems	M	M-H	H	H	H
Riparian areas		H	H	M	
Storm water: Impervious		H	H	H	
Combined sewer overflow (CSO)	H	H	H		
Storm water: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	
Bank erosion	H	M			

Note: Potential relative importance of source area to contribute loads under given hydrologic condition (H: High; M: Medium; L: Low)

The load duration curve approach is based upon the premise that loads vary depending upon the flow, and different sources may contribute loads under different flow conditions. Using the load duration curve approach assists with determining which implementation practices are most effective for reducing loads based on flow magnitude. For example, if existing loads exceed allowable loads primarily during storm and winter snow melt events, implementation efforts can target those best management practices (BMPs) that will most effectively reduce loads associated with runoff. The approach also aids in sharing the responsibility for nutrient and pathogen reductions among various stakeholders in the TMDL watershed, which encourages efficient and collective implementation efforts.

The load duration curve is a cost-effective TMDL approach that addresses the reductions necessary to meet target loads. This TMDL ties directly into Ohio’s numeric water quality standard for pathogens and numeric criteria for nutrients, therefore meeting these loading capacities should result in attainment of water quality standards.

Weaknesses of this TMDL approach are that non-point source load allocations were not assigned to specific sources within the watershed, and the identified sources of pathogens and nutrients were assumed based on the data collected in the watershed, rather than determined by detailed monitoring and sampling efforts or modeling. Moreover, specific source reductions were not quantified. Despite the limitations of the load duration curve approach, Ohio EPA believes the strengths of the approach outweigh the weaknesses and that this methodology is appropriate based upon the information available.

3.2 Stream Flow Estimates

Daily stream flows for each monitoring site of interest are needed to apply the load duration curve. Continuous stream flow data are not available for the Beaver Creek or Grand Lake St. Marys watershed. Since the load duration approach requires a stream flow time series for each site where the method is applied, stream flows were extrapolated from a surrogate gage station for each load duration site. The Mississinewa River near Ridgeville, Indiana (USGS gage # 03325500) was selected as the surrogate station because it is located within the ECBP ecoregion, it has a comparable drainage area (133 square miles), and it is in close proximity to the Beaver Creek and Grand Lake St. Marys watershed. Daily average flows for the Mississinewa River gage station were downloaded from **http://waterdata.usgs.gov/nwis**.

Flow time series for each load duration site were estimated using a multiplier based upon the ratio of the upstream drainage area for a given site to the drainage area of the Mississinewa River. For example, the drainage area at the Barnes Creek monitoring site (300040) is 3.08 square miles which, if divided by the drainage area of Mississinewa River (133 square miles), equals 0.023. Thus, the observed daily stream flows at the Mississinewa River USGS gage were multiplied by 0.023 to estimate the daily stream flows at the Barnes Creek monitoring site. Table 3-2 presents the drainage area ratios used to estimate stream flow for all of the load duration sites included in this TMDL; the locations of the sites are shown in Figure 3-2. Median estimated flows for the five stream flow zones are provided in the TMDL tables for each site.

Table 3-2. Drainage Area Ratios Used to Estimate Stream Flow for Load Duration Analyses in the Beaver Creek and Grand Lake St. Marys Watershed.

11-Digit AU	14-Digit HUC	Station ID	Stream Name	Location	River Mile	Upstream Drainage Area (Sq. mi.)	Drainage Area Ratio
05120101020	10	300040	Barnes Creek	At bridge on State Route 364 near St. Marys Twp Building	1.55	3.08	0.023
	10	Z01B13/ CAFO15	Little Chickasaw Creek	At Mercer CR 219-A	3.36	5.03	0.038
	10	CAFO2	Chickasaw Creek	At Mercer CR 219-A	3.07	16.25	0.122
	20	300043	Prairie Creek	At bridge on Kittle Road	1.3	5.10	0.038
	20	Z01B08	Burntwood Creek	At Clover Four Road [1]	3.08	5.43	0.041
	20	COC2	Beaver Creek	At bridge on Cassella-Montezuma Road	1.23	18.35	0.138
	20	CAFO8	Beaver Creek	At Depweg Road	2.65	14.33	0.108
	20	COC1	Coldwater Creek	At bridge on Johnston Road	0.28	19.82	0.149
	20	Z01P16	Coldwater Creek	At Fleetfoot Road	3.51	11.51	0.087
05120101030	10	605020	Beaver Creek	At Meyer Road	9.65	3.69	0.028
	10	Z01P15	Hardin Creek	At Fleetfoot Road	1.01	4.78	0.036
	20	Z01B03	Little Beaver Creek	At Menchhofer Road	4.70	8.76	0.066
	30	Z01P06	Big Run	At State Route 29	0.12	8.80	0.066
	30	Z01P07	Prairie Branch	At Mud Pike	0.10	8.09	0.061
	30	Z01P04	Beaver Creek	At Erastus-Durbin Road	2.65	37.09	0.279

[1] Clover Four Road is known as Siegrist-Jutte Road west of U.S. Route 127. This note is applicable to further references to where Burntwood Creek intersects Clover Four Road.

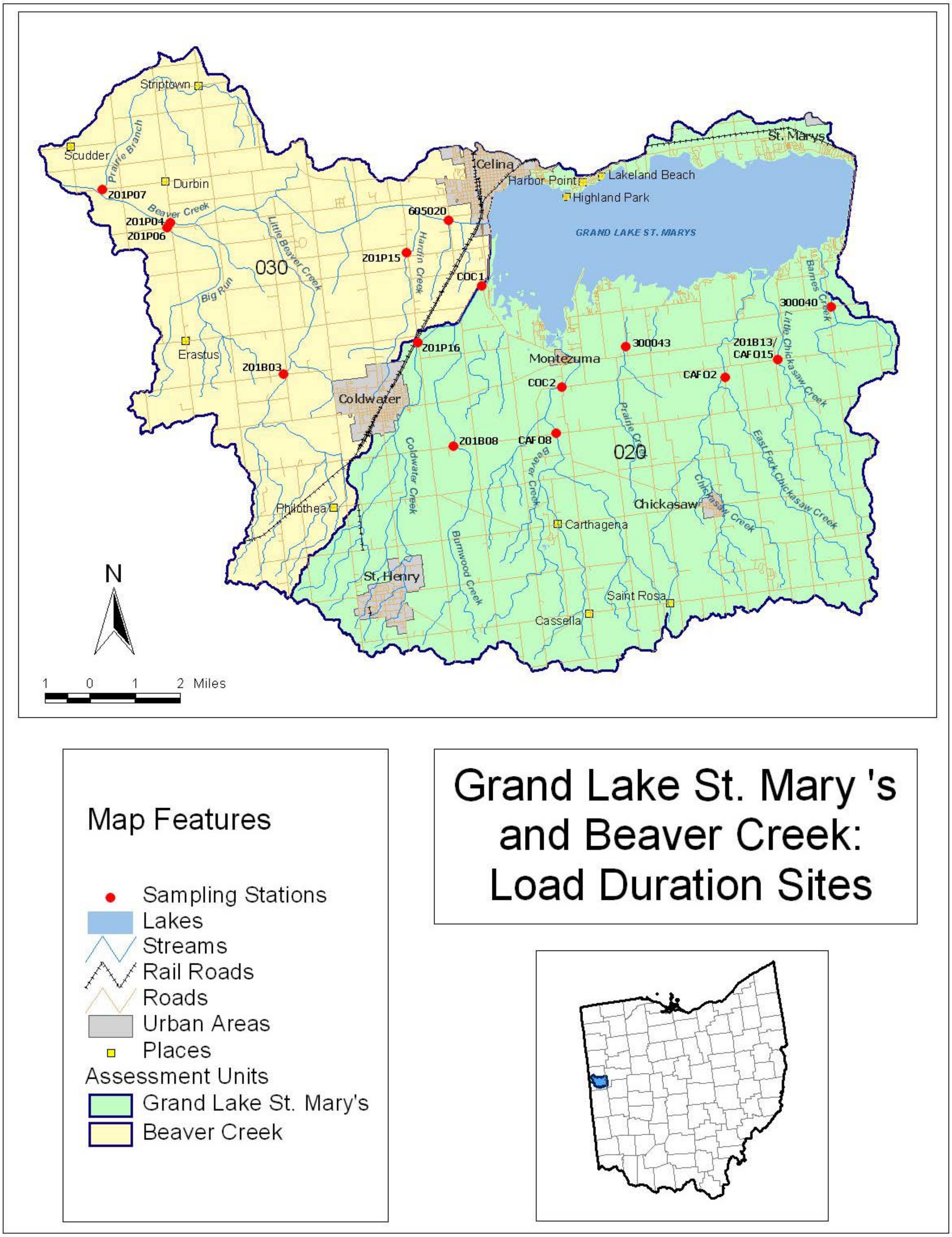

Figure 3-2. Location of load duration sites.

4.0 TMDL RESULTS

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this is defined by the equation:

$$TMDL = WLA + LA + MOS$$

A summary of the load reductions needed for all parameters in the Grand Lake St. Marys and Beaver Creek watersheds is presented in this section of the report. The allocations by each of the various sources and parameters are shown in the following tables. WLAs were established for facilities with individual National Pollutant Discharge Elimination System (NPDES) permits and for the one Municipal Separate Storm Sewer System (MS4), the City of Celina, regulated under Phase II of EPA’s storm water program. Typically, an allowance for Future Growth within the watershed is also factored into TMDL calculation. However, because minimal future growth is anticipated in the Beaver Creek and Grand Lake St. Marys watershed, this factor was excluded from TMDL calculation.

The WLAs for individual facilities are summarized in Appendix C and were established based on each facility’s design flow and the following concentrations:

- TP and nitrate WLAs for facilities with available TP and/or nitrate data were calculated using the average concentrations obtained from Monthly Operating Reports (MORs) because no permit limits currently exist for these two parameters.

- WLAs for facilities without available TP and/or nitrate data were calculated using 1 mg/L as a TP limit and 10 mg/L as a nitrate limit.

- All fecal coliform WLAs were calculated using a concentration of 1000 counts/100 mL, as this is the permitted limit.

Load duration analyses were conducted for all sites with a sufficient number of samples (in most cases more than 10) within each of the two major assessment units. The Ohio EPA Northwest District Office provided water quality data from survey sampling that took place in 1999. Additional sampling was completed by the Northwest District Office and the Division of Environmental Services in 2006 to further evaluate water quality issues in the watershed and to facilitate the creation of load duration curves. The City of Celina also collected water quality samples in 2005/2006 and these data were used in the load duration analyses. Appendix A contains the load duration results for all stations for all three water quality parameters (total phosphorus, nitrate+nitrite, and fecal coliform).

4.1 Assessment Unit 020: Grand Lake St. Marys and Tributaries

The load duration approach was applied to nine sampling stations located within Assessment Unit 020 (Figure 4-1):

- One site on each of the major tributaries flowing into Grand Lake St. Marys:
  - Barnes Creek on State Route 364, near the St. Marys Township building (300040).
  - Little Chickasaw Creek at Mercer County Road 219-A (Z01B13/CAFO15).

    - Chickasaw Creek at Mercer County Road 219-A (CAFO2).
    - Prairie Creek at bridge on Kittle Road (300043).
    - Burntwood Creek at Clover Four Road (Z01B08).
- Two sites on Beaver Creek:
    - At bridge on Cassella-Montezuma Road (COC2).
    - At Depweg Road (CAFO8).
- Two sites on Coldwater Creek:
    - At bridge on Johnston Road (COC1).
    - At Fleetfoot Road (Z01P16).

For each load duration site, all appropriate and available water quality and flow data were used. The load duration analyses for fecal coliform were based on flows and samples collected during the recreation season (May 1 to October 15) to be consistent with Ohio's water quality standards. Table 4-1 summarizes the data used for the load duration analyses in Assessment Unit 020. Assessment unit 020 TMDL summary tables can be found in Appendix C.

Table 4-1. Summary of Available Data for Load Duration Sites in Assessment Unit 020.

Subwatershed/ Stream	Location (Monitoring Station)	Parameter	Count	Average	Minimum	Maximum	Period of Record
Barnes Creek	At bridge on State Route 364 near St. Marys Twp Building (300040)	TP (mg/L)	41	1.00	0.04	8.12	2/10/2005-6/22/2006
		Nitrate (mg/L)	15	11.40	0.25	31.40	1/26/2006-6/22/2006
		Fecal Coliform (#/100ml)	5	21,180	560	99,000	5/3/2006-6/19/2006
Little Chickasaw Creek	At Mercer CR 219-A (Z01B13/CAFO15)	TP (mg/L)	44	0.60	0.02	3.16	2/8/2005-6/22/2006
		Nitrate (mg/L)	19	14.54	0.22	38.30	2/8/2005-6/22/2006
		Fecal Coliform (#/100ml)	5	13,532	860	57,000	5/3/2006-6/19/2006
Chickasaw Creek	At Mercer CR 219-A (CAFO2)	TP (mg/L)	45	0.99	0.04	3.48	2/8/2005-6/22/2006
		Nitrate (mg/L)	19	16.70	0.00	54.40	2/8/2005-6/22/2006
		Fecal Coliform (#/100ml)	5	47,980	1,000	200,000	5/3/2006-6/19/2006
Prairie Creek	At bridge on Kittle Road (300043)	TP (mg/L)	42	2.02	0.00	11.00	2/10/2005-6/22/2006
		Nitrate (mg/L)	16	24.06	11.70	68.60	1/26/2006-6/22/2006
		Fecal Coliform (#/100ml)	5	41,300	2,700	130,000	5/3/2006-6/19/2006
Burntwood Creek	At Clover Four Road (Z01B08)	TP (mg/L)	16	0.33	0.09	0.76	7/1/1999-2/15/2006
		Nitrate (mg/L)	15	10.45	0.05	36.00	7/1/1999-6/19/2006
		Fecal Coliform (#/100ml)	8	36,774	790	200,000	7/27/1999-6/19/2006
Beaver Creek	At bridge on Cassella-Montezuma Road (COC2)	TP (mg/L)	35	1.50	0.00	5.34	2/10/2005-6/22/2006
		Nitrate (mg/L)	9	15.95	9.30	37.33	2/23/2006-6/22/2006
		Fecal Coliform (#/100ml)	No Data	No Data	No Data	No Data	No Data

Subwatershed/ Stream	Location (Monitoring Station)	Parameter	Count	Average	Minimum	Maximum	Period of Record
Beaver Creek	At Depweg Road (CAFO8)	TP (mg/L)	10	0.49	0.16	1.82	2/19/2004-6/19/2006
		Nitrate (mg/L)	12	17.56	0.20	56.00	2/19/2004-6/19/2006
		Fecal Coliform (#/100ml)	5	59,700	2,900	200,000	5/3/2006-6/19/2006
Coldwater Creek	At bridge on Johnston Road (COC1)	TP (mg/L)	35	1.79	0.12	7.54	2/10/2005-6/22/2006
		Nitrate (mg/L)	9	8.87	2.72	20.20	2/23/2006-6/22/2006
		Fecal Coliform (#/100ml)	No Data	No Data	No Data	No Data	No Data
Coldwater Creek	At Fleetfoot Road (Z01P16)	TP (mg/L)	15	1.07	0.30	2.56	7/1/1999-6/19/2006
		Nitrate (mg/L)	15	7.92	0.05	30.90	7/1/1999-6/19/2006
		Fecal Coliform	8	52,738	1,300	200,000	7/27/1999-6/19/2006

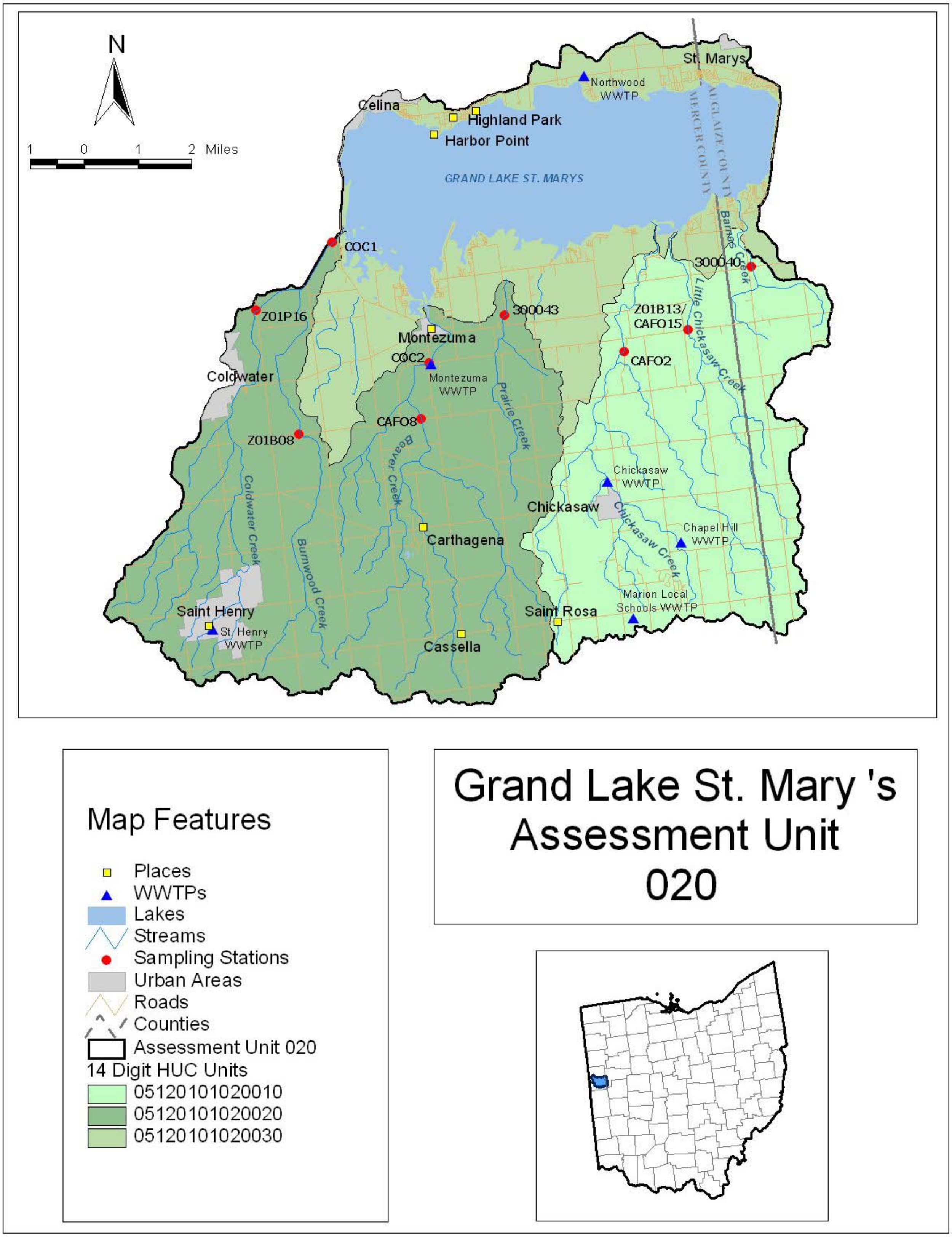

Figure 4-1. Load duration sites within the Grand Lake St. Marys and tributaries, Assessment Unit 020.

4.1.1 Barnes Creek (300040)

Existing and allowable loads were calculated for Barnes Creek at the bridge on State Route 364 near the St. Marys Township building (300040). This sampling station drains 3.08 square miles and land use/land cover upstream of this station consists primarily of row crops (86%), pasture/hay (7%), and deciduous forest (6%). A total of 41 TP samples, 15 nitrate samples, and 5 fecal coliform samples were available for the load duration analysis at site 300040 (Table 4-1). Water quality data for this station include samples collected by Ohio EPA and the City of Celina. Most data have been collected during high and moist flow conditions. There are no permitted WWTP facilities that discharge upstream of sampling station 300040.

Table 4-2 presents the TMDL summary for site 300040. Forty of the forty-one TP, all fifteen nitrate, and three of five fecal coliform observations exceed the loading limit, resulting in observed loads well above allowable loads (Appendix A). During high flow conditions, all three parameters have needed reductions of 91 percent or greater. Reductions are consistently high across all sampled flow conditions for TP and nitrate, while fecal coliform reductions drop from 99 to 17 percent from high to moist conditions.

Table 4-2. Loading Statistics for Barnes Creek (300040).

Barnes Creek (300040) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**14.31 cfs**	**2.23 cfs**	**0.79 cfs**	**0.26 cfs**	**0.07 cfs**
Total Phosphorus (kg/day)	Current Load	29.34	1.89	0.8	1.28	0.17
	TMDL= LA+WLA+MOS	**2.80**	**0.44**	**0.15**	**0.05**	**0.01**
	LA	2.66	0.42	0.14	0.048	0.0093
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	0.14	0.02	0.01	0.002	0.0007
	TMDL Reduction (%)	**91%**	**78%**	**82%**	**96%**	**92%**
Nitrate Nitrogen (kg/day)	Current Load	1,780	50	16	No Data	No Data
	TMDL= LA+WLA+MOS	**35**	**5**	**2**	**1**	**0.18**
	LA	33	4.73	1.90	0.97	0.17
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	2	0.27	0.10	0.03	0.01
	TMDL Reduction (%)	**98%**	**90%**	**89%**	No Data	No Data
Fecal Coliform (Million/day)	**Summer Flows (cfs)***	**9.49**	**1.23**	**0.44**	**0.16**	**0.06**
	Current Load	33,060,103	34,493	No Data	No Data	No Data
	TMDL= LA+WLA+MOS	**232,144**	**30,068**	**10,779**	**3,858**	**1,475**
	LA	220,537	28,565	10,240	3,665	1,401
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	11,607	1,503	539	193	74
	TMDL Reduction (%)	**99%**	**17%**	No Data	No Data	No Data

*Summer flows (May 1 -October 15) are presented because the fecal coliform standards only apply to the recreation season. Fecal coliform TMDLs were developed using summer flows only.

4.1.2 Little Chickasaw Creek (Z01B13/CAFO15)

Existing and allowable loads were calculated for Little Chickasaw Creek at Mercer County Road 219-A (Z01B13/CAFO15). This sampling station drains 5.03 square miles and land use/land cover upstream of this station consists primarily of row crops (88%), pasture/hay (7%), and deciduous forest (4%) land uses. A total of 43 TP samples, 18 nitrate samples, and 5 fecal coliform samples were available for the load duration analysis at site Z01B13/CAFO15 (Table 4-1). Water quality data for this station include samples collected by Ohio EPA and the City of Celina. Most data have been collected during high and moist flow conditions. There are no permitted WWTP facilities that discharge upstream of this sampling station.

Table 4-3 presents the TMDL summary for site Z01B13/CAFO15. Thirty-nine of the forty-three TP, all nitrate, and four out of five fecal coliform observations exceeded the loading limit (Appendix A). All three parameters show needed reductions of 94 percent or greater at high flows. TP reductions are lower at moist and mid-range flow conditions (70 and 54 percent, respectively), but increase at dry flow conditions to 89 percent. Needed nitrate reductions are greater than 90 percent for all available flow conditions. At high flows, 99 percent reductions in fecal coliform loads are needed.

Table 4-3. Loading Statistics for Little Chickasaw Creek (Z01B13/CAFO15).

Little Chickasaw Creek (Z01B13/CAFO15) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**23.32 cfs**	**3.63 cfs**	**1.29 cfs**	**0.42 cfs**	**0.12 cfs**
Total Phosphorus (kg/day)	Current Load	74.8	2.22	0.52	0.73	No Data
	TMDL= LA+WLA+MOS	**4.56**	**0.71**	**0.25**	**0.08**	**0.02**
	LA	4.33	0.67	0.24	0.076	0.019
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	0.23	0.04	0.01	0.004	0.001
	TMDL Reduction (%)	**94%**	**70%**	**54%**	**89%**	No Data
Nitrate Nitrogen (kg/day)	Current Load	2,857	116	34	No Data	No Data
	TMDL= LA+WLA+MOS	**57**	**9**	**3**	**1**	**0.30**
	LA	54	8.56	2.84	0.95	0.29
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	3	0.44	0.16	0.05	0.01
	TMDL Reduction (%)	**98%**	**93%**	**91%**	No Data	No Data
Fecal Coliform (Million/day)	**Summer Flows (cfs)**	**15.47**	**2.00**	**0.72**	**0.26**	**0.10**
	Current Load	31,038,635	289,904	No Data	No Data	No Data
	TMDL= LA+WLA+MOS	**378,400**	**49,011**	**17,570**	**6,288**	**2,404**
	LA	359,480	46,560	16,692	5,974	2,284
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	18,920	2,451	878	314	120
	TMDL Reduction (%)	**99%**	**84%**	No Data	No Data	No Data

4.1.3 Chickasaw Creek (CAFO2)

Existing and allowable loads were calculated for Chickasaw Creek at Mercer County Road 219-A (CAFO2). This sampling station drains 16.25 square miles and land use/land cover upstream of this station consists primarily of row crops (87%), pasture/hay (8%), and deciduous forest (3%) land uses. A total of 45 TP samples, 19 nitrate samples, and 5 fecal coliform samples were available for the load duration analysis at site CAFO2 (Table 4-1). Water quality data for this station include samples collected by Ohio EPA and the City of Celina. Most data have been collected during high and moist flow conditions.

The Marion Local Schools, Chapel Hill, and Chickasaw WWTPs discharge into Chickasaw Creek upstream of this sampling station. Marion Local Schools and Chapel Hill WWTPs are continuously discharging facilities while Chickasaw WWTP is a controlled discharge utilizing treatment lagoons. Chickasaw WWTP is not yet discharging but its permit requires that the discharge only occur when upstream flows are 1 cfs or greater. The Chickasaw controlled discharge is also limited to a final plant effluent of no more than 90 gallons per minute (gpm) for each one cubic foot per second (cfs) of stream flow measured upstream of the discharge.

As shown in Table 4-4 below, the median estimated flows during low and dry flow conditions upstream of the Chickasaw WWTP are below 1 cfs. A zero WLA for these flow zones were therefore assigned in Table 4-5. During high, moist, and mid-range flow conditions the upstream flows are above 1 cfs and therefore the WLA is based on the maximum design flow of 0.070 MGD.

Table 4-4. Median estimated stream flows upstream of the Chickasaw WWTP.

Flow Exceedence Range	Median Estimated Stream Flow (cfs)	Allowed Design Flow (MGD)
High Flows	21.88	0.070 (max)
Moist Flow Conditions	3.40	0.070 (max)
Mid-Range Flows	1.21	0.070 (max)
Dry Flow Conditions	0.39	None
Low Flows	0.11	None

Table 4-5 presents the TMDL summary for site CAFO2. Forty-four of forty-five TP and all nitrate and fecal coliform observations exceeded the loading limit at CAFO2 (Appendix A). Needed reductions for all three parameters at high flow conditions are 95 percent or greater. TP displays needed reductions of 80 to 97 percent across all flow conditions. All nitrate needed reductions are 91 percent or greater and fecal coliform loads need to be reduced by more than 99% at high flow conditions.

Table 4-5. Loading Statistics for Chickasaw Creek (CAFO2).

Chickasaw Creek (CAFO2) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**75.38 cfs**	**11.73 cfs**	**4.15 cfs**	**1.34 cfs**	**0.39 cfs**
Total Phosphorus (kg/day)	Current Load	296.27	11.48	5.86	6.95	2.32
	TMDL= LA+WLA+MOS	**14.75**	**2.30**	**0.81**	**0.26**	**0.08**
	LA	13.58	1.76	0.34	0.08	0.076
	WLA: Marion Local Schools WWTP	0.09	0.09	0.09	0.09	0
	WLA: Chapel Hill WWTP	0.08	0.08	0.08	0.08	0
	WLA: Chickasaw WWTP	0.26	0.26	0.26	0	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0.43	0.43	0.43	0.17	0
	MOS (5%)	0.74	0.11	0.04	0.01	0.004
	TMDL Reduction (%)	**95%**	**81%**	**87%**	**96%**	**97%**
Nitrate Nitrogen (kg/day)	Current Load	11,679	447	112	No Data	No Data
	TMDL= LA+WLA+MOS	**184**	**29**	**10**	**3**	**1**
	LA	170	23	4	2.84	0.95
	WLA: Marion Local Schools WWTP	1	1	1	0	0
	WLA: Chapel Hill WWTP	1	1	1	0	0
	WLA: Chickasaw WWTP	3	3	3	0	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	5	5	5	0	0
	MOS (5%)	9	1	1	0.16	0.05
	TMDL Reduction (%)	**98%**	**94%**	**91%**	No Data	No Data
Fecal Coliform (Million/day)	**Summer Flows (cfs)**	**49.99**	**6.47**	**2.32**	**0.83**	**0.32**
	Current Load	352,685,364	709,854	No Data	No Data	No Data
	TMDL= LA+WLA+MOS	**1,223,040**	**158,410**	**56,788**	**20,324**	**7,771**
	LA	1,157,535	146,137	49,596	17,605	5,679
	WLA: Marion Local Schools WWTP	946	946	946	946	946
	WLA: Chapel Hill WWTP	757	757	757	757	757
	WLA: Chickasaw WWTP	2,650	2,650	2,650	0	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	4,353	4,353	4,353	1,703	1,703
	MOS (5%)	61,152	7,920	2,839	1,016	389
	TMDL Reduction (%)	**>99%**	**79%**	No Data	No Data	No Data

As demonstrated in Table 4-5, the vast majority of pollutant loading in Chickasaw Creek occurs during high flow conditions and runoff from the surrounding agricultural land uses is strongly suspected to be the source of these loads. However, as stream flows decrease, the upstream point sources have the potential to have a greater influence on nutrient loads as noted by their increasing proportion of the allowable loads. During dry conditions and low flows, the combined design loads of the Marion Local Schools and Chapel Hill WWTPs exceed or nearly exceed the total allowable load for TP and nitrate. To avoid negative load allocations, these WLAs were replaced with zeros in the TMDL tables. This also reflects that there is no “allowed design flow” during dry/low flows

Again, the loads from all three facilities appear to be a minor proportion of the total nutrient and pathogen loads in Chickasaw Creek during high, moist, and mid-range flows. However, if the design loads are maintained during dry and low flow conditions, the two continuously discharging facilities may have significant influence on TP and nitrate levels. The Chickasaw WWTP is only permitted to discharge at high, moist, and mid-range flow conditions, and appears to have minimal influence on nutrient and pathogen loads during those flow categories.

The Marion Local School WWTP and Chapel Hill WWTP discharges will soon be eliminated once wastewater is redirected to the Chickasaw WWTP as part of a planned expansion at that facility. This expansion may also involve a sewer connection from the Maria Stein area where there are many unsewered homes and businesses that contribute sources of inadequately treated wastewater to the Chickasaw Creek subwatershed.

4.1.4 Prairie Creek (300043)

Existing and allowable loads were calculated for Prairie Creek at the bridge on Kittle Road (300043). This sampling station drains 5.10 square miles and land use/land cover upstream of this station consists primarily of row crops (90%), pasture/hay (7%) and deciduous forest (2%) land uses. A total of 42 TP samples, 16 nitrate samples, and 5 fecal coliform samples were available for the load duration analysis at site 300043 (Table 4-1). Water quality data for this station include samples collected by Ohio EPA and the City of Celina. Most data have been collected during high and moist flow conditions. There are no permitted WWTP facilities upstream of sampling station 300043.

Table 4-6 presents the TMDL summary for site 300043. All TP, nitrate, and fecal coliform observations at sampling station 300043 exceeded loading limits for Prairie Creek (Appendix A). Needed TP reductions range from 87 percent (moist flow conditions) to 99 percent at both dry and low flow conditions. The needed reductions for nitrate are all above 94 percent and fecal coliform loads need to be reduced by 83 percent or greater.

Table 4-6. Loading Statistics for Prairie Creek (300043).

Prairie Creek (300043) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**23.67 cfs**	**3.68 cfs**	**1.30 cfs**	**0.42 cfs**	**0.12 cfs**
Total Phosphorus (kg/day)	Current Load	84.91	5.49	2.76	5.57	3.51
	TMDL= LA+WLA+MOS	**4.63**	**0.72**	**0.26**	**0.08**	**0.02**
	LA	4.40	0.68	0.25	0.076	0.019
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	0.23	0.04	0.01	0.004	0.001
	TMDL Reduction (%)	**95%**	**88%**	**91%**	**99%**	**99%**
Nitrate Nitrogen (kg/day)	Current Load	5,484	170	57	No Data	No Data
	TMDL= LA+WLA+MOS	**58**	**9**	**3**	**1**	**0.30**
	LA	55	8.55	2.84	0.95	0.28
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	3	0.45	0.16	0.05	0.02
	TMDL Reduction (%)	**99%**	**95%**	**95%**	No Data	No Data
Fecal Coliform (Million/day)	**Summer Flows (cfs)**	**15.70**	**2.03**	**0.73**	**0.26**	**0.10**
	Current Load	72,007,838	279,921	No Data	No Data	No Data
	TMDL= LA+WLA+MOS	**384,117**	**49,751**	**17,835**	**6,383**	**2,441**
	LA	364,911	47,263	16,943	6,064	2,319
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	19,206	2,488	892	319	122
	TMDL Reduction (%)	**99%**	**83%**	No Data	No Data	No Data

4.1.5 Burntwood Creek (Z01B08)

Existing and allowable loads were calculated for Burntwood Creek at Clover Four Road (Z01B08). This sampling station drains 5.43 square miles and land use/land cover upstream of this station consists primarily of row crops (86%), pasture/hay (9%) and deciduous forest (4%) land uses. A total of 16 TP samples, 15 nitrate samples, and 8 fecal coliform samples were available for the load duration analysis at site Z01B08 (Table 4-1). Most data have been collected during high, moist, dry, and low flow conditions. There are no permitted WWTP facilities upstream of sampling station Z01B08.

Table 4-7 presents the TMDL summary for site Z01B08. All TP, nine of fifteen nitrate, and seven of eight fecal coliform observations at Z01B08 exceed loading limits for Burntwood Creek (Appendix A). Needed TP reductions steadily increase from low flow (60 percent) to high flow (93 percent) conditions. Fecal coliform samples follow a similar trend of increasing needed reductions with increasing flows.

Nitrate loads did not show any needed reductions during dry or low flow conditions. However, nitrate load reductions are needed during high and moist flows at 94 percent or greater.

Table 4-7. Loading Statistics for Burntwood Creek (Z01B08).

Burntwood Creek (Z01B08) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**25.20 cfs**	**3.92 cfs**	**1.39 cfs**	**0.45 cfs**	**0.13 cfs**
Total Phosphorus (kg/day)	Current Load	68.29	3.80	No Data	0.24	0.06
	TMDL= LA+WLA+MOS	**4.93**	**0.77**	**0.27**	**0.09**	**0.03**
	LA	4.68	0.73	0.26	0.086	0.029
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	0.25	0.04	0.01	0.004	0.001
	TMDL Reduction (%)	**93%**	**81%**	No Data	**65%**	**60%**
Nitrate Nitrogen (kg/day)	Current Load	4,210	141	No Data	0.14	0.01
	TMDL= LA+WLA+MOS	**62**	**10**	**3**	**1**	**0.32**
	LA	59	9.52	2.83	0.95	0.30
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	3	0.48	0.17	0.05	0.02
	TMDL Reduction (%)	**99%**	**94%**	No Data	**0%**	**0%**
Fecal Coliform (Million/day)	**Summer Flows (cfs)**	**16.72**	**2.17**	**0.78**	**0.28**	**0.11**
	Current Load	33,740,625	1,490,144	No Data	15,946	5,667
	TMDL= LA+WLA+MOS	**408,965**	**52,970**	**18,989**	**6,796**	**2,599**
	LA	388,517	50,322	18,040	6,456	2,469
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	20,448	2,648	949	340	130
	TMDL Reduction (%)	**99%**	**97%**	No Data	**60%**	**56%**

4.1.6 Beaver Creek (COC2)

Existing and allowable loads were calculated for Beaver Creek at the bridge on Cassella-Montezuma Road (COC2). This sampling station drains 18.35 square miles and land use/land cover upstream of this station consists primarily of row crops (88%), pasture/hay (8%) and deciduous forest (3%) land uses. A total of 35 TP samples and 9 nitrate samples were available for the load duration analysis at site COC2 (Table 4-1). All water quality data for this station are from sampling performed by the City of Celina. No pathogen samples were obtained during these sampling events. Most data have been collected during high, moist, and mid-range flow conditions. The Montezuma Club Island WWTP discharges into Beaver Creek upstream of station COC2.

Two TMDL tables (Table 4-8 and 4-9) were generated for this station because the Montezuma Club Island WWTP is only permitted to discharge between October 16 and April 30 (non-recreational season). (A WLA of zero is therefore specified for the recreation season (Table 4-8)). All nitrate and TP observations exceed the loading limits for sampling station COC2 (Appendix A). The needed TP and nitrate reductions are 92 percent or greater across all flow regimes for the recreation and non-recreation seasons. No fecal coliform samples have been obtained at this sampling station. Another load duration site (CAFO8) is also located on Beaver Creek upstream of Montezuma Club Island WWTP, and this station is discussed below.

Table 4-8. Loading Statistics for Beaver Creek (COC2) During the Recreation Season (May1 – October 15).

COC2 (Recreation Season) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**56.45 cfs**	**7.31 cfs**	**2.62 cfs**	**0.94 cfs**	**0.36 cfs**
Total Phosphorus (kg/day)	Current Load	541.77	20.18	9.95	4.15	1.74
	TMDL= LA+WLA+MOS	**11.05**	**1.43**	**0.51**	**0.18**	**0.07**
	LA	10.50	1.36	0.48	0.17	0.067
	WLA: Montezuma WWTP	0	0	0	0	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	0.55	0.07	0.03	0.01	0.003
	TMDL Reduction (%)	**98%**	**93%**	**95%**	**96%**	**96%**
Nitrate Nitrogen (kg/day)	Current Load	8,867	420	No Data	No Data	No Data
	TMDL= LA+WLA+MOS	**138**	**18**	**6**	**2**	**1**
	LA	131	17.11	5.68	1.89	0.96
	WLA: Montezuma WWTP	0	0	0	0	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	7	0.89	0.32	0.11	0.04
	TMDL Reduction (%)	**99%**	**96%**	No Data	No Data	No Data

Table 4-9. Loading Statistics for Beaver Creek (COC2) During the Non-Recreation Season (October 16 – April 30).

COC2 (Non-Recreation Season) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**111.41 cfs**	**21.41 cfs**	**9.96 cfs**	**5.68 cfs**	**3.35 cfs**
Total Phosphorus (kg/day)	Current Load	374.85	107.96	29.64	13.51	No Data
	TMDL= LA+WLA+MOS	21.81	4.19	1.95	1.11	0.66
	LA	18.62	1.88	0	0	0.63
	WLA: Montezuma WWTP	2.10	2.10	1.85	1.05	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	2.10	2.10	1.85	1.05	0
	MOS (5%)	1.09	0.21	0.10	0.06	0.03
	TMDL Reduction (%)	**94%**	**96%**	**94%**	**92%**	No Data
Nitrate Nitrogen (kg/day)	Current Load	No Data	991.14	302.94	197.31	No Data
	TMDL= LA+WLA+MOS	272.57	52.37	24.36	13.89	8.19
	LA	257.41	48.22	21.61	11.67	7.78
	WLA: Montezuma WWTP	1.53	1.53	1.53	1.53	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	1.53	1.53	1.53	1.53	0
	MOS (5%)	13.63	2.62	1.22	0.69	0.41
	TMDL Reduction (%)	No Data	**95%**	**92%**	**93%**	No Data

The Montezuma Club Island WWTP utilizes treatment lagoons and is only allowed to discharge when in-stream flow is greater than one cfs. This controlled discharge is also limited to a final plant effluent of no more than 90 gallons per minute (gpm) for each cubic foot per second (cfs) of stream flow measured upstream of the discharge and no discharge is allowed at this facility during the recreational season (May 1 through October 15). In Table 4-9 above, adjustments were made to the total phosphorus LA and WLA to ensure that the TMDL equals the LA + WLA + MOS.

As shown in Table 4-10, the median estimated flow during low flow conditions upstream of the Montezuma Club Island WWTP is below one cfs, resulting in a WLA of zero for this flow condition (Table 4-7). Across all other flow conditions, upstream flows are above one cfs and the WLA is based on either the maximum design flow of 0.370 MGD or the loading capacity of the stream (minus the MOS for the TMDL).

Table 4-10. Median estimated stream flows upstream of the Montezuma Club Island WWTP during the non-recreational season (October 16 – April 30).

Flow Exceedence Range	Median Estimated Stream Flow (cfs)	Allowed Design Flow (MGD)
High Flows	108.77	0.370 (max)
Moist Flow Conditions	18.76	0.370 (max)
Mid-Range Flows	7.31	0.370 (max)
Dry Flow Conditions	3.03	0.370 (max)
Low Flows	0.70	None

As shown in Table 4-9, the maximum allowable TP loads for the Montezuma Club Island WWTP are a significant proportion of the allowable TP loads in Beaver Creek during all but high flow conditions. It is unknown whether the facility actually discharges at these lower flow conditions. However, comparing the TMDL reductions needed between COC2 and CAFO8 indicates that much higher TP reductions are needed downstream of the Montezuma Club Island WWTP, most notably during moist and dry flow conditions.

Despite the potential significance of the WWTP during low flow periods, it is important to remember that the Montezuma WWTP loads (both TP and nitrate) still only make up a small portion of the total observed loads in Beaver Creek. This is due to the fact that most of the loading occurs during high flow periods and suggests that there are other, more significant pollutant sources within the watershed.

4.1.7 Beaver Creek (CAFO8)

Existing and allowable loads were calculated for Beaver Creek at Depweg Road (CAFO8). This sampling station drains 14.33 square miles and land use/land cover upstream of this station consists primarily of row crops (88%), pasture/hay (8%) and deciduous forest (3%) land uses. A total of 10 TP samples, 12 nitrate samples, and 5 fecal coliform samples were available for the load duration analysis at site CAFO8 (Table 4-1). Most data have been collected during high and moist flow conditions. There are no permitted WWTP discharges upstream of sampling station CAFO8.

Table 4-8 presents the TMDL summary for site CAFO8. Eleven of twelve nitrate and all TP and fecal coliform observations exceed the loading limits for Beaver Creek at sampling station CAFO8 (Appendix A). TP displays needed reductions of 95 percent at high flows and much lower needed reductions at moist and dry conditions. Load reductions for nitrate are 94 percent or greater at moist and high flow conditions and zero percent at dry conditions. Fecal coliform loads show 99 percent needed reductions during high flows and 88 percent at moist conditions.

Table 4-11. Loading Statistics for Beaver Creek (CAFO8).

Beaver Creek (CAFO8) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**66.49 cfs**	**10.35 cfs**	**3.66 cfs**	**1.19 cfs**	**0.34 cfs**
Total Phosphorus (kg/day)	Current Load	270.26	4.40	No Data	0.52	No Data
	TMDL= LA+WLA+MOS	**13.01**	**2.02**	**0.72**	**0.23**	**0.07**
	LA	12.36	1.92	0.68	0.22	0.067
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	0.65	0.10	0.04	0.01	0.003
	TMDL Reduction (%)	**95%**	**56%**	No Data	**58%**	No Data
Nitrate Nitrogen (kg/day)	Current Load	8,744	418	No Data	1	No Data
	TMDL= LA+WLA+MOS	**163**	**25**	**9**	**3**	**1**
	LA	155	24	8.55	2.85	0.96
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	8	1	0.45	0.15	0.04
	TMDL Reduction (%)	**98%**	**94%**	No Data	**0%**	No Data
Fecal Coliform (Million/day)	**Summer Flows (cfs)**	**44.10**	**5.71**	**2.05**	**0.73**	**0.28**
	Current Load	127,571,943	1,152,195	No Data	No Data	No Data
	TMDL= LA+WLA+MOS	**1,078,896**	**139,740**	**50,095**	**17,929**	**6,855**
	LA	1,024,951	132,753	47,590	17,033	6,512
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	53,945	6,987	2,505	896	343
	TMDL Reduction (%)	**99%**	**88%**	No Data	No Data	No Data

4.1.8 Coldwater Creek (COC1)

Existing and allowable loads were calculated for Coldwater Creek at the bridge on Johnston Road (COC1). This sampling station drains 19.82 square miles and land use/land cover upstream of this station consists primarily of row crops (81%), pasture/hay (11%) deciduous forest (3%), and low intensity residential (3%) land uses. A total of 34 TP samples and 8 nitrate samples were available for the load duration analysis at site COC1 (Table 4-1). All water quality data for this station are from sampling performed by the City of Celina. No pathogen samples were obtained during these sampling events. Most data have been collected during high, moist, and mid-range flow conditions.

The St. Henry WWTP discharges into Coldwater Creek upstream of sampling station COC1. The St. Henry WWTP utilizes treatment lagoons and is only allowed to discharge when in-stream flow is greater than 1 cfs, resulting in a WLA of zero during certain flow periods (based on median estimated stream flows; see Appendix A for details). This controlled discharge is also limited to a final plant effluent of no more than 90 gallons per minute (gpm) for each cubic foot per second (cfs) of stream flow measured upstream of the discharge. As shown in Table 4-12 below, the median estimated flows from low to moist flow conditions upstream of the St. Henry WWTP are below 1 cfs, resulting in a WLA of zero for those flow conditions (Table 4-13). During high flow conditions, upstream flows are above 1 cfs permitting the facility to discharge at its maximum design flow of 0.019 MGD and still be in compliance with permitted dilution ratios.

Table 4-12. Median observed stream flows upstream of the St. Henry WWTP.

Flow Exceedence Range	Median Observed Stream Flow (cfs)	Allowed Design Flow (MGD)
High Flows	1.67	0.019 (max)
Moist Flow Conditions	0.26	None
Mid-Range Flows	0.09	None
Dry Flow Conditions	0.03	None
Low Flows	0.01	None

Table 4-13 presents the TMDL summary for site COC1. All TP and nitrate observations at sampling station COC1 exceed the loading limit for Coldwater Creek (Appendix A). Both parameters display relatively consistent needed reductions across all available flow conditions. TP reductions range from 89 percent at mid-range flows to 97 percent at both high and low flows. The St. Henry WWTP WLA is a minimal portion of the total allowable load in Coldwater Creek during high flow conditions.

Table 4-13. Loading Statistics for Coldwater Creek (COC1).

Coldwater Creek (COC1) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**91.97 cfs**	**14.31 cfs**	**5.07 cfs**	**1.64 cfs**	**0.48 cfs**
Total Phosphorus (kg/day)	Current Load	575.57	39.20	8.86	8.42	2.80
	TMDL= LA+WLA+MOS	**18.00**	**2.80**	**0.99**	**0.32**	**0.09**
	LA	17.03	2.66	0.94	0.30	0.085
	WLA: St. Henry WWTP	0.07	0	0	0	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0.07	0	0	0	0
	MOS (5%)	0.90	0.14	0.05	0.02	0.005
	TMDL Reduction (%)	**97%**	**93%**	**89%**	**96%**	**97%**
Nitrate Nitrogen (kg/day)	Current Load	5,081	324	82	No Data	No Data
	TMDL= LA+WLA+MOS	**225**	**35**	**12**	**4**	**1**
	LA	213.28	33	11	3.80	0.94
	WLA: St. Henry WWTP	0.72	0	0	0	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0.72	0	0	0	0
	MOS (5%)	11	2	1	0.20	0.06
	TMDL Reduction (%)	**96%**	**90%**	**86%**	No Data	No Data

4.1.9 Coldwater Creek (Z01P16)

Existing and allowable loads were calculated for Coldwater Creek at Fleetfoot Road (Z01P16). This sampling station drains 11.51 square miles and land use/land cover upstream of this station consists primarily of row crops (76%), pasture/hay (12%), low intensity residential (5%) and deciduous forest (3%) land uses. A total of 15 TP samples, 15 nitrate samples, and 8 fecal coliform samples were available for the load duration analysis at site Z01P16 (Table 4-1). Most data have been collected during high, moist, dry, and low flow conditions. The St. Henry WWTP discharges into Coldwater Creek upstream of sampling station Z01P16 (see Table 4-12 and associated text for WLA description).

Table 4-14 presents the TMDL summary for site Z01P16. All TP, eleven of fifteen nitrate, and all fecal coliform observations exceed loading limits for sampling station Z01P16 (Appendix A). TP load reductions are consistently above 88 percent across all flow conditions. Needed nitrate and fecal coliform reductions display an increase with increasing flow conditions. The St. Henry WWTP loads appear to be a minor proportion of the nutrient and pathogen loads in Coldwater Creek during high flows.

Table 4-14. Loading Statistics for Coldwater Creek (Z01P16).

Coldwater Creek (Z01P16) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**56.53 cfs**	**11.44 cfs**	**6.08 cfs**	**4.09 cfs**	**3.41 cfs**
Total Phos-phorus (kg/day)	Current Load	243.14	17.27	No Data	12.65	15.86
	TMDL= LA+WLA+MOS	**11.07**	**2.24**	**1.19**	**0.80**	**0.67**
	LA	10.45	2.13	1.13	0.76	0.64
	WLA: St. Henry WWTP	0.07	0	0	0	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	10.52	2.13	1.13	0.76	0.64
	MOS (5%)	0.55	0.11	0.06	0.04	0.03
	TMDL Reduction (%)	**96%**	**88%**	No Data	**94%**	**96%**
Nitrate Nitrogen (kg/day)	Current Load	7,892	290	No Data	2	11
	TMDL= LA+WLA+MOS	**138**	**28**	**15**	**10**	**8**
	LA	130.28	27	14	9	7.58
	WLA: St. Henry WWTP	0.72	0	0	0	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0.72	0	0	0	0
	MOS (5%)	7	1	1	1	0.42
	TMDL Reduction (%)	**98%**	**91%**	No Data	**0%**	**27%**
Fecal Coliform (Million/ day)	**Summer Flows (cfs)**	**38.55**	**7.72**	**4.78**	**3.73**	**3.36**
	Current Load	232,363,419	2,250,878	No Data	542,872	280,349
	TMDL= LA+WLA+MOS	**943,154**	**188,958**	**116,968**	**91,137**	**82,244**
	LA	895,277	179,510	111,120	86,580	78,132
	WLA: St. Henry WWTP	719	0	0	0	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	719	0	0	0	0
	MOS (5%)	47,158	9,448	5,848	4,557	4,112
	TMDL Reduction (%)	**100%**	**92%**	No Data	**84%**	**72%**

4.2 Assessment Unit 030: Beaver Creek (Downstream of Grand Lake St. Marys to Mouth)

The load duration approach was applied to six sampling stations located within Assessment Unit 030 (Figure 4-2):

- Two sites on the mainstem of Beaver Creek:
  - At Meyer Road (605020).
  - At Erastus-Durbin Road (Z01P04).
- One site on each of the major tributaries to Beaver Creek:
  - Hardin Creek at Fleetfoot Road (Z01P15).
  - Little Beaver Creek at Menchhofer Road (Z01B03).
  - Big Run at State Route 29 (Z01P06).
  - Prairie Creek at Mud Pike (Z01P07).

For each load duration site, all appropriate and available water quality and flow data were used. Table 4-15 summarizes all data used for the load duration analyses in Assessment Unit 030. Assessment unit 030 TMDL summary tables can be found in Appendix C.

Table 4-15. Summary of Available Data for Load Duration Sites in Assessment Unit 030.

Subwatershed/ Stream	Location (Monitoring Station)	Parameter	Count	Average	Minimum	Maximum	Period of Record
Beaver Creek	At Meyer Road (605020)	TP (mg/L)	6	0.74	0.3	1.41	6/28/1999-8/30/1999
		Nitrate (mg/L)	6	1.03	0.43	2.73	6/28/1999-8/30/1999
		Fecal Coliform (#/100ml)	3	1,667	1,200	2,100	7/26/1999-8/16/1999
Hardin Creek	At Fleetfoot Road (Z01P15)	TP (mg/L)	14	0.44	0.04	1.64	6/28/1999-6/19/2006
		Nitrate (mg/L)	14	8.13	0.05	36	6/28/1999-6/19/2006
		Fecal Coliform (#/100ml)	8	5,595	350	23,000	7/26/1999-6/19/2006
Little Beaver Creek	At Menchhofer Road (Z01B03)	TP (mg/L)	6	1.28	0.74	1.62	6/28/1999-8/30/1999
		Nitrate (mg/L)	6	0.38	0.1	0.9	6/28/1999-8/30/1999
		Fecal Coliform (#/100ml)	3	2,467	1,000	3,400	7/26/1999-8/16/1999
Beaver Creek	At Erastus-Durbin Road (Z01P04)	TP (mg/L)	14	0.33	0.08	0.89	6/28/1999-6/19/2006
		Nitrate (mg/L)	14	3.98	0.19	25.55	6/28/1999-6/19/2006
		Fecal Coliform (#/100ml)	8	18,733	86	140,000	7/26/1999-6/19/2006
Big Run	At State Route 29 (Z01P06)	TP (mg/L)	15	1.07	0.3	2.56	7/1/1999-6/19/2006
		Nitrate (mg/L)	14	9.12	0.05	48.2	6/28/1999-6/19/2006
		Fecal Coliform (#/100ml)	8	38,253	44	200,000	7/26/1999-6/19/2006
Prairie Creek	At Mud Pike (Z01P07)	TP (mg/L)	15	0.15	0.04	0.42	6/28/1999-6/19/2006
		Nitrate (mg/L)	14	10.34	0.05	46.3	7/12/1999-6/19/2006
		Fecal Coliform (#/100ml)	8	9,151	270	49,000	7/26/1999-6/19/2006

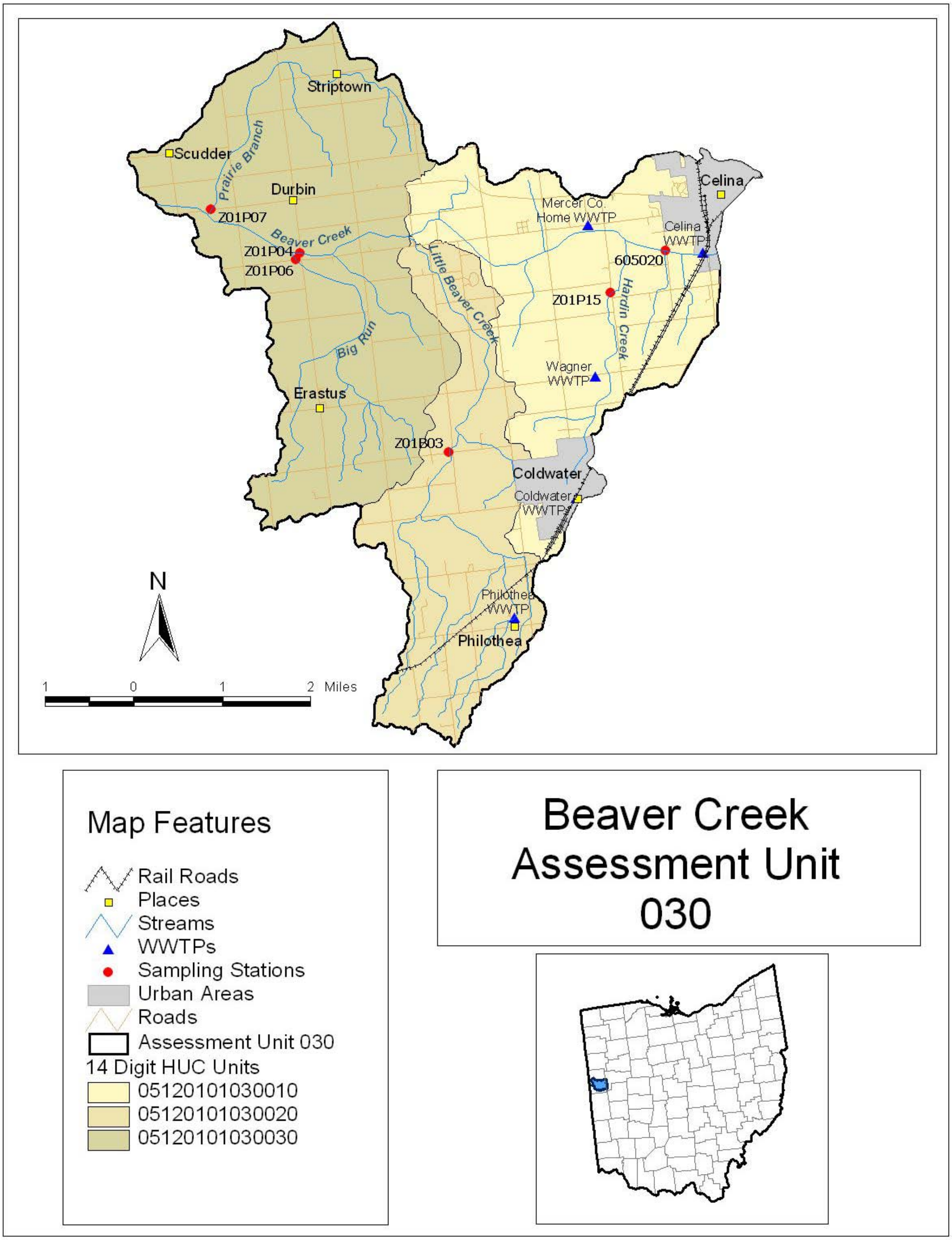

Figure 4-2. Load duration sites within the Beaver Creek (downstream of Grand Lake St. Marys to mouth), Assessment Unit 030.

4.2.1 Beaver Creek (605020)

Existing and allowable loads were calculated for Beaver Creek at Meyer Road (605020). This sampling station drains 3.69 square miles and land use/land cover upstream of this station consists primarily of row crops (46%), low intensity residential (25%), commercial/industrial/transportation (12%), and pasture/hay (8%) land uses. A total of 6 TP samples, 6 nitrate samples, and 3 fecal coliform samples were available for the load duration analysis at site 605020 (Table 4-15). Average monthly flows from the Grand Lake St. Marys spillway have been incorporated into the continuous flow estimations at this station. Most data have been collected during mid-range flow conditions. The Celina WWTP discharges into Beaver Creek just upstream of station 605020 and runoff from the City of Celina requires a WLA under the Phase II Storm water Program. The WLA was estimated based on the proportion of the upstream drainage area located within the city's boundaries and storm water runoff was only assumed to occur during high flow, moist conditions, and mid-range flows.

Table 4-16 presents the TMDL summary for site 605020. All TP and fecal coliform and two of six nitrate observations were found to exceed the loading limit for Beaver Creek at site 605020. TP reductions for high, mid-range, and dry conditions are all 86 percent or greater. The only needed nitrate reductions are 12 percent for mid-range flows. Fecal coliform loads display 69 percent needed reductions during moist conditions and about half that at mid-range flows. The daily loads, needed reductions, and WLA for site 605020 suggest that during lower flow conditions, the Celina WWTP discharge is a significant component of the allowable TP load. In fact, the calculated total phosphorus and nitrate WLAs for the Celina WWTP for some flow conditions had to be set to zero in Table 4-16 to ensure that the TMDL equals the LA + WLA + MOS. The load from the WWTP is also a significant component of the nitrate load; however, the load duration analysis indicates that no nitrate reductions are required during low flow conditions.

Table 4-16. Loading Statistics for Beaver Creek (605020).

Beaver Creek (605020) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**222.25 cfs**	**182.85 cfs**	**108.43 cfs**	**85.51 cfs**	**24.92 cfs**
Total Phosphorus (kg/day)	Current Load	369.05	No Data	143.95	141.03	No Data
	TMDL= LA+WLA+MOS	**43.50**	**35.79**	**21.22**	**16.74**	**4.88**
	LA	20.07	15.46	6.74	6.44	4.64
	WLA: Celina WWTP	9.46	9.46	9.46	9.46	0
	WLA: Celina MS4	11.79	9.08	3.96	0	0
	Total WLA	21.25	18.54	13.42	9.46	0
	MOS (5%)	2.18	1.79	1.06	0.84	0.24
	TMDL Reduction (%)	**89%**	No Data	**86%**	**89%**	No Data
Nitrate Nitrogen (kg/day)	Current Load	324	No Data	285	144	No Data
	TMDL= LA+WLA+MOS	**544**	**447**	**265**	**209**	**61**
	LA	266	208	99	104	58
	WLA: Celina WWTP	95	95	95	95	0
	WLA: Celina MS4	156	122	58	0	0
	Total WLA	251	217	153	95	0
	MOS (5%)	27	22	13	10	3
	TMDL Reduction (%)	**0%**	No Data	**12%**	**0%**	No Data
Fecal Coliform (Million/day)	**Summer Flows (cfs)**	**222.90**	**153.95**	**105.13**	**40.03**	**27.29**
	Current Load	No Data	11,397,233	3,729,111	No Data	No Data
	TMDL= LA+WLA+MOS	**5,453,366**	**3,766,601**	**2,572,081**	**979,400**	**667,677**
	LA	3,204,220	2,194,691	1,479,771	835,795	539,658
	WLA: Celina WWTP	94,635	94,635	94,635	94,635	94,635
	WLA: Celina MS4	1,881,843	1,288,945	869,071	0	0
	Total WLA	1,976,478	1,383,580	963,706	94,635	94,635
	MOS (5%)	272,668	188,330	128,604	48,970	33,384
	TMDL Reduction (%)	No Data	**69%**	**34%**	No Data	No Data

4.2.2 Hardin Creek (Z01P15)

Existing and allowable loads were calculated for Hardin Creek at Fleetfoot Road (Z01P15). This sampling station drains 4.78 square miles and land use/land cover upstream of this station consists primarily of row crops (72%), low intensity residential (9%), pasture/hay (7%), and commercial/industrial/transportation (5%) land uses. A total of 14 TP samples, 14 nitrate samples, and 8 fecal coliform samples were available for the load duration analysis at site Z01P15 (Table 4-15). Most data have been collected during high, moist, dry, and low flow conditions. The Coldwater and Wagner WWTPs discharge into Hardin Creek upstream of sampling station Z01P15.

Table 4-17 presents the TMDL summary for site Z01P15. Eleven of fourteen TP, eight of fourteen nitrate, and four of eight fecal coliform observations exceeded the daily loading limits in Hardin Creek. TP needed reductions were highest at high flows (95 percent) and dry conditions (87 percent) but were only 5 percent during moist conditions. Nitrate loads displayed needed reductions of 89 percent or greater at moist to high flow conditions, but zero percent from mid-range to low flow conditions. Fecal coliform showed similar results with 97 percent needed reductions at high flows and zero percent at moist, dry, and low flow conditions.

Table 4-17. Loading Statistics for Hardin Creek (Z01P15).

Hardin Creek (Z01P15) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**24.36 cfs**	**5.63 cfs**	**3.40 cfs**	**2.57 cfs**	**2.29 cfs**
Total Phosphorus (kg/day)	Current Load	84.66	1.10	2.94	3.67	1.35
	TMDL= LA+WLA+MOS	**4.77**	**1.10**	**0.66**	**0.50**	**0.45**
	LA	1.77	1.00	0.59	0.43	0.39
	WLA: Coldwater WWTP	2.72	0	0	0	0
	WLA: Wagner WWTP	0.04	0.04	0.04	0.04	0.04
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	2.76	0.04	0.04	0.04	0.04
	MOS (5%)	0.24	0.06	0.03	0.03	0.02
	TMDL Reduction (%)	**95%**	**5%**	**79%**	**87%**	**68%**
Nitrate Nitrogen (kg/day)	Current Load	3,897	118	6	0.29	2
	TMDL= LA+WLA+MOS	**60**	**14**	**8**	**6**	**6**
	LA	49.38	12.62	7.20	5.31	5.34
	WLA: Coldwater WWTP	7.24	0	0	0	0
	WLA: Wagner WWTP	0.38	0.38	0.38	0.38	0.38
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	7.62	0.38	0.38	0.38	0.38
	MOS (5%)	3	1	0.42	0.31	0.28
	TMDL Reduction (%)	**99%**	**89%**	**0%**	**0%**	**0%**
Fecal Coliform (Million/day)	**Summer Flows (cfs)**	**16.89**	**4.08**	**2.86**	**2.42**	**2.27**
	Current Load	12,633,225	80,697	No Data	46,339	28,003
	TMDL= LA+WLA+MOS	**413,219**	**99,821**	**69,907**	**59,173**	**55,478**
	LA	364,962	94,451	66,033	55,835	52,325
	WLA: Coldwater WWTP	27,217	0	0	0	0
	WLA: Wagner WWTP	379	379	379	379	379
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	27,596	379	379	379	379
	MOS (5%)	20,661	4,991	3,495	2,959	2,774
	TMDL Reduction (%)	**97%**	**0%**	No Data	**0%**	**0%**

The Coldwater WWTP utilizes treatment lagoons and is only allowed to discharge when in-stream flow is greater than 1 cfs; however the median estimated flows across all flow regimes at this station are all above that limit (Appendix A). This controlled discharge is also limited to a final plant effluent of no more than 90 gallons per minute (gpm) for each cubic foot per second (cfs) of stream flow measured upstream of the discharge. As shown in Table 4-18, the median estimated flow during low, dry, mid-range, and moist flow conditions upstream of the Coldwater WWTP are below 1 cfs, resulting in a WLA of zero during these flow categories (Table 4-17). During high flow conditions, in-stream flows are above 1 cfs but to maintain the 5:2 dilution ration (90 gpm per 1 cfs), a "stepped WLA" is applied. This maintains the 5:2 dilution ratio by stepping down the facility's design flow from the maximum of 0.900 MGD to 0.719 MGD.

Table 4-18. Median observed stream flows upstream of the Coldwater WWTP.

Flow Exceedence Range	Median Observed Stream Flow (cfs)	Allowed Design Flow (MGD)
High Flows	5.56	0.719 (max is 0.900)
Moist Flow Conditions	0.86	None
Mid-Range Flows	0.31	None
Dry Flow Conditions	0.10	None
Low Flows	0.03	None

Based on the design load for TP, the Coldwater WWTP is potentially contributing a significant component of the total allowable TP load to Hardin Creek during high flows. The Coldwater WWTP does not appear to be a significant source of nitrate or fecal coliform, and the Wagner WWTP loads appear to be a minor proportion of the nutrient and pathogen loads in Hardin Creek, even during low flows.

4.2.3 Little Beaver Creek (Z01B03)

Existing and allowable loads were calculated for Little Beaver Creek at Menchhofer Road (Z01B03). This sampling station drains 8.76 square miles and land use/land cover upstream of this station consists primarily of row crops (76%), pasture/hay (18%), and deciduous forest (5%) land uses. A total of 6 TP samples, 6 nitrate samples, and 3 fecal coliform samples were available for the load duration analysis at site Z01B03 (Table 4-15). Most data have been collected during dry and low flow conditions. The Philothea WWTP discharges into Little Beaver Creek upstream of sampling station Z01B03.

Table 4-19 presents the TMDL summary for site Z01B03. All TP and fecal coliform observations exceeded load limits at this site in Little Beaver Creek. No nitrate observations exceeded the target; however, only data from mid-range to low flows are available. Both TP and fecal coliform display needed reductions at lower flow conditions, 92 percent and greater for TP and 55 to 74 percent for fecal coliform. Philothea WWTP is upstream of this sampling site and may be a significant source of TP during mid-range and dry flow conditions, but not at low flows due to permit restrictions only allowing discharge above 1 cfs. During summer flows (May 1 through October 15), Philothea WWTP is not permitted to discharge at dry and low flow conditions based on median estimated flows at site Z01B03 (Appendix A), indicating the facility should not be a source of fecal coliform during these flow conditions.

Table 4-19. Loading Statistics for Little Beaver Creek (Z01B03).

Little Beaver Creek (Z01B03) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**41.04 cfs**	**6.72 cfs**	**2.63 cfs**	**1.12 cfs**	**0.61 cfs**
Total Phosphorus (kg/day)	Current Load	No Data	No Data	6.50	2.97	1.69
	TMDL= LA+WLA+MOS	**8.03**	**1.32**	**0.52**	**0.22**	**0.12**
	LA	7.54	1.16	0.40	0.12	0.11
	WLA: Philothea WWTP	0.09	0.09	0.09	0.09	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0.09	0.09	0.09	0.09	0
	MOS (5%)	0.40	0.07	0.03	0.01	0.01
	TMDL Reduction (%)	No Data	No Data	**92%**	**93%**	**93%**
Nitrate Nitrogen (kg/day)	Current Load	No Data	No Data	5	0.25	1
	TMDL= LA+WLA+MOS	**100**	**16**	**6**	**3**	**1**
	LA	94	14	4.68	1.86	0.93
	WLA: Philothea WWTP	1	1	1	1	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	1	1	1	1	0
	MOS (5%)	5	1	0.32	0.14	0.07
	TMDL Reduction (%)	No Data	No Data	**0%**	**0%**	**0%**
Fecal Coliform (Million/day)	**Summer Flows (cfs)**	**27.35**	**3.89**	**1.65**	**0.84**	**0.57**
	Current Load	No Data	No Data	No Data	43,349	50,405
	TMDL= LA+WLA+MOS	**669,167**	**95,087**	**40,290**	**20,627**	**13,858**
	LA	634,801	89,425	37,368	19,596	13,165
	WLA: Philothea WWTP	908	908	908	0	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	908	908	908	0	0
	MOS (5%)	33,458	4,754	2,014	1,031	693
	TMDL Reduction (%)	No Data	No Data	No Data	**55%**	**74%**

4.2.4 Beaver Creek (Z01P04)

Existing and allowable loads were calculated for Beaver Creek at Erastus-Durbin Road (Z01P04). This sampling station drains 37.09 square miles and land use/land cover upstream of this station consists primarily of row crops (78%), pasture/hay (11%), deciduous forest (4%), and low intensity residential (4%) land uses. A total of 14 TP samples, 14 nitrate samples, and 8 fecal coliform samples were available for the load duration analysis at site Z01P04 (Table 4-15). Average monthly flows from the Grand Lake St. Marys spillway have been incorporated into the continuous flow estimations at this station. Most data have been collected during high, moist, mid-range, and dry flow conditions. The Celina and Mercer County Home WWTPs discharge directly into Beaver Creek upstream of sampling station Z01P04. The Wagner, Philothea, and Coldwater WWTPs discharge into tributaries that flow into Beaver Creek upstream of station Z01P04.

Table 4-20 presents the TMDL summary for site Z01P04. Thirteen of fourteen TP, eight of fourteen nitrate, and five of eight fecal coliform observations exceeded loading limits for Beaver Creek at this site. TP loads display 93 percent needed reductions at high flows and 79 percent reductions during dry conditions. Reductions are much lower at moist and mid range conditions at 28 and 32 percent, respectively. Nitrate and fecal coliform loads show similar patterns in needed reductions as they require 97 percent or greater reductions at high flows, but slowly drop to zero percent needed reductions moving from moist to dry conditions. The numerous WWTP facilities upstream of site Z01P04 comprise a significant portion of the allowable TP and nitrate loads at lower flow conditions, with the exception of the Coldwater WWTP which is not allowed to discharge below high flow conditions (see Table 4-18 and associated text above).

Table 4-20. Loading Statistics for Beaver Creek (Z01P04).

Beaver Creek (Z01P04) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**321.02 cfs**	**219.83 cfs**	**136.46 cfs**	**93.29 cfs**	**30.66 cfs**
Total Phosphorus (kg/day)	Current Load	1037.62	70.50	46.39	102.05	No Data
	TMDL=LA+WLA+MOS	**78.54**	**53.78**	**33.39**	**22.82**	**7.50**
	LA	62.18	41.38	22.01	11.97	6.87
	WLA: Celina WWTP	9.46	9.46	9.46	9.46	0
	WLA: Mercer Co. Home WWTP	0.12	0.12	0.12	0.12	0.12
	WLA: Wagner WWTP	0.04	0.04	0.04	0.04	0.04
	WLA: Philothea WWTP	0.09	0.09	0.09	0.09	0.09
	WLA: Coldwater WWTP	2.72	0	0	0	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	12.43	9.71	9.71	9.71	0.25
	MOS (5%)	3.93	2.69	1.67	1.14	0.38
	TMDL Reduction (%)	**93%**	**28%**	**32%**	**79%**	No Data
Nitrate Nitrogen (kg/day)	Current Load	29,721	2,167	567	161	No Data
	TMDL=LA+WLA+MOS	**785**	**538**	**334**	**228**	**75**
	LA	641.38	413.62	219.62	119.62	68.62
	WLA: Celina WWTP	95	95	95	95	0
	WLA: Mercer Co. Home WWTP	1	1	1	1	1
	WLA: Wagner WWTP	0.38	0.38	0.38	0.38	0.38
	WLA: Philothea WWTP	1	1	1	1	1
	WLA: Coldwater WWTP	7.24	0	0	0	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	104.62	97.38	97.38	97.38	2.38
	MOS (5%)	39	27	17	11	4
	TMDL Reduction (%)	**97%**	**76%**	**44%**	**0%**	No Data
Fecal Coliform (Million/day)	**Summer Flows (cfs)**	**269.01**	**190.49**	**110.32**	**82.48**	**32.08**
	Current Load	1,628,556,132	11,012,479	2,962,521	224,434	No Data
	TMDL=LA+WLA+MOS	**6,581,575**	**4,660,568**	**2,698,945**	**2,018,026**	**784,915**
	LA	6,128,146	4,330,407	2,466,865	1,819,992	648,537
	WLA: Celina WWTP	94,635	94,635	94,635	94,635	94,635
	WLA: Mercer Co. Home WWTP	1,211	1,211	1,211	1,211	1,211
	WLA: Wagner WWTP	379	379	379	379	379
	WLA: Philothea WWTP	908	908	908	908	908
	WLA: Coldwater WWTP	27,217	0	0	0	0
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	123,139	95,922	95,922	95,922	95,922
	MOS (5%)	329,079	233,028	134,947	100,901	39,246
	TMDL Reduction (%)	**100%**	**60%**	**13%**	**0%**	No Data

4.2.5 Big Run (Z01P06)

Existing and allowable loads were calculated for Big Run at State Route 29 (Z01P06). This sampling station drains 8.80 square miles and land use/land cover upstream of this station consists primarily of row crops (86%), deciduous forest (7%), and pasture/hay (6%) land uses. A total of 15 TP samples, 14 nitrate samples, and 8 fecal coliform samples were available for the load duration analysis at site Z01P06 (Table 4-15). Most data have been collected during high, moist, dry, and low flow conditions. There are no permitted WWTP facilities discharging upstream of sampling station Z01P06.

Table 4-21 presents the TMDL summary for site Z01P06. Eight of fourteen TP, eight of fourteen nitrate, and four of eight fecal coliform observations exceed the loading limits of Big Run. Needed reductions for TP vary from 95 percent at high flows to zero percent at moist and dry conditions, to 6 percent at low flows. Nitrate and fecal coliform loads require 99 percent reductions at high flows and fecal coliform loads display zero percent reductions for moist, dry, and low flow conditions. Nitrate has needed reductions of 89 percent at moist conditions and zero percent from mid-range to low flows.

Table 4-21. Loading Statistics for Big Run (Z01P06).

Big Run (Z01P06) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**40.81 cfs**	**6.35 cfs**	**2.25 cfs**	**0.73 cfs**	**0.21 cfs**
Total Phosphorus (kg/day)	Current Load	167.2	0.69	0.68	0.12	0.04
	TMDL= LA+WLA+MOS	**7.99**	**1.24**	**0.44**	**0.14**	**0.04**
	LA	7.59	1.18	0.42	0.13	0.038
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	0.40	0.06	0.02	0.01	0.002
	TMDL Reduction (%)	**95%**	**0%**	**38%**	**0%**	**6%**
Nitrate Nitrogen (kg/day)	Current Load	9,127	129	0.24	0.05	0.02
	TMDL= LA+WLA+MOS	**100**	**16**	**6**	**2**	**1**
	LA	95	15	5.72	1.91	0.97
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	5	1	0.28	0.09	0.03
	TMDL Reduction (%)	**99%**	**89%**	**0%**	**0%**	**0%**
Fecal Coliform (Million/day)	**Summer Flows (cfs)**	**27.07**	**3.51**	**1.26**	**0.45**	**0.17**
	Current Load	95,227,228	44,587	No Data	10,228	228
	TMDL= LA+WLA+MOS	**662,253**	**85,776**	**30,750**	**11,005**	**4,208**
	LA	629,140	81,487	29,213	10,455	3,998
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	33,113	4,289	1,537	550	210
	TMDL Reduction (%)	**99%**	**0%**	No Data	**0%**	**0%**

4.2.6 Prairie Creek (Z01P07)

Existing and allowable loads were calculated for Prairie Creek at Mud Pike (Z01P07). This sampling station drains 8.09 square miles and land use/land cover upstream of this station consists primarily of row crops (89%), deciduous forest (5%), and pasture/hay (5%) land uses. A total of 15 TP samples, 14 nitrate samples, and 8 fecal coliform samples were available for the load duration analysis at site Z01P07 (Table 4-15). Most data have been collected during high, moist, dry, and low flow conditions. No permitted WWTP facilities discharge upstream of sampling station Z01P07 in Prairie Creek.

Table 4-22 displays the TMDL summary for site Z01P07. Twelve of fifteen TP, nine of fourteen nitrate, and four of eight fecal coliform observations exceed the loading limits for Prairie Creek. Needed TP reductions are greatest at high flows (90 percent), but decrease with decreasing flow conditions to zero percent at dry conditions. TP reductions increase to 29 percent during low flows. Nitrate load reductions are 92 percent or greater at moist and high flows, but drop to zero percent at dry and low flow conditions. Fecal coliform load reductions are 99 percent at high flows, zero percent at moist conditions, and 80 percent or greater at dry and low flow conditions. TP and fecal coliform reductions persist at low flows, possibly indicating the influence of constant discharge sources of these two parameters in Prairie Creek.

Table 4-22. Loading Statistics for Prairie Creek (Z01P07).

Prairie Creek (Z01P07) TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**37.53 cfs**	**5.84 cfs**	**2.07 cfs**	**0.67 cfs**	**0.19 cfs**
Total Phosphorus (kg/day)	Current Load	73.12	1.68	0.40	0.08	0.05
	TMDL= LA+WLA+MOS	**7.34**	**1.14**	**0.40**	**0.13**	**0.04**
	LA	6.97	1.08	0.38	0.12	0.038
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	0.37	0.06	0.02	0.01	0.002
	TMDL Reduction (%)	**90%**	**35%**	**4%**	**0%**	**29%**
Nitrate Nitrogen (kg/day)	Current Load	8,061	161	No Data	0.06	0.04
	TMDL= LA+WLA+MOS	**92**	**14**	**5**	**2**	**0.48**
	LA	87	13	4.75	1.92	0.45
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	5	1	0.25	0.08	0.02
	TMDL Reduction (%)	**99%**	**92%**	No Data	**0%**	**0%**
Fecal Coliform (Million/day)	**Summer Flows (cfs)**	**24.89**	**3.22**	**1.16**	**0.41**	**0.16**
	Current Load	42,951,329	69,401	No Data	47,676	47,616
	TMDL= LA+WLA+MOS	**608,892**	**78,864**	**28,272**	**10,118**	**3,869**
	LA	578,448	74,921	26,858	9,612	3,676
	WLA: Facilities	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	Total WLA	0	0	0	0	0
	MOS (5%)	30,445	3,943	1,414	506	193
	TMDL Reduction (%)	**99%**	**0%**	No Data	**80%**	**92%**

4.3 Pollutant Sources

Because pastureland and row crops are the dominant land cover in the watershed (approximately 90 percent of the watershed area when the surface area of Grand Lake St. Marys is not included; Table 2-2), many of the probable sources of impairment in this watershed are tied to agricultural practices. As these practices encroach on riparian and in-stream habitats, habitat may be altered through stream channelization, riparian vegetation removal, and subsequent stream bank destabilization. Without the natural filtering capabilities of a healthy, vegetated riparian buffer, runoff from pasturelands/row crops carries pathogens and nutrients from recent manure and fertilizer applications directly into streams.

There are numerous small Animal Feeding Operations (AFOs) and larger Concentrated Animal Feeding Operations (CAFOs) in this watershed that are also noted sources of nutrients and pathogens. Animals grazing in and near streams can be a direct source, while runoff from these operations' pastures, holding areas, and manure application fields can also be a significant nonpoint source. This is especially true in the absence of effective manure management plans and appropriately sized waste storage facilities.

Another source of pathogen and nutrient impairment in the Beaver Creek and Grand Lake St. Marys watershed comes from human waste. Unsewered areas with failing septic systems are of serious concern as untreated sanitary wastewater from residential areas is discharged directly into streams. Projects are underway to obtain funding for tying many of these areas into local sewers and treatment plants. On August 23, 2006 a public meeting was held to discuss the water quality of Grand Lake St. Marys (an extensive Q & A can be found at **http://www.mercercountyohio.org/commissioners/Lake_q&a.htm**).

CAFOs and septic systems within the Beaver Creek/Grand Lake St. Marys watershed received a zero WLA for all parameters.

4.4 Margin of Safety

The Clean Water Act requires that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality. U.S. EPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS). An explicit MOS has been applied as part of all of the Grand Lake St. Marys and Beaver Creek TMDLs by reserving five percent of the allowable load (see allocation tables in Sections 4.1 and 4.2). A relatively low MOS was selected based on the use of load duration curves, which minimize potential uncertainties associated with calculating the allowable loads (i.e., the allowable loads are based on observed data rather than modeling simulations).

An additional implicit MOS has been applied as part of the fecal coliform TMDLs by comparing individual samples to the geometric mean component of the standard to determine the needed load reductions. This is considered conservative because the geometric mean component of the standard is intended to be used when five samples in a 30 day period are available (i.e., taking the geometric mean of five samples will "dampen" the effect of high values).

4.5 Critical Conditions and Seasonality

The Clean Water Act requires that TMDLs take into account critical conditions for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. Through the load duration curve approach it has been determined that load reductions are needed for specific flow conditions; however, the critical conditions (the periods when the greatest reductions are required) vary by location and are inherently addressed by specifying different levels of reduction according to flow.

The allocation of point source loads (i.e., the WLA) also takes into account critical conditions by assuming the facilities will always discharge at their maximum design flows. In reality, many facilities discharge at below their design flows.

The Clean Water Act also requires that TMDLs be established with consideration of seasonal variations. Seasonal variations are addressed in this TMDL by only assessing conditions during the season when the water quality standard applies (May through October). The load duration approach also accounts for seasonality by evaluating allowable loads on a daily basis over the entire range of estimated flows and presenting daily allowable loads that vary by flow.

5.0 ASSESSING THE POTENTIAL IMPACT OF INCREASED AGRICULTURAL BMPS

As part of the Beaver Creek and Grand Lake St. Marys TMDL analysis a watershed modeling simulation was conducted to assess the potential impact of increased agricultural best management practices (BMPs)[1]. Information on other BMPs that could not be directly modeled was also compiled and these two sources of information were used to create Table 5-1. The table illustrates that there is a wide range of BMPs available that can be used to achieve the load reductions identified through the TMDL analysis. Widespread and strategic use of these BMPs will be needed to achieve the TMDL loads due to the significant reductions that have been identified.

[1] The Soil and Water Assessment Tool (SWAT) model previously set up and calibrated to the neighboring Wabash River watershed was used for the analysis (U.S. EPA, 2004). SWAT predicts the impact of land management practices on water, sediment and agricultural chemical yields in large complex watersheds with varying soils, land use, and management conditions over long periods of time. It was considered appropriate for the Beaver Creek and Grand Lake St. Marys watershed because of the extensive agricultural land uses. The modeling parameters derived for the previous Wabash River modeling application were applied to the Beaver Creek and Grand Lake St. Marys land uses but no further calibration effort was performed. Therefore the model results are meant to be used as an illustration of the potential relative change in loads resulting from various BMPs.

Table 5-1. Potential effectiveness of various best management practices applicable to the Grand Lake St. Marys and Beaver Creek watersheds.

BMP	Description and Removal Mechanism	Estimated Removal Rate			
		Sediment/ TSS	TN	TP	Fecal
Nutrient management plan	Site specific guidance on appropriate fertilization rates, methods of application, and timing. Appropriate application rates for optimized crop yield reduce loading from excessive nutrient application.	Minimal	Minimal based on SWAT modeling	Approximately 20 percent based on SWAT modeling	Minimal
Conservation tillage	Reduced tillage practice with a minimum of 30 percent cover of crop residuals. Reduces erosion rates and phosphorus losses. Increases soil quality by providing organic material and nutrient supplementation.	75 to 88 percent reduction in soil loss rates [1; 2, respectively]	Minimal based on SWAT modeling	30 to 40 percent based on SWAT modeling	Minimal
Manure composting	Composting is the biological decomposition and stabilization of organic material. The process produces heat that, in turn, produces a final product that is stable, free of pathogens and viable plant seeds, and can be beneficially applied to the land.	Application of composted manure improves soil infiltration and reduces sediment loss by 68 percent [3]	30 to 75 percent due to volatization that occurs during storage	Minimal	Reductions of up to 99% in fecal coliform concentrations have resulted from composted manure [4]
Providing alternative sources of water for cattle	Providing water sources for cattle away from streams. Reduces streambank trampling and deposition of fecal matter in the stream.	90 percent reduction in direct deposition of fecal matter [1]	90 percent reduction in direct deposition of fecal matter [1]	90 percent reduction in direct deposition of fecal matter [1]	90 percent reduction in direct deposition of fecal matter [1]
Cattle exclusion from streams	Placement of fencing between the cattle grazing area and stream channel. Reduces streambank trampling and deposition of fecal matter in the stream.	Theoretically, 100 percent reduction in direct deposition of fecal matter	15 percent reduction in nitrogen loading [1]	15 percent reduction in phosphorus loading [1]	Theoretically, 100 percent reduction in direct deposition of fecal matter
Grazing land protection	Use of cover crop or rotational grazing patterns to maximize ground cover and reduce soil compaction.	88 percent reduction in sediment loading assuming increased ground cover from 60 percent to 95 percent [5]	60 percent reduction in nitrogen loading [1]	49 to 60 percent reduction in phosphorus loading [1]	29 to 46 percent reduction in fecal coliform loading [1]
Precision Feeding	Feeding strategies designed to reduce nitrogen (N) and phosphorus (P) losses include more precise diet formulation, enhancing the digestibility of feed ingredients, genetic enhancement of cereal grains and other ingredients resulting in increased feed digestibility, and improved quality control.	Minimal	20 to 30 percent reduction in nitrogen loading [6]	20 to 30 percent reduction in phosphorus loading [6]	Not Available

BMP	Description and Removal Mechanism	Estimated Removal Rate			
		Sediment/ TSS	TN	TP	Fecal
Controlled drainage	This practice involves placing simple water control structures at various locations in the tiling system to raise the water elevation. Decreases in nitrate losses have been attributed primarily to reductions in the volume of water drained and, to a somewhat lesser extent, by increased denitrification in the soil. If managed properly, controlled drainage has the potential to improve crop yields by making more water available to plants.	Minimal	40 to 50 percent reduction in nitrogen loading compared to conventionally drained fields	Minimal	Minimal
Cover crop	Use of ground cover plants on fallow fields. Reduces erosion, provides organic materials and nutrients to soil matrix, reduces nutrient losses, suppresses weeds, and controls insects.	88 percent reduction in soil erosion [3]	30 percent reduction in nitrogen loading rates [5]	70 to 85 percent removal of total phosphorus [3]	Variable
Filter Strips	Placement of vegetated strips in the path of field drainage to treat sediment and nutrients.	60 to 65 percent reduction in sediment [1]	70 percent reduction in total nitrogen [1]	~ 65 percent removal of total phosphorus [7; 8]	55 percent reduction in fecal coliform [1]
Grass swales	A runoff conveyance that provides storage for approximately 24 hours. Removes pollutants by sedimentation and plant uptake. Reduces peak flow velocities and subsequent erosion.	93 percent reduction of TSS [7]	92 percent removal of total nitrogen [7]	83 percent removal of total phosphorus [7]	Minimal
Conservation Easements	Conversion of highly erodible land or land near nutrient sensitive waterbodies to grass or forest cover. Reduces loading rates to natural conditions.	98 percent reduction in sediment loading rates [5]	92 percent reduction in nitrogen loading rates [5]	90 percent reduction in phosphorus loading rates [5]	Variable impacts depending on presence of cattle and wildlife in the area
Restoration of Riparian Buffers	Conversion of land adjacent to stream channels to vegetated buffer zones. Removes pollutants by sedimentation and plant uptake. Provides stream bank stability, stream shading, and aesthetic enhancement.	97 percent removal of sediment from treated area, assuming a 90 ft buffer width [9]	80 percent removal of total nitrogen from treated area, assuming a 90 ft buffer width [9]	78 percent removal of total phosphorus from treated area, assuming a 90 ft buffer width [9]	Variable impacts depending on presence of cattle and wildlife in the area

BMP	Description and Removal Mechanism	Estimated Removal Rate			
		Sediment/ TSS	TN	TP	Fecal
Proper use of onsite wastewater disposal systems.	Includes periodic maintenance (e.g., pumping every 3 to 5 years) and inspection of all onsite wastewater disposal systems in the watershed. Requires immediate repairs (or replacement) of malfunctioning systems as well as disconnection of direct discharges to tile drainage systems.	Variable depending on the degree and type of failure as well as type of onsite system used	Variable depending on the degree and type of failure as well as type of onsite system used	Variable depending on the degree and type of failure as well as type of onsite system used	Variable depending on the degree and type of failure as well as type of onsite system used

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6.0 MODELING THE IMPACTS OF WATERSHED LOAD REDUCTIONS ON GRAND LAKE ST. MARYS

A BATHTUB model was set up for Grand Lake St. Marys to assess the impacts of reducing total phosphorus and nitrate loads to the lake relative to existing conditions. The BATHTUB model was developed by the U.S. Army Corps of Engineers and performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network, which accounts for pollutant transport and sedimentation. Eutrophication-related water quality conditions (e.g., phosphorus, nitrogen, chlorophyll *a*, and transparency) are predicted using empirical relationships previously developed and tested for reservoir applications (Walker, 1987).

The BATHTUB model requires nutrient loading inputs from the upstream watershed and atmospheric deposition, morphometric data for the lake, and estimates of mixing depth and nonalgal turbidity. Sources of all these data for the Grand Lake St. Marys modeling are documented in Appendix B. The BATHTUB model was calibrated to the observed data and then annual simulations were made to predict in-lake nitrogen, phosphorus, chlorophyll *a*, and Secchi depth responses to applying the recommended TMDL reductions.

The results of the BATHTUB simulations suggest that water quality in Grand Lake St. Marys will improve if the load reductions identified by the TMDL analysis can be achieved. Total nitrogen concentrations are predicted to decrease by 50 percent and total phosphorus concentrations are predicted to decrease by 59 percent. The decrease in nitrogen and phosphorus concentration is predicted to result in average algae concentrations (as measured by chlorophyll *a*) decreasing from over 300 µg/L to approximately 85 µg/L. The resulting water clarity (as measured by Secchi disk depth) is predicted to increase by 250 percent.

While the potential water quality improvements are considerable, it is important to note that if the modeled TMDL reductions are achieved, Grand Lake St. Marys will still be classified as a hypereutrophic lake. As shown in Table 5-1, the modeled TMDL reduction conditions may result in a significant improvement in water quality. However the total phosphorus, total nitrogen, and chlorophyll *a* concentrations would continue to be well above the ecoregional reference conditions. Secchi depth would also be much lower than target conditions, even after the modeled load reductions. Further information regarding Grand Lake St. Marys can be found in Appendix D.

Table 6-1. Comparison of reference condition target values to modeled existing and reduction conditions in Grand Lake St. Marys.

Parameter	Target Conditions[a]	Modeled Existing Conditions	TMDL Reduction Conditions
Total Phosphorus (µg/L)	35	250	100
Total Nitrogen (mg/L)	0.782	4.9	2.4
Chlorophyll *a* (µg/L)	5.36[b]	312	85
Secchi Depth (meters)	0.87	0.13	0.46

[a]Target conditions are based on 25th percentile reference condition values for Level III ecoregion 55 lakes (U.S. EPA, 2000).
[b]The chlorophyll *a* target is the average of the listed chlorophyll *a* value measured by Spectrophotometric method with acid correction and the chlorophyll *a* value measured by Trichromatic method.

7.0 PUBLIC PARTICIPATION

The Ohio EPA convened an external advisory group (EAG) in 1998 to assist the Agency in developing the TMDL program in Ohio. The EAG met multiple times over eighteen months and in July 2000 issued a report to the Director of Ohio EPA on their findings and recommendations. The Beaver Creek and Grand Lake St. Marys TMDL has been completed using the process endorsed by the EAG.

Locally, discussion of actions to restore the watershed has been occurring as diverse partners have worked to develop watershed action plans over the past three to four years. The Grand Lake/Wabash Watershed Alliance (GLWWA) has written and received state endorsement in 2005 for a Grand Lake St. Marys Watershed Action Plan and is in the process of preparing a comprehensive plan for the entire Wabash River watershed in Ohio, which will include actions for all subwatersheds of the river and an update of the Grand Lake St. Marys plan. This group will also be vital to the implementation of the Beaver Creek-GLSM Watershed TMDL recommendations.

GLWWA and its partners in three counties are serving as community advocates for the watershed, and have become important forces to maintain momentum and sponsorship of water quality improvement efforts. For example, the Lake Improvement Association has established a strong outreach program to engage the public with factual information and promote activities to restore and protect the lake. Several activities during the past year indicate a high interest in restoring the watershed.

- A Summit on the Lake was sponsored by Representative Keith Faber on August 23, 2006. Various state and local resource professionals were asked to participate in a panel discussion on issues that impact the lake as a public drinking water supply and a recreational resource. The summit was well attended by the public.

- During 2006 and 2007, much effort has been made to educate farmers on nutrient management, especially focused on the land application of manure during winter months. Natural Resource Conservation Service and local Soil and Water Conservation District staff from both Auglaize and Mercer Counties held workshops and meetings in conjunction with GLWWA to provide assistance for proper storage and application of manure.

- Some producers are exploring the possibility of composting or brokering the export of manure from the watershed. Additional practices for managing nutrients and livestock waste have been introduced through collaborative projects with the City of Celina and Lake Improvement Association, including proposed wetlands and geo-tube filters.

As part of the watershed planning process, the watershed coordinators have held public meetings over the last three years to get input on watershed problems and potential solutions, and local newspapers have been providing regular updates on watershed activities, thus contributing to a growing awareness and understanding of the challenges to restoring water quality in the lake and these watersheds. Higher local interest is leading to an increased desire to take action.

In addition to soliciting input and recommendations from the GLWWA, the Ohio EPA requested input from local landowners. This was accomplished at a public information meeting held in the watershed on February 21, 2007. The meeting was attended by nearly 60 citizens and members of local groups and agencies. The purpose of the meeting was to gather suggestions for restoration actions that would lead to water quality improvements in the Beaver Creek and Grand Lake St. Marys watersheds. In addition to the statewide recommendations for point source discharges, storm water, and public drinking water programs, these locally accepted solutions have credibility for addressing the agricultural sources of pollution. The feedback was used to complete the draft TMDL report prepared by Tetra Tech and Ohio EPA.

An outcome of the public information meeting was confirmation that land use has the largest affect on water quality in these streams and the lake. The water quality studies done over several years and a variety of stream flow conditions indicate that the majority of impairments are caused by row crop and livestock agriculture in both Beaver Creek and the tributaries of Grand Lake St. Marys. There are currently no regulations governing nonpoint source pollution from rural/agricultural runoff, and implementation of the TMDL will largely be accomplished through voluntary actions.

Ohio EPA acknowledges the local frustration with a lack of regulatory authority or a prescribed timeline for accomplishing water quality goals that need to come from agricultural landowners. It is hoped that the high level of concern and interest in the lake will lead to continued adoption of multiple strategies for reducing the nutrient and bacteria loads to the lake. Improvements to riparian and stream habitat will be achieved through longer-term collaborative efforts to create and protect stream side buffers, re-create wetlands, and modify the current drainage maintenance programs.

Consistent with Ohio's current Continuous Planning Process (CPP), the draft TMDL report was available for public review from June 15 through July 16, 2007 and a copy of the draft report was available on Ohio EPA's web page at **http://www.epa.state.oh.us/dsw/index.html**. General information on TMDLs, water quality standards, 208 planning, permitting, and other Ohio EPA programs are also available on this site. A summary of the comments received and the associated responses was completed after the public comment period and included in Appendix E.

Public involvement is vital to the success of any TMDL project. Ohio EPA will continue to support the implementation process and will facilitate, to the fullest extent possible, restoration actions that are acceptable to the communities and stakeholders in the study area and to Ohio EPA. Ohio EPA is reluctant to rely solely on regulatory actions and strongly upholds the need for voluntary actions facilitated by the local stakeholders, watershed organization, and agency partners to bring the Beaver Creek and Grand Lake St. Marys watersheds into water quality attainment.

8.0 WATER QUALITY IMPROVEMENT STRATEGY

This section provides a strategy for improving water resources in the Beaver Creek and Grand Lake St. Marys (Beaver Creek-GLSM) watershed to the full attainment of applicable water quality standards (WQS). The actions recommended are aimed at reaching the water quality goals and load reductions discussed in this report and address the documented sources of impairment. Additionally, protections are recommended for sustaining water quality in areas that later begin meeting the applicable WQS. Some recommendations would bear regulatory authority, while others are based on voluntarily action.

An effort was made to address the following items as they relate to the recommended actions:

- Water quality problems addressed
- Effectiveness (see Table 5-1)
- Resources available for assistance
- Locations where activities should take place
- Participation needed for successful implementation
- Timeframe under which actions should occur

A process for validating that the recommended actions are effectively achieving the water quality goals is also provided. Details include a recommended monitoring strategy, conditions sufficient to warrant revising the existing recommendations, and a methodology for selecting alternative actions.

The remainder of this chapter is organized as follows:

- Implementation approach and rationale
- Recommendations for each of the subwatersheds (assessment units)
- Reasonable assurance that recommended actions are carried out
- Process for evaluation and revision of the water quality improvement strategy

8.1 Implementation Approach and Rationale

TMDLs are developed for ***pathogens*** to address impairment of recreational uses and also for ***nitrogen (N)*** and ***total phosphorus (TP)*** to address impairment of aquatic life uses. ***Habitat*** and ***sediment*** are also recognized as impairments to water quality, but will not receive specific TMDL calculations. Recreational use impairment is pervasive throughout most of the basin, while aquatic life use impairment occurs more discretely on a segment-by-segment basis. The recommendations that follow provide a basic approach for addressing each of these causes of impairment and their respective sources (summarized in Table 8-1). Also included are recommendations regarding ***stream geomorphology, in-stream and riparian habitat enhancement, floodplain connectivity***, ***sediment and erosion control,*** and ***storm water management*** that are intended to provide further enhancement and protection of aquatic life uses.

It is possible that some stream segments not surveyed are impaired by the same sources that have been identified in surveyed segments. A broad application across the watershed of some of the recommendations is likely to abate those sources as well.

The discussion in this section is organized according to the cause of impairment. It provides a broad overview of what is necessary for meeting and maintaining water quality standards and often includes technical or scientific rationale. Recommendations being made for specific locations will be discussed in the following section, and a more detailed discussion regarding causes and sources of impairment can be found in Section 4.3. A summary table discussing recommendations for each major source of impairment is presented at the end of the section (see Table 8-2).

Table 8-1. Summary of the cause/source associations and the respective area of the watershed where they are impairing designated recreational and/or aquatic life uses.

Region of watershed and dominant land use	Major cause/source associations leading to impairment
Entire watershed with agricultural land use • Grand Lake St. Marys and Tributaries (05120101 020) • Beaver Creek Downstream of Grand Lake St. Marys to Mouth (05120101 030)	• Channelization (for drainage improvement) resulting in habitat degradation and sedimentation • Removal of riparian vegetation resulting in habitat degradation, high water temperature and low dissolved oxygen • Stream bank destabilization resulting in sedimentation • Row crop production resulting in high nutrient and sediment loading • Point source discharges from WWTPs contribute large portion of nutrient loads at low flows • AFOs and CAFOs (NPS) contribute excessive nutrient and pathogen loading during wet weather events • Failing HSTS resulting in nutrient and pathogen loading

8.1.1 Pathogens

Recreational use impairments throughout the Beaver Creek-GLSM watershed are primarily attributable to point source discharges, failing home sewage treatment systems (HSTS), and manure originating from livestock operations. Livestock farming is extensive in the watershed, and the total number of operations and equivalent animal units has increased significantly from 1997 to 2007. The land application of manure, especially during winter months, is a large source of impairment. Wildlife is believed to make a small contribution to the pathogen load because of the comparatively low population density in this watershed. In rural residential areas, pathogen contamination is primarily the result of failing HSTS. The municipal and county owned wastewater treatment facilities do not discharge partially treated water through combined sewer overflows anywhere in this watershed.

Separate sewer overflows

Separate sanitary overflows (SSOs) within the City of Coldwater are being addressed through the requirements in NPDES permit 2PB00013*GD, which expires on November 30, 2007. The renewal permit will include recommendations of this TMDL.

Celina is required to develop a Capacity Management Operations and Maintenance Program (CMOM) to evaluate their sewer system and prevent SSOs from recurring.

Home sewage treatment systems (HSTS)

Addressing HSTS as a source of bacterial pollution is permanently resolved by eliminating individual sewage systems and connecting residences to centralized treatment systems. However, it is not practical to extend sanitary sewers to some rural areas in the watershed because of prohibitive costs and the potential for environmental degradation during the installation of sewer lines. An effective alternative to centralization requires repairing or replacing failed systems. Installation of new and replacement systems must be in compliance with applicable regulations (OAC 3701-29). Ensuring that HSTS are properly maintained is important for preventing pollution problems in the future.

Any direct routing of septic lines to surface waters, such as by-passing leach fields and/or septic tanks, is an illegal practice and creates unhealthy and unsafe conditions. These types of connections should be identified and enforcement and/or other actions be taken to correct the situation. Local health departments are responsible for responding to complaints issued regarding illicit connections as well as being proactive in locating them (OAC 3701-29).

Livestock production

Ohio EPA is currently responsible for issuing NPDES permits to animal feeding operations (AFOs) that meet the definition of a concentrated animal feeding operation (CAFO; **http://www.epa.state.oh.us/dsw/cafo/index.html**). Currently there is only one large CAFO (e.g., greater than 82,000 laying hens) that has an NPDES CAFO permit in the Beaver-GLSM watershed at this time (Albers Poultry, Mercer 2GA00002*AG, issued on 12/15/2005). There are 13 additional large CAFOs in the watershed. Operations may be required to apply for a CAFO NPDES permit in the future if they have a discharge to waters of the state from their production area. Ohio EPA will make every effort to investigate or work with other state agencies (e.g., Ohio Department of Agriculture-Livestock Environmental Permitting Program and Ohio Department of Natural Resources) operations where discharges are alleged, and determine if an NPDES permit is needed. Any new CAFO permits would be issued with the expectation to reduce nutrient loading and bacteria in waterways since both the production area and land application activities will be more closely regulated. In addition, CAFO permit holders will be required to attend training related to water quality and manure handling as a condition of their permit.

Permit conditions and requirements are not expected to change significantly when the NPDES authority for CAFOs is transferred to the Ohio Department of Agriculture (ODA). Ohio EPA will continue to work closely with the Department of Agriculture in establishing requirements to protect water quality, especially in critical watersheds such as Beaver-GLSM.

Given the large number of dairy farms in the Beaver-GLSM watershed, it is possible that numerous direct discharges exist from smaller operations not subject to NPDES permit requirements that contribute significantly to the loading of bacteria to adjacent waterways. Identification and elimination of these “milk house” waste discharges, including often-associated open-lot runoff from similar facilities, is important not only to meet recreational use water quality criteria related to pathogens, but also for the reduction of nutrient loadings to streams within the watershed. Collaboration by effective and judicious use of Pollution Abatement Rules (ODNR-DSWC), Livestock Environmental Permitting Program Rules (ODA-LEPP), and Water Quality Standards (Ohio EPA-DSW) is essential for the successful identification and elimination of such discharges.

Pathogen contamination from livestock manure can be reduced through proper manure handling and storage. Reduced runoff contamination of streams is achieved through the construction of adequately sized storage facilities and storm water controls for open feedlots and manure storage areas. Providing cover or eliminating open feedlots near drainage channels is recommended. Manure that is land-applied should be done so according to guidance from the Natural Resource Conservation Service (NRCS) and applicable standards (Standard 633) or a Comprehensive Nutrient Management Plan (CNMP) that is specific to an operation. Another source of bacteria from livestock comes from animals wading in streams. Alternate water sources and exclusion fencing will limit or deny livestock access to streams. NRCS conservation practices that are appropriate for abating this source of pollution include *Livestock Use Exclusion (472), Waste utilization (633), Nutrient Management (590), Watering Facility (614), and Waste Storage Facility (313)*.

Composting manure may also be a viable way to utilize livestock waste and reduce the threat to water quality. The stabilization of the manure materials during the composting process and the proper handling and storage of this material reduces the risk of pollutant loading via storm water runoff. More information regarding composting can be found on the Ohio Composting and Manure Management Program’s web site (**http://www.oardc.ohio-state.edu/ocamm/**).

8.1.2 Habitat

In the Beaver Creek-GLSM watershed, degraded stream habitat is primarily the result of channelization and ongoing maintenance activities carried out to improve water conveyance. Nearly all stream channels have been modified and an extensive subsurface tile drainage network has been installed. Riparian vegetation has been removed. Stream banks are engineered and channel "bottom dip-outs" are routinely performed. Natural stream habitats are essentially absent in the watershed basin. Most channelization is found on the small- to medium-sized Grand Lake St. Marys tributaries, but also along some parts of the mainstem of Beaver Creek.

Habitat is also impaired or threatened by channel instability resulting from altered hydrology. In agricultural areas, practices specifically designed to increase drainage efficiency, such as subsurface drainage and channelization, increase peak flows during storms. Efficient drainage also results in low flow conditions that are more extreme and occur more frequently. Such hydrologic alterations diminish the capacity of the system to assimilate pollutants and support diverse aquatic communities. In urban and developing areas, impervious roofed and paved surfaces create substantial increases in runoff, which increases channel erosion and decreases stability.

Habitat can also be degraded by sedimentation. Sediment impairs substrate habitat and aquatic communities, but discussion regarding its abatement will be reserved for sub-section 8.1.3. The following sub-sections discuss habitat improvements that address channelization and stream instability.

Channelization
Channelization creates deeply incised and straight ditches or streams. This disconnects waterways from floodplains, which has damaging impacts on the quality of the system. Channelized streams change little along their length, lack features such as riffles and pools and have minimal variation in flow characteristics. This homogenous configuration reduces biological diversity (Hahn, 1982; Mathias and Moyle, 1992). Additionally, in-stream cover important for diverse aquatic communities is often absent.

Channelization enhances the drainage of agricultural land, which increases field accessibility and improves and/or protects crop growth (OSU, 1998 Bulletin 871-98 http://ohioline.osu.edu/b871/index.html). These practices are sanctioned through Ohio's drainage laws (ORC 6131 and OAC 1511) for valid socio-economic reasons. However, these laws and the commonly employed drainage improvement practices were created long before current State and federal water quality laws and, more significantly, before today's understanding of water quality sciences. A challenge is to carry out actions that improve water quality while maintaining adequate drainage for profitable agriculture.

In terms of drainage related to agriculture, a primary function of a stream or ditch is to provide an outlet for subsurface drainage tiles. This requires that the elevation of the channel bottom be far below the elevation of the surrounding crop fields, which results in floodplain disconnections. Adequate outlets can be provided and habitat improvements achieved through stream restoration and two-stage or over-wide ditch designs.

<u>Two-stage and over-wide channel design</u>
Stream restoration that employs natural channel design is superior to a two-stage ditch approach when strictly considering environmental benefits, but since stream restoration entails more earth moving and is considerably more expensive, a two-stage approach may be practical for addressing channelization on a large scale.

A two-stage channelized stream is similar to a typical maintained ditch but differs in some key ways. Two-stage channelized streams are wider at the top of their banks, which increases the overall capacity of the stream and out-of-bank flooding occurs less often. The bottom of a two-stage channelized stream has low elevation benches that are inundated during moderately high and higher flow events. The low flow channel is narrower than a typical ditch bottom and often develops a low-amplitude, sinusoidal pattern within the larger channel. More information regarding two-stage ditches can be found at **http://streams.osu.edu/naturalchannel.php**. See Figure 8-1 for depictions of a two-stage ditch.

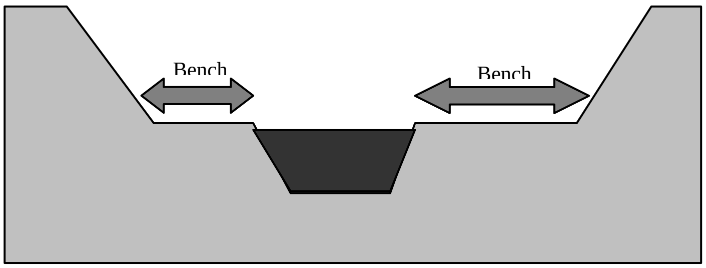

Figure 8-1. Graphical depiction of a two-stage ditch (left) and photo (right) that was taken in Wood County, Ohio. Notice the slight meander pattern along the ditch bottom in the picture.

Two-stage channels yield modest improvements to stream habitat as compared to one-stage ditches. These benefits are realized because benches function to some degree like floodplains and the channels undergo more stable erosion and deposition processes. Bank erosion is less likely to occur because the toe is protected by vegetated bench deposits and flow depths are lower, which results in lower shear stress. Decreased bank erosion in these fairly unstable systems is beneficial to immediate and downstream reaches because in-stream sources of sediment are reduced.

Stream flow in the narrower low flow channel is more competent to move and redistribute fine sediment than wider channel bottoms typical of highly maintained ditches. Fine sediment is deposited and stored on the benches, which increases assimilative capacity of the system. Channel substrate has less fine material (i.e., is of higher quality) and habitat associated with channel sinuosity and riffle-pool development is likely to increase (Sablak, 2004), which adds habitat heterogeneity to these extremely homogenous systems. Two-stage channels are also likely to have greater assimilative capacity for nutrients (Powell, 2004), which will be discussed in following sections.

Construction of a two-stage channel requires widening the ditch and/or creating the low elevation benches. However, if conditions permit, two-stage ditches form on their own, in which case simply refraining from removing bench sediment (i.e., dipping) is nearly all that is necessary from a maintenance or management perspective. Simon and Hupp (1986) describe a model for channel evolution of incised streams in which the end result is analogous to a two-stage channel. Optimal conditions for two-stage channels to develop on their own are when the channel is overly wide for the amount of contributing drainage area, banks are steep, and riparian trees are absent.

Applying a two-stage channel approach to highly maintained ditches (e.g., streams designated as MWH) is likely to be a reasonably cost-effective way to improve these resources over a substantial percentage of the drainage network. Although cost analysis for three two-stage ditch construction projects show expenses to range from $5 to $25 per linear foot (Jeong, 2005, unpublished), when the two-stage approach is applied by leaving existing benches intact, costs may be lower than typical ditch maintenance that includes periodic reconstruction. It is probable that a two-stage approach can be widely adopted at relatively low costs for landowners, county governments, and/or local organizations.

A primary objective is to effectively communicate the overall benefits that are derived from this approach to decision makers and designers who rely on familiar methods or ones they are comfortable using. Individuals who are particularly important to communicate with regarding a two-stage channel approach include County Engineers and their staff, Soil and Water Conservation District (SWCD)/NRCS personnel, and drainage contractors who conduct much of the design and construction work associated with drainage improvement. The benches that form in two-stage channels are often regarded as flow impedances that result in a reduction in the flow capacity of streams. Ohio EPA is unaware of hydrologic analyses that support this idea, but rather concurs that the capacity of the stream to contain high flows increases if the channel widens in forming the benches (**http://streams.osu.edu/streams_pdf/2stage(ward).pdf**).

Two-stage construction may be inappropriate for improving the stream biota and/or water quality when it is necessary to remove riparian trees in the process. Such consideration is particularly important when the channel demonstrates that it is recovering from past channelization.

Two-stage channels are clearly inappropriate when it results in a reduction in the amount of floodplain connectivity. This includes natural to moderately modified streams that have an intact connection to a floodplain and riparian areas. Such action would degrade the resource and the ameliorative effects of the benches will be far inferior to those of an established floodplain.

Bio-engineering techniques

Bank stabilization and channel erosion controls that use "hard engineering" techniques such as concrete or rock have little to no value in terms of aquatic habitat. Bio-engineering techniques promoted by the Ohio Department of Natural Resources (**http://www.dnr.state.oh.us/water/pubs/fs_st/streamfs.htm**) use more natural materials and construction techniques that provide bank habitat structure. When bank erosion control is necessary, bio-engineering approaches should be promoted by local conservation authorities (e.g., NRCS and SWCD) and used by private and public entities as a means for abatement. However, it should be noted that channel erosion and lateral migration occur naturally even in stable streams. If property loss is not an issue, abating bank erosion should be considered in light of whether it is occurring under stable stream conditions, and avoided if unnecessary.

Stream stability

Stream stability is related to habitat quality and sedimentation in streams, and can have a significant impact on stream biota. The geomorphology of a stream is a primary indicator of stability. Areas of the watershed that currently exhibit poor stream geomorphology are associated with previous channelization and ongoing drainage maintenance activity.

Floodplains are important for maintaining stream stability and provide additional water quality benefits. For this reason, it is recommended that throughout the entire Beaver Creek-GLSM watershed, an effort should be made to maintain, create, or facilitate the development of floodplains.

Agricultural areas

Ameliorating the impact of channelization can be achieved by methods discussed in the preceding sub-section on channelization. Natural channel design and/or a two-stage or over-wide channel approach can reduce the severity of erosion processes and provide some storage of fine sediment. Additionally, the strong relationship between hydrology and stream stability and aquatic communities, indicates that steps taken to stabilize watershed hydrology will be beneficial.

Activities related to agriculture may be substantially impacting watershed hydrology (Baker et al., 2004) and the stability of stream channels. It is suggested that subsurface drainage in combination with reduced surface water retention, due to smoothing of the landscape and altering vegetation and soil properties, has been increasing peak storm discharges. At the other extreme, more efficient drainage results in less infiltration and storage in the watershed, which leads to a reduction in base flow during drier periods (Baker et al., 2004; Robinson and Rycroft, 1999). The two phenomena result in an increase in the flashiness of the watershed, which is a measure of the rate and magnitude of changes in stream flow.

Although the causes of the observed increase in flashiness are not yet entirely known, activities that are likely to increase infiltration and reduce runoff should be pursued. In areas where drainage improvement practices are applied intensely, infrastructure and management measures such as water table management and wetland detention are recommended.

Water table management (NRCS Practice Standard 554) is a means to reduce the discharge of subsurface drainage water (**http://ohioline.osu.edu/aex-fact/0321.html**). Water table management requires the use of controlled drainage structures (e.g., Agri-Drain or Hancor types) that are installed within new or retrofitted to existing subsurface tile systems. Drainage water passing through these structures must have adequate hydraulic head to rise to an elevation that is pre-set according to the height of the flashboard risers that are part of the structure. This system allows for management of the effective elevation of the drainage tile outlets. When this elevation is set high enough the effect is analogous to there being no subsurface drainage infrastructure.

Benefits of water table management are reductions in annual drainage water discharges. These reductions have been estimated over several years of research to be approximately 40% (Fausey, 2004). Although Ohio EPA is unaware of comprehensive water budgets completed for water table management, it is reasonable to assume that a significant proportion returns to the stream as base flow and interflow over a protracted timeframe (David Baker, personal communication, 2006) or is otherwise taken up through evapo-transpiration. The extended period of discharge can also benefit the aquatic community by providing flow during critical drier periods.

The use of water table management may be limited in some areas. Topography dictates the area that can be controlled by a given structure because water table elevations greater than the top of the control structure are no longer influenced by it. Additional structures located within fields would often be needed to be able to manage an entire subsurface drainage system. Other limiting factors include the layout of the subsurface drainage system and whether or not the pipes can be readily located.

Wetlands provide detention capacity for runoff and increase infiltration. Numerous studies have shown that wetlands improve water quality and watershed hydrology as well as provide excellent wildlife habitat (Mitsch and Gosselink, 2000; Vellidis, 2003). Establishing wetlands often entails disabling a portion of the drainage infrastructure servicing that area and a relatively minor amount of earth work. The NRCS standards for wetland creation (NRCS Practice Standard 658) and wetland enhancement (NRCS Practice Standard 659) provide details regarding size and site condition considerations.

Depressions on the landscape with appropriate hydric soils are ideal locations for creating or enhancing wetlands, since it is likely that they were wetlands prior to land use conversions. In such cases, reversion to wetland is likely to require less effort and will have a greater probability of meeting the goals of the water resource improvements. The placement of wetlands adjacent to or near streams or ditches allows for treatment just prior to entering those waters, which may facilitate the treatment of a large volume of runoff due to its position in the drainage system.

Land use conversions from crop fields to grassland or forest also increase the retention and/or detention of rainwater. These land covers result in greater infiltration and a higher degree of storage through initial abstraction compared to row crops and/or barren ground and may help restore a more suitable hydrology. Such improvement may take several years to reach their full benefits, especially when land returns to forest cover. The Conservation Reserve Program (see section 8.3.3) compensates producers for land set-asides.

8.1.3 Nutrient and sediment

Nutrient and sediment loads in the Beaver Creek and Grand Lake St. Marys tributaries are primarily caused by livestock (AFO and CAFO) manure disposal, polluted runoff from row crop agriculture, channel degradation and point source discharges. NPDES permit revisions for point source dischargers will be carried out according to recommendation in Chapter 4 of this report. Other sources include failing HSTS and livestock manure from a significantly increased population of animals in the watershed. Abatement strategies for these sources of nutrients and solids are identical to those discussed earlier in section 8.1.1. In the residential and urban areas of the watershed, polluted runoff from residential and commercial land uses as well as erosion from construction sites around the lake shore are contributing to elevated sediment and nutrient loads.

Point source discharges

Permit modifications are the most straightforward means to achieve the necessary reductions in nutrients. It is therefore recommended that permits be modified to reflect the load limits for nutrients prescribed by this TMDL. Costs for total phosphorus removal are variable and depend on the concentration of TP in the treated water, the size of the facility, the chemicals used for treatment and when they are applied in the system. However, for a 1 MGD facility under somewhat average conditions costs are estimated to be $475 per day (Ohio EPA, 2006b).

Sources from agricultural runoff and drainage infrastructure

Many management practices abate sediment and nutrient loading to surface waters from crop fields. Examples include vegetated buffer strips, grassed waterways, nutrient management, conservation tillage, conservation crop rotations, wetland restoration, and water table management. For decades conservation professionals have researched these practices, improved their effectiveness, and worked with private landowners to implement them. Programs currently funded under the Farm Bill provide cost share and dollar incentives for land set-asides, and structural and management conservation practices.

A compilation of research suggests that grass filter strips would reduce sediment loading by 60 to 65%, nitrogen by 70%, total phosphorus by nearly 65%, and fecal coliform by 55% (Peterjohn and Correll, 1986; Osborne and Kovacich, 1993).

Vegetated buffer strips (e.g., riparian trees or grass filter strips) slow the velocity of overland surface flow allowing sediment particles to fall out of suspension. Buffers also increase infiltration of surface water because of better soil structure, macropores created by roots and soil invertebrates, and reduced surface crusting. Greater infiltration reduces surface discharges and the associated sediment and nutrient loads (Prichard, 1998). However, the effectiveness of buffers decreases dramatically when small concentrated flow paths allow water to rapidly move across them. Such flow paths typically develop at low points along the fields/buffer border or where the vegetation of the buffer is disturbed. These situations should be corrected as they are identified by landowners, farm operators, and conservation agency staff. Subsurface drainage creates a by-pass to the buffer strips where there is no contact between the vegetation and the drainage water and flow is not slowed. However, water table management (e.g., NRCS practice 554) is a means to reduce the volume and/or rate of discharging subsurface drainage water, thereby counteracting the “short circuiting” that occurs through buffer strips.

Benefits of buffer strips that go beyond improving chemical water quality of surface runoff are related to channel stability, structural habitat, light availability, stream temperature, and food resources. Providing a stream buffer may reduce the need and/or importance for stream bank management and erosion control as crop losses would not be occurring. In some cases armoring stream banks to minimize erosion prevents the naturalization of the stream's geomorphology (i.e., channel evolution) and perpetuates stream instability. Additionally, tree cover shades streams, which may limit algal growth and reduce stream temperatures. Temperature is inversely proportional to the stream's capacity to hold dissolved oxygen and high temperatures can severely impact aquatic life. Woody debris and detritus contributed to the stream system by riparian trees also have a significant role in the quality and diversity of habitat and food resources of the aquatic ecosystem (Ward, 1993; Wallace et al., 1997; Baer et al., 2001). These factors have a significant impact on the aquatic biological community and therefore the capacity for the system to attain its designated aquatic life use.

Livestock production

Within the Beaver-GLSM watershed, there are 14 large CAFOs (see Livestock Production in Section 8.1.1). The most critical aspect of minimizing water quality impacts from any size animal feeding operation is the proper management of manure. All operations should have updated manure management plans and make every effort to avoid land application of their manure during wet weather onto frozen and/or snow-covered ground when runoff is more likely to occur. Ohio EPA is committed to responding promptly to complaints, and will strive to work with partners to inform producers about emerging technology and BMPs as well as updates to the technical standards for manure handling and application. Another critical aspect in this regard is the need for continued efforts by local Soil Water Conservation Districts (SWCD) and Natural Resource Conservation Service (NRCS) staff to proactively identify existing soil and water resource concerns at livestock facilities and work with producers to address those resource concerns by installing new conservation controls and by updating nutrient management plans.

Livestock farming is extensive in the watershed, and the total number of operations and equivalent animal units has increased significantly from 1997 to 2007. The quantity of manure produced in the watershed has increased correspondingly. The land application of manure, especially during winter months, is a large source both bacteria and nutrients entering streams and subsurface drainage tiles. Recommended strategies for reducing nutrients are found in Table 8-2. They include developing and following improved nutrient management plans; planting winter cover crops and practicing crop rotation to provide more acreage for winter manure application; soil testing with agronomic fertilizer applications; and using tile plugs or drainage water management on tiled fields. While some poultry manure is currently brokered for distribution outside of the Grand Lake and Wabash watershed, there is a need to develop other methods to manage and export liquid manures.

Sources from urban and residential runoff

The relatively high volume of runoff generated in urban and high density residential areas increases the potential for pollution. Sediment and nutrient residues on surfaces that are impervious or poorly pervious (e.g., compacted lawns, gravel drives, etc.) are more easily transported in this higher volume of runoff and attenuation of the loading by infiltration does not occur. Reducing imperviousness and improving on-site retention and infiltration can abate sediment and nutrient loading by reducing the runoff discharge.

Residential and commercial development can contribute high loads of sediment during construction. Phase II storm water regulations now require prescribed management practices for construction activities be included in a site's Storm Water Pollution Prevention Plan (SWP3). This includes the installation and maintenance of sediment and erosion control practices for construction projects, and implementation of post-construction storm water controls on construction projects that, either by themselves or as part of a total common plan of development or sale, collectively disturb one (1) acre or more (**http://www.epa.state.oh.us/dsw/storm/construction_index.html**).

Lawn care that limits the application of nutrients and increases the likelihood of uptake and retention is recommended. This includes reducing the amount and/or frequency of fertilizer applications. The timing of application should be such that it is unlikely to immediately precede a runoff event (e.g., precipitation or irrigation). More stable alternatives to chemical fertilizers should be adopted such as organic-based compost and manure. Organic materials also provide carbon that improves soil structure and increases permeability and greater storm water infiltration.

The NRCS, in collaboration with the National Association of Conservation Districts (NACD) and the Wildlife Habitat Council (WHC), developed a backyard conservation manual that highlights ten activities that collectively are designed to improve water and soil quality and wildlife habitat. This document can be found on the world-wide web at **http://www.nrcs.usda.gov/feature/backyard/**.

Assimilative capacity

Increasing the assimilative capacity of the stream system itself is a viable means to help achieve water quality goals. Such an increase can help abate pollutant loads in the event that controls for landscape-based and point sources are inadequate. One of the most important ways to increase the assimilative capacity of the system is to provide and/or preserve floodplain connection. Other means include ensuring high-quality bottom substrate and appropriate channel morphology. A sufficient source of carbon is needed to support many of the organisms that are critical for in-stream biological processing; therefore, detritus from riparian trees and floodplains is important (Wallace et al., 1997; Baer et al., 2001; Crenshaw et al., 2002).

8.1.4 Summary

The major source of impairment in the Beaver Creek-GLSM watershed is caused by agricultural land use practices and requires multiple implementation actions. The basic principles of providing floodplain connectivity, stable stream morphology and watershed hydrology that approximates natural conditions are applicable to the agricultural and residential/urban areas of the watershed. A broad adoption of soil and nutrient management for lawns, crop fields and livestock production will be necessary to achieve sediment and nutrient load reductions. Likewise, stream buffers are appropriate for all land use types in the watershed for protection of the water resources. A list of various best management practices and their potential effectiveness in the Beaver Creek-GLSM watershed is found in Table 5-1. Ohio EPA recognizes that the technical effectiveness of certain BMPs to reduce loads is just one consideration. Local stakeholders are encouraged to explore alternate BMPs to find the most effective, acceptable, and sustainable means of reducing nutrients and sediment in the watershed.

Point source reductions are needed at six wastewater treatment facilities throughout the basin. HSTS failures must be addressed in rural areas. Overland sediment loading is primarily a concern in the agricultural areas and where residential and commercial development is occurring. Nutrient loading from farm chemicals and manure sources is widespread in the watershed and conservation and management practices promoted by NRCS are recommended to abate these sources. Table 8-2 summarizes the causes and sources of impairment within the watershed and the action steps recommended for improving those impairments. Also refer to ODNR document Manure and Excess Nutrient alternatives for West Central Ohio (2/2007) found in Appendix F.

Additionally, the Ohio EPA 208 Program may provide a venue for local citizens to design and direct actions that abate pollution and preserve clean water within the watershed. Further information is in Section 8.3.1 and at **http://www.epa.state.oh.us/dsw/mgmtplans/208index.html**.

Table 8-2. Summary of the strategies for addressing each listed cause of impairment in the Beaver Creek-GLSM watershed.

<table>
<tr><th colspan="2">PATHOGENS</th></tr>
<tr><td>• Reduce point sources
o Eliminate Separate Sewer Overflows
o Provide centralized collection and treatment for unsewered communities
• Reduce loading from HSTS
o Identify and repair/replace failing home sewage systems
o Protect against future failures through training and education on system maintenance
o Central sewerage (where feasible)</td><td>• Reduce loading from livestock operations
o Provide increased waste storage
o Cover or eliminate open feedlots
o Eliminate or reduce livestock access to streams
o Improve manure storage and handling operations
o Implement BMPs included in NRCS 633 standards for winter application of manure and application of liquid manure on tile-drained fields
o Plant winter cover (green manure) crops to provide manure application sites
o Increase set-back distances from streams and roadside ditches</td></tr>
<tr><th colspan="2">HABITAT</th></tr>
<tr><td><u>Channelization</u>
• Increase heterogeneity of channel morphology and flow conditions
o Natural Channel design and stream restoration
o Two-stage or over-wide construction on maintained drainage ditches
• Create and protect in-stream habitat
o Stream restoration and bio-engineering techniques</td><td><u>Stream Bank Stability</u>
• Approximate natural hydrology of watershed
o Increase natural vegetative cover
o Permanent riparian protection
o Wetland creation and restoration
• Create or restore floodplain connections
• Establish filter strips on all tributaries with woody vegetation</td></tr>
<tr><th colspan="2">NUTRIENTS</th></tr>
<tr><td>• Reduce point source loads
o Permit restrictions
• Increase assimilative capacity of stream system
o Increase floodplain connection
o Improve stream bed substrate
o Increase stream detention time
▪ Increase sinuosity
▪ Increase riffle-pool development
• Reduce overland sources
o Develop improved nutrient management plans for livestock operations and monitor or audit the extent to which NMPs are fully implemented
o Update existing NMPs to current standards, including identification of critical source areas
o Drainage water management or tile plugs on drained fields that receive manure application
o Plant winter cover crops to uptake soil and manure nutrients
o Broker the export of manure from the watershed</td><td>• Reduce overland sources (cont.)
o Adjust crop rotations so there is more available acreage to apply manure throughout the calendar year (i.e., in periods where potential for losses are least and potential for crop uptake are the greatest)
o Improve timing of fertilizer application
o Conduct regular soil testing and follow agronomist nutrient recommendations
o Adjust feed nutrients based on animal nutritionist recommendations
o Develop (require) CNMPs on a regional/ watershed level
o Amend State Water Quality Management (208) Plan to address nutrient overload in these watersheds

• Provide riparian corridor
• Install wetlands at outlets of headwater tile mains
• Install water table management structures on tile systems</td></tr>
</table>

SEDIMENT	
• *Reduce overland sediment loading* o Reduce potential for surface erosion ▪ Protective cover ▪ Conservation tillage o Establish filter strips on all tributaries o Permanent protection of stream side buffering o Adopt and implement storm water controls on construction sites o Implement Storm Water Pollution Prevention Plan post-construction controls	• *Reduce in-stream erosion* o Improve stream stability (see habitat above) • *Increase assimilative capacity of stream system (see nutrients above)*

8.2 Recommended Implementation Actions by Subwatershed

Implementation of this report's recommendations will be accomplished by state and local partners, including the voluntary efforts of landowners. Actions recommended to address the causes and sources of impairment are arranged according to the subwatersheds (assessment units) discussed earlier in this report. The major causes and sources of impairment are listed for each subwatershed. Locations are given for areas that are known to have impairment or are threatened by the presence of sources of impairment. Included with the implementation actions are the organizations important for successful implementation. When possible, attention was given to issues of timeframe, resource availability to assist implementation, and potential barriers to success.

Locally, discussion of actions to restore the watershed has occurred as diverse partners have worked to develop watershed action plans. The Grand Lake/Wabash Watershed Alliance (GLWWA) has written and received state endorsement for a Grand Lake St. Marys Watershed Action Plan and is in process of preparing a comprehensive plan for the entire Wabash River Watershed in Ohio, which will include actions with proposed timelines for all subwatersheds of the river and an update of the Grand Lake St. Marys plan.

GLWWA and its partners in three counties are serving as community advocates for the watershed, and have become important forces to maintain momentum and sponsor improvement efforts. For example, the Lake Improvement Association has established a strong outreach program to engage the public with factual information and promote activities to restore and protect the lake.

8.2.1 Grand Lake St. Marys (HUC 05120101 020)

Major causes and sources of impairment in the subwatershed:

- Pathogen and nutrient loading from failed HSTS
- Pathogen and nutrient loading from livestock operations
- Habitat degradation from channelization and routine ditch maintenance
- High nutrient and sediment loads from row crop agriculture
- Nutrients from point sources

Pathogen loading

Unsewered Areas

Areas of particular importance for addressing failed HSTS or providing centralized sewerage treatment are the following:

- Maria Stein
- St. Johns
- St. Rose
- Casella
- Carthagena
- Sebastian

Failing HSTS

Mercer and Auglaize County Health Departments should take steps to improve the condition of failing HSTS in this part of the subwatershed. Detailed information regarding the location of failing systems as well as the number and types of failures would improve chances of reaching the appropriate landowners. Actions recommended include providing information to residents owning these systems regarding upgrades and improvements, proper maintenance, and the consequences for having a failed system. Enforcement actions should be pursued for flagrant violations of HSTS rules. Planning and implementation should be done with the participation of local health departments to ensure that existing resources, programs, and expertise are used to the greatest extent possible.

Funding may be provided through Water Pollution Control Loan Fund (WPCLF) grants that are administered through the Division of Environmental and Financial Assistance (DEFA) at the Ohio EPA. Other sources for funding may include private grants and local governments.

Livestock Operations

Livestock manure storage and land application in all of the sub watersheds need practices to reduce nutrient and pathogen impairments, especially during runoff events. The streams are listed in order from higher to lower priority for funding and restoration actions:

- Grassy and Monroe Creeks
- Chickasaw Creek
- Beaver Creek
- Coldwater/Burntwood Creeks
- Prairie Creek
- Barnes Creek
- North Shore tributaries

NRCS and SWCD staff should work to inform livestock farm operators of the water quality threat posed by poor or inadequate manure management practices, particularly within the areas identified in this report as being a source of impairment. Technical assistance and cost share should be extended to such operations as appropriate. Some appropriate conservation practices are given in section 8.1.1 of this report. The Environmental Quality Incentives Program (EQIP) provides both cost share and incentive payments for structural and management BMPs (see section 8.3.3).

It is also recommended that the farmer coalitions and advocacy groups that have established programs to address environmental issues associated with livestock production take an active role in educating and providing technical and financial assistance where appropriate. Examples include the Ohio Farm Bureau Federation, local young farmer groups, the Lake Improvement Association and the Ohio Livestock Coalition. The Grand Lake/Wabash Watershed Alliance (GLWWA) works specifically to improve water resources and has a focus on abating deleterious impacts caused by agricultural production. GLWWA's continued efforts are encouraged. It is recommended that these groups work collectively to promote sound conservation practices and land stewardship within the agricultural community. Also, the development of partnerships with industry that supports livestock production (e.g., feed industry, various equipment dealers) may lead to more efficient and successful promotion of best management practices.

Habitat degradation

Channelization

Areas of particular importance for increasing or protecting riparian habitat are the following in order from higher to lower priority:

- Barnes Creek
- Grassy and Monroe Creeks
- Prairie Creek
- Beaver Creek
- Chickasaw Creek
- Coldwater and Burntwood Creeks

Stream restoration is recommended wherever possible. Areas in non-attainment should be prioritized. It is recommended that a two-stage channel approach be taken for channelized streams in this basin that exhibit poor, one-stage morphology.

Buffer strips, particularly forested buffers, should be promoted through the Lake Erie CREP (see section 8.3.3), other forms of assistance, and/or uncompensated voluntary adoption. Land purchases and easements secured by land preservation organizations or private entities should consider giving priority to streamside areas.

Nutrient and sediment loading

Row crop agriculture

Areas of particular importance for reducing sediment impairments are the following in order from higher to lower priority:

- Beaver Creek
- Chickasaw Creek
- Coldwater and Burntwood Creeks
- Grassy and Monroe Creeks
- Prairie Creek
- Barnes Creek

NRCS and SWCD staff should actively promote the Lake Erie CREP to maximize participation in that set-aside program. Both buffers and wetlands are available for funding and are appropriate to abate sediment and nutrient loading. Conservation tillage practices should be promoted on fields that are listed as highly erodible lands (HEL). Other NRCS practices to be promoted that address nutrients are listed in section 8.1.5. Two-stage channels are likely to increase the assimilative capacity of streams that have poor, one-stage channel morphology and should be promoted as described in the preceding sub-section.

Water table management should be promoted by NRCS and SWCD staff for its potential to reduce nitrogen and soluble phosphorus loading. It is recommended that risk management programs be explored as a means to reduce the risk of yield loss through the adoption of this and/or other types of management practices that reduce nutrient export.

Point sources

The Village of St Henry, Village of Chickasaw, Chapel Hill, Marion Schools, and Montezuma Club Island WWTPs should have their NPDES permits modified to include a monitoring requirement for total phosphorus. Ohio EPA will work with these communities to discuss needed modifications to discharge permits. In some cases the modifications can be delayed to take effect when permits are scheduled for renewal. Standard nutrient monitoring should be sufficient to determine the need for future permit modifications.

Urban and Residential Runoff
Phase II Storm Water regulations now require prescribed management practices for construction activities be described in a site's SWP3 that include:

- Installation and maintenance of sediment and erosion control practices for construction projects which, either by themselves or as part of a total common plan of development or sale, collectively disturb one acre or more
- Implementation of post-construction storm water controls on construction projects which, either by themselves or as part of a total common plan of development or sale, collectively disturb one acre or more

8.2.2 Beaver Creek (HUC 05120101 030)

Major causes and sources of impairment in the subwatershed:
- Pathogen and nutrient loading from failed HSTS
- Pathogen and nutrient loading from livestock operations
- Habitat degradation from channelization and ditch maintenance
- High nutrient and sediment loads from row crop agriculture
- Nutrients from point sources

Pathogen loading
Unsewered Areas
Areas of particular importance for addressing failed HSTS or providing centralized sewage treatment are the following:
- ➢ Menchoffer Woods and Fleetfoot Road area
- ➢ Northeast corner of St. Anthony Road and SR 118 in Butler Township
- ➢ Northeast corner of Burkettsville-St. Henry Road and Lange Road in Granville Township

Livestock Operations
Livestock manure storage and land application in all of the sub watersheds need practices to reduce nutrient and pathogen impairments, especially during runoff events. The streams are listed in order from higher to lower priority for funding and restoration actions:
- ➢ Little Beaver Creek
- ➢ Beaver Creek
- ➢ Big Run
- ➢ Brush Run
- ➢ Hardin Creek

Habitat degradation
Channelization
Areas of particular importance for increasing or protecting riparian habitat are the following in order from higher to lower priority:
- ➢ Beaver Creek, Big Run, Brush Run
- ➢ Little Beaver Creek
- ➢ Beaver Creek, Hardin Creek

Recommendations and sources for assistance in this subwatershed are similar to those for the Grand Lake St. Marys subwatershed.

Nutrient and sediment loading

Row crop agriculture

Areas of particular importance for reducing sediment impairments are the following:

- Beaver Creek below Little Beaver Creek to Wabash River (Big Run and Prairie Creek) would be the first priority based on acreage of HEL and it has the most documented occurrences of conventional tillage.
- Little Beaver Creek area has the second highest acreage of HEL, but also has the most documented no-till practices.

Recommendations and sources for assistance in this subwatershed are similar to those for Grand Lake St. Marys subwatershed.

Point sources

As of March 1, 2007, the City of Celina WWTP NPDES permit was modified. The final effluent table limits total phosphorus to 1.0 mg/l (monthly) with a compliance date of December 1, 2011. The Village of Coldwater, Philothea Sewer District, Mercer County Home, Pax Machine, Elks Club, and Wagner Subdivision should have their NPDES permits modified to include a monitoring requirement for total phosphorus. Ohio EPA will work with these communities to discuss needed modifications to discharge permits. In some cases the modifications can be delayed to take effect when permits are scheduled for renewal. Standard nutrient monitoring should be sufficient to determine the need for future permit modifications.

Urban and Residential Runoff

Phase II Storm Water regulations now require prescribed management practices for construction activities be described in a site's SWP3 that include:

- Installation and maintenance of sediment and erosion control practices for construction projects which, either by themselves or as part of a total common plan of development or sale, collectively disturb one acre or more
- Implementation of post-construction storm water controls on construction projects which, either by themselves or as part of a total common plan of development or sale, collectively disturb one acre or more

8.3 Reasonable Assurances

The recommendations made in this TMDL report will be carried out if the appropriate entities work to implement them. In particular, activities that do not fall under regulatory authority require that there be a committed effort by state and local agencies, governments, and private groups to carry out and/or facilitate such actions. The availability of adequate resources is also imperative for successful implementation.

The following discusses organizations and programs that have an important role or can provide assistance for meeting the goals and recommendations of this TMDL. This section establishes why it is reasonable to be assured of successful implementation.

8.3.1 Ohio EPA

Several programs that Ohio EPA Division of Surface Water (DSW) administers are designed to control pollution from point sources and certain storm water discharges as well as provide assistance for abating non-point sources of pollution. Other divisions within the Ohio EPA provide assistance such as funding, technical assistance, and education for water resource related issues. Information regarding the specific programs within the Ohio EPA DSW can be found on the web at **http://www.epa.state.oh.us/dsw/**, and information about the Division of Environmental and Financial Assistance (DEFA) at **http://www.epa.state.oh.us/defa/**. What follows are programs within the agency that are especially important for the implementation of this TMDL.

NPDES Program

National Pollution Discharge Elimination System (NPDES) permits authorize the discharge of substances at levels that meet the more stringent of technology- or water-based effluent limits and establish condition requirements related to combined sewer overflows, pretreatment, concentrated animal feeding operations and sludge disposal. All entities that wish to discharge to the waters of the state must obtain a NPDES permit and both general and individual permits are available for coverage. Through the NPDES program (**http://www.epa.state.oh.us/dsw/permits/permits.html**), the Ohio EPA will use its authority to ensure that recommended effluent limits are applied to the appropriate permit holders within the Beaver Creek-GLSM watershed. Ohio EPA staff in the NPDES program can provide technical assistance for permitted entities when needed.

Currently, Ohio EPA administers the NPDES permit program for CAFOs (**http://www.epa.state.oh.us/dsw/cafo/index.html**). The CAFO permits regulate the production area and land application fields under the control of the operation for animal feeding operations that discharge or propose to discharge pollutants to surface waters. Under this program, Ohio EPA responds to manure-related complaints and works to resolve livestock operation resource concerns with ODA, ODNR, and local Soil and Water Conservation Districts.

Combined Sewer Overflow Program

Ohio EPA implements CSO controls through provisions included in NPDES permits and by using orders and consent agreements when appropriate. The NPDES permits for CSO communities require the implementation of nine minimum control measures (Ohio EPA, 1995; **http://www.epa.state.oh.us/dsw/cso/csostrem.pdf**). Requirements to develop and implement Long Term Control Plans are also included where appropriate

Storm Water Program

Ohio EPA implements the federal regulations for storm water dischargers (**http://cfpub1.epa.gov/npdes/home.cfm?program_id=6**). Under OAC 3745-39, Ohio EPA has designated the City of Celina to obtain NPDES permit coverage as an Appendix 7 Small MS4. Celina meets the criteria for size and population density and 303(d) listed impaired surface waters in the tributaries to Grand Lake St. Marys and Beaver Creek, which receive urban runoff from City of Celina. The storm water management program plan is due to Ohio EPA on May 1, 2007 (**http://www.epa.state.oh.us/dsw/storm/ms4_index.html**).

Besides the City of Celina, other dischargers covered under the storm water program are those facilities that meet the definition of industrial activity, including construction, in the federal regulations. Both general and individual permits can be used for coverage of storm water effluent. To protect a receiving stream's physical, chemical, and biological characteristics and maintain stream functions, the post-construction storm water practices shall provide perpetual management of runoff quality and quantity. To meet the post-construction requirements of the NPDES Construction General Permit, the SWP3 must contain a description of the post-construction BMPs that will be installed during construction for the site and the rationale for their selection. The rationale must address the anticipated impacts on the channel and floodplain morphology, hydrology, and water quality. To this end, appropriate BMPs are to be considered and implemented that address the causes of impairment for this watershed, including habitat alteration, nutrient enrichment, siltation, flow alteration, and bacteria. The post-construction BMP(s) chosen must be able to detain storm water runoff for protection of the stream channels, stream erosion control, and improved water quality (**http://www.epa.state.oh.us/dsw/storm/construction_index.html** and **http://www.epa.state.oh.us/dsw/storm/CGP-PC-Q&A.html**).

Staff within the Storm Water Program provide technical assistance to permitted entities when needed. District Office staff within the Storm Water Program respond to and investigate complaints received by individuals and organizations. Through the Storm Water Program, the Ohio EPA will ensure that the storm water permit-related recommendations of this TMDL are applied.

401 Water Quality Certification Program
In Ohio, anyone wishing to discharge dredged or fill material into the waters of the U.S., regardless of whether on private or public property, must obtain a Section 404 permit from the U.S. Army Corps of Engineers and a Section 401 Water Quality Certification (WQC) from the state.

Stream and wetland mitigation is used as a condition for granting 401 certificates and is the means of ensuring that water resources do not experience net decline in quality. When a wetland or stream segment is impacted, an appropriate compensation is required such that there is no net loss of wetlands or unimpaired stream length. Restoration, creation, or other forms of enhancement are required at a level that depends upon the original quality of the resource.

Currently there are proposed rules changes to the 401 Program that are designed to provide a more scientific basis for determining appropriate criteria for 401 permit decisions (i.e., acceptance or denial) as well as mitigation stipulations for the respective projects (**http://www.epa.state.oh.us/dsw/401/index.html**). These rule changes are expected to be finalized in 2008. Ohio EPA staff will conduct reviews and issue permits to provide the most reasonable protections and improvements, where possible, of surface waters in the Beaver Creek-GLSM watershed.

The Mitigation Clearinghouse, coordinated by the Section 401 section, promotes the exchange of information between applicants that are seeking projects for mitigation of unavoidable environmental impacts to wetlands, streams and lakes that may be part of a Section 401 Water Quality Certification or Isolated Wetland Permit, and individuals that may have property or projects that are available. The Clearinghouse may also be beneficial for parties seeking to locate potential supplemental environmental projects, Water Resource Restoration Sponsor Program projects, or actions to be taken consistent with needs identified in a Total Maximum Daily Load for a watershed.

Interested parties with potential mitigation sites submit information on the Ohio EPA Data Sheet located at **http://www.epa.state.oh.us/dsw/MCH/index.html**. Ohio EPA enters that information into a database. Submitted projects may be viewed by anyone interested in finding potential mitigation areas by clicking on the map included on the web site. Inclusion of a potential mitigation site in the Mitigation Clearinghouse does not constitute Ohio EPA endorsement or approval of that site; it means only that Ohio EPA received sufficient information to post the information in the Mitigation Clearinghouse. When a potential mitigation site is submitted as part of a permit application, Ohio EPA will determine if that particular mitigation proposal is appropriate for the specific impact to surface waters on a case-by-case basis.

Wetland Protection Program
House Bill 231 established a permanent permitting process for isolated wetlands. Reviewers in the 401 Water Quality Certification Section are responsible for the isolated wetland permits required by this State law. Ohio EPA staff will conduct reviews and issue permits to provide the most reasonable protections and improvements of surface waters in the Beaver Creek-GLSM watershed.

Enforcement Program
In cases that Ohio EPA is unable to resolve continuing water quality problems, DSW may recommend that enforcement action be taken. The enforcement and compliance staff work with Ohio EPA attorneys, as well as the Attorney General's Office, to resolve these cases. Where possible, an added emphasis and priority is given to actions in sensitive watersheds. All completed enforcement actions are posted on the DSW web page.

208 Program (State Water Quality Management Plans)
Ohio EPA oversees the State Water Quality Management (WQM) Plan. The State WQM Plan is like an encyclopedia of information used to plan, direct and evaluate actions that abate pollution and preserve clean water. All types of water quality issues may be addressed and potential solutions framed within the context of both voluntary incentive-based programs and regulation of pollution sources through applicable laws and rules. Where existing laws and regulations fall short of being able to achieve the clean water standards in a particular water body the State's 208 Plan provides a process to set forth procedures and methods that would control sources of pollution. This process might employ existing legal authorities in a different fashion, or the process might require new legal authorities granted by the appropriate State and local governmental bodies. Normally the State's Plan is reviewed and updated as needed on an annual basis.

The Beaver Creek-GLSM TMDL will become a part of the State WQM Plan when it is approved by U.S. EPA. Recommended TMDL targets for nutrients are established in the Beaver Creek and Grand Lake St. Marys watersheds. The large reductions in nutrient loadings that are necessary to achieve the water quality standards may be beyond the reach of existing voluntary incentive-based programs and regulation. Progress on in this effort should be closely tracked and documented. The State 208 planning process provides a mechanism for local stakeholders to seek additional authorities should it prove necessary for achieving the water quality standards in the drinking water source water protection area and other water bodies.

Nonpoint Source Program
The Ohio Nonpoint Source (NPS) program focuses on identifying and supporting implementation of best management practices (BMPs) and measures that reduce pollutant loadings, control pollution from nonpoint sources and improve the overall quality of these waters (**http://www.epa.state.oh.us/dsw/nps/index.html**). Ohio EPA receives federal Section 319(h) funding to implement a statewide NPS program, including offering grants to address nonpoint sources of pollution. Staff from the NPS program work with state and local agencies, governments, watershed groups, and citizens.

In addressing sources of impairment related to agricultural activities, NPS staff will correspond with Ohio DNR to promote BMPs as well as cost-share and incentive based conservation programs. In particular, Ohio EPA will encourage the Ohio DNR to continue to work with Farm Service Agency personnel and staff from local SWCD and NRCS offices. NPS staff will also provide assistance to agencies and groups actively promoting conservation as well as direction to other appropriate resources within the Ohio EPA.

NPS staff will continue to work with the watershed group that is active in the Beaver Creek-GLSM basin, which is developing a watershed management plan (see watershed groups below). Local NPS implementation is a key to achieving state environmental targets. Additionally, there is a reliance on watershed management plans to identify and outline actions to correct water quality problems caused by NPS pollution.

Section 319(h) grants are expected to be directed to projects that eliminate or reduce water quality impairments caused by nonpoint sources of pollution. Applicants may apply for a maximum of $500,000 for a three year period. Each project funded must provide an additional 40% matching share and the total federally funded share of project costs may not exceed 60%. Since a TMDL has been initiated, grant proposals for work within the Beaver Creek-GLSM watershed will receive special consideration for funding.

Source Water Protection

The City of Celina operates a community public water system that serves a population of approximately 11,520 people. The source is surface water drawn from Grand Lake St. Marys. The Superintendent of the City of Celina Water Treatment Plant received a source water assessment completed by Ohio EPA for the source water area contributing to Grand Lake. This assessment includes a delineation of a Source Water Assessment and Protection (SWAP) area (**http://www.epa.state.oh.us/ddagw/pdu/swap.html**), a Corridor Management Zone along all contributing streams and an Emergency Management Zone around the intake. The assessment includes an examination of the characteristics of the watershed contributing to the lake and water quality. An inventory of potential pollutants within the protection areas is also included. Finally, the report suggests actions that the public water supplier and local community may take to reduce the risk of contaminating their source of drinking water.

Over the last few years, the City of Celina's public water system staff have been collecting and analyzing raw water samples in Grand Lake St. Marys and its tributaries, to monitor source water quality and adjust water treatment accordingly. They have shared their water quality data with other environmental groups in the area, including the Grand Lake/Wabash Watershed Alliance. On November 14, 2006, Ohio EPA met with the Superintendent of the Celina public water system to discuss preparing a source water protection plan. When implemented, the source water protection plan will reinforce activities conducted under a watershed action plan, such as public education and encouragement of best management practices. In addition, a source water protection plan emphasizes contingency planning for potential catastrophic spills or releases into the drinking water source. The public water system staff can be a powerful advocate for watershed protection, within City Council and in the wider community.

Excessive nutrient inputs to the lake have promoted growth of algae and contribute to a high level of organic material that is expensive to remove from the raw drinking water. The City of Celina is currently under orders to reduce total trihalomethanes (THMs) levels in their finished water. THMs are chemical byproducts created when chlorine added for disinfection reacts with the organic material. Trihalomethanes and other disinfection byproducts pose a significant health risk as they have been shown to be either carcinogenic or potentially carcinogenic.

Strategies for protecting the City of Celina source water should include:

- Follow BMPs for management and land application of manure – Develop and improve nutrient management plans to address site-specific resource concerns.
    - Improve management of feedlot to minimize discharges and runoff – Lack of containment on open feedlots or exposure of feedlots to precipitation contributes to the load of nutrients in the watershed.
    - Improve cropping rotations to allow for more year-round application of manures – Manure management systems designed only to provide once per year or twice per year manure application onto crop land increases the potential for greater losses attributable to less than desirable soil

and/or weather conditions. Further, manure applied post harvest in the absence of cover crops are more vulnerable to loss to the watershed.
  - Establish riparian corridors along streams – Promote stream shading and increase assimilative capacity.
  - Install tile drainage control structures – Proper installation and management of tiles drainage control structures can allow nutrient-laden water to remain in the root zone and control rate of discharge to streams.
  - Discharge tiles to restored wetlands instead of streams – Promote nutrient assimilation of nutrients by wetland plants before water discharges to a stream.
- Extend sewer lines to unsewered areas.
- Promote proper homeowner fertilization practices.

Division of Environmental and Financial Assistance

The Division of Environmental and Financial Assistance (DEFA) provides incentive financing, supports the development of effective projects, and encourages environmentally proactive behaviors through the Ohio Water Pollution Control Loan Fund (WPCLF; **http://www.epa.state.oh.us/defa/wpclf.html**). Municipal wastewater treatment improvements—sewage treatment facilities, interceptor sewers, sewage collection systems and storm sewer separation projects—are eligible for financing. Nonpoint pollution control projects that are eligible for financing include:

- Improvement or replacement of on-lot wastewater treatment systems
- Agricultural runoff control and best management practices
- Urban storm water runoff
- Septage receiving facilities
- Forestry best management practices

The Water Resource Restoration Sponsor Program (WRRSP) is a part of the WPCLF and directs funding towards stream protection and restoration projects. The primary focus of this program is to improve and protect stream habitat. Like Section 319 (h) grants, proposals for stream improvements within the Beaver Creek-GLSM watershed will receive special consideration. For a link to the WRRSP fact sheet go to **http://www.epa.state.oh.us/defa/current_program_links.html**.

8.3.2 Ohio Department of Natural Resources

The Ohio Department of Natural Resources (Ohio DNR) works to protect land and water resources throughout Ohio. A specific objective in regards to water resources is to *"Lead in the development and implementation of stream and wetlands conservation initiatives, applying advanced science, technology and research to restore and protect stream and wetlands habitats"* (Ohio DNR web site). This commitment attests that the Ohio DNR will be a reliable partner in addressing causes and sources of impairment in the Beaver Creek-GLSM watershed.

The following are programs within the Ohio DNR that are particularly instrumental in protecting and improving water resources within the Beaver Creek-GLSM watershed.

Pollution Abatement program

Under Ohio's Pollution Abatement Rules (OAC 1501), the Ohio DNR is required to respond to written and non-written complaints regarding agricultural pollution. As defined by OAC 1501, agricultural pollution is the "failure to use management or conservation practices in farming or silvicultural operations to abate wind or water erosion of the soil or to abate the degradation of waters of the state by animal waste or soil sediment including substances attached thereto." In cooperation with SWCDs, an investigation is begun within 5 days of receipt of the complaint and a Pollution Investigation Report (PIR) is generated within 10 days. Resource management specialists from Ohio DNR within the Division of

Soil and Water Conservation (DSWC) typically become involved with pollution abatement cases in their respective areas of the state.

If it is determined necessary, an operation and management plan will generated to abate the pollution. This plan is to be approved by the SWCD or Ohio DNR and implemented by the landowner. Cost share funding may be available to assist producers in implementing the appropriate management practices to abate the pollution problems and such practices may be phased in if necessary. If a landowner fails to take corrective action within the required timeframe, the Chief of the Division of Soil and Water Conservation (Ohio DNR) may issue an order such that failure to comply is a first degree misdemeanor. This program will provide safeguards against chronic problems that lead to the degradation of water quality within the Beaver Creek-GLSM watershed.

SWCD Program

Ohio DNR-DSWC has a cooperative working agreement with the Soil and Water Conservation Districts throughout Ohio and the NRCS. According to the agreement, Ohio DNR-DSWC is responsible to "provide leadership to Districts in strategic planning, technical assistance, fiscal management, staffing, and administering District programs." The Division also provides "training and technical assistance to District supervisors and personnel in their duties, responsibilities, and authorities." Program Specialists from Ohio DNR work with the SWCDs to identify program needs and training opportunities. Ohio DNR also ensures that program standards and technical specifications are available to SWCDs and NRCS personnel. State matching dollars from the Ohio DNR constitute roughly half of the annual operating budgets of SWCDs.

Through the partnership established by the working agreement and their history of collaboration, Ohio DNR can communicate the goals and recommendations highlighted in this TMDL to SWCDs and provide guidance to actively promote conservation efforts that are consistent with those goals.

8.3.3 Agricultural Services and Programs

Local SWCD, NRCS, and Farm Service Agency (FSA) offices often work to serve the county's agricultural community. Staff from these offices establish working relationships with private landowners and operators within their county, which are often based on trust and cooperation.

SWCD and NRCS staff are trained to provide sound conservation advice and technical assistance (based on standard practices) to landowners and operators as they manage and work the land. Sediment and erosion control and water quality protections make up a large component of the mission of their work. SWCD and NRCS activities also include outreach and education in order to promote stewardship and conservation of natural resources. The close working relationships that SWCD and NRCS staff typically have with local land owners and producers make them well suited for promoting both widely-used conservation practices as well as some that are more innovative. During autumn 2006, a winter cover crop demonstration program was created and managed by the Grand Lake/Wabash Watershed Alliance. Remaining funds from an ODNR Pollution Abatement grant were used to administer the program. Approximately 112 acres within the GLSM watershed were planted to annual ryegrass, oats, oilseed radish, rye and wheat. The main goal of the program was for livestock producers to have an area for winter manure application if it became necessary.

Federal Farm Bill programs are administered by the local NRCS and FSA offices. NRCS is responsible for the Environmental Quality Incentives Program (EQIP), while FSA is responsible for set-aside programs such as the Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), and the Wetland Reserve Program (WRP).

Environmental Quality Incentives Program

The Environmental Quality Incentives Program (EQIP) is an incentive-based, voluntary program designed to increase the use of agriculturally-related best management and conservation practices. EQIP is available to operators throughout the entire Beaver Creek-GLSM watershed, irrespective of whether they own or rent the land that they farm. Through this program, operators receive cost share and/or incentive payments for employing conservation management practices. Contracts are five years in length.

Eligible conservation practices cover broad categories such as nutrient and pesticide management, conservation tillage, conservation crop rotation, cover cropping, manure management and storage, pesticide and fertilizer handling facilities, livestock fencing, pastureland management, and drainage water management, among others. However, funding for these practices is competitive and limited to the allocations made to any respective county in Ohio. Each county in receives a minimum of $100,000 per year and may receive more depending on state priorities for that year. More information on this program is available on the NRCS website at **www.nrcs.usda.gov**.

Conservation Reserve Program and Wetland Reserve Program

The Conservation Reserve and Wetland Reserve Programs (CRP and WRP, respectively) are set aside programs much like the Conservation Reserve Enhancement Program (CREP, see below), which is the enhanced version of CRP. The goals of these programs are to protect environmentally sensitive lands (e.g., highly erodible soils) and improve water quality and wildlife habitat.

Set-aside programs are voluntary and incentive-based and provide compensation to farmers for establishing and maintaining buffers, wetlands, grasslands or woodlands on land that would otherwise be used for agricultural production. Compensation is restricted to the timeframe established in the contract agreement. Incentive payments for these two programs are lower than the enhanced versions (i.e., CREP and WREP), which are limited to areas that have been approved by the USDA for the additional funding. These programs can assist in creating land use changes that improve water resource quality in the Beaver Creek-GLSM watershed.

Ohio Lake Erie Conservation Reserve Enhancement Program

CREP is a voluntary program that helps agricultural producers protect environmentally sensitive land, decrease erosion, restore wildlife habitat, and safeguard ground and surface water. These conservation practices will target environmentally sensitive areas in the Lake Erie Watershed to reduce sediments and nutrients, prevent water pollution and minimize the risk of flooding and enhance wildlife habitat. The Lake Erie CREP is available in 27 counties that includes; Allen, Ashland, Auglaize, Crawford, Defiance, Erie, Fulton, Hancock, Hardin, Henry, Huron, Lucas, Lorain, Marion, Medina, Mercer, Ottawa, Paulding, Putnam, Richland, Sandusky, Seneca, Shelby, Van Wert, Williams, Wood and Wyandot. The Grand Lake St. Marys assessment unit (05120101 020) falls within the program, though the Beaver Creek unit (05120101 030) does not.

The Ohio Lake Erie CREP officially began in May of 2001. There are no acreage limits per county, so it is hard to predict the extent at which the program's conservation practices will be installed in any given area. Within the GLSM watershed there are currently approximately 86 acres enrolled in CP21, the filter strip CREP practice. Approximately three acres are enrolled in CP22 (riparian buffers), and approximately 7.4 acres are enrolled in CP5A (windbreaks).

The program will run on a continuous basis, meaning eligible land may be enrolled at any time until 67,000 acres have been enrolled or until December 31, 2007, whichever comes first. Currently, 25,500 acres are enrolled in the program. With the changes in this amendment, farmers and landowners will have thirteen different Lake Erie CREP practices to choose from, including grass filter strips, wetlands, riparian buffers and develop wildlife habitats. The cleaner watered filtered through the streamside buffers will directly benefit landowners, farmers, aquatic and upland wildlife, as well as help maintain the lucrative Great Lakes tourism and water sports economy. Information regarding this program is available on the web at: **http://www.dnr.state.oh.us/soilandwater/crephome.htm**.

8.3.4 Extension and Development Services

Each county in Ohio has an extension agent dedicated to agricultural and natural resource issues. The primary purpose of extension is to disseminate up-to-date science and technology so it can be applied for the betterment of the environment and society. Like SWCD and NRCS staff, extension agents provide technical advice to landowners and operators and often develop strong relationships with the local community. Local extension agents are particularly well suited for promoting innovative conservation measures that have not yet been established in the standard practices developed by NRCS.

The Top of Ohio Resource Conservation and Development Service (RC&D) works to facilitate sustainable uses of natural and economic resources (for detailed information, see **http://www.oh.nrcs.usda.gov/programs/RCD/topofohiohome.html**). RC&Ds are non-profit organizations that receive technical support from the NRCS. The Top of Ohio RC&D is available to the public for assistance in developing water quality improvements initiatives in the Beaver Creek/GLSM watershed.

8.3.5 Agricultural Organizations and Programs

Agricultural organizations are working to address water quality problems associated with traditional farming practices. The Ohio Farm Bureau Federation (OFBF) seeks to improve water quality through the employment of economically sound conservation management practices (**http://www.ofbf.org/**). In order to pursue this mission, OFBF initiated programs aimed at engaging producers in voluntary water quality protection and improvement efforts. At the local level most county Farm Bureaus (FBs) have a chairperson of an Agricultural Ecology committee that is responsible to administer FB programs related to environmental quality. The Agricultural Ecology chairperson often works with the county's Organizational Director, who is a staff member of the OFBF, to implement program initiatives.

The Agricultural Watershed Awareness and Resource Evaluation (AWARE) program within the OFBF promotes water quality monitoring and education so that producers have more information when making decisions regarding their operations. OFBF has collaborated with other organizations through the Ohio Agricultural Environmental Assurance Alliance (OAEAA) in developing a self assessment program aimed at identifying source of water pollution on farms and developing strategies to abate those problems. OFBF also offers assistance to producers who are having difficulties in complying with environmental regulations. This program has been discussed as a possible future program for landowners and producers in the Beaver Creek-GLSM watershed.

The Ohio Livestock Coalition (OLC) developed the Livestock Environmental Assurance Program (LEAP). This program provides training to producers to employ best management practices in regard to their livestock operations. The On Farm Assessment and Environmental Review (OFAER) is a national program that is like LEAP but provides a more comprehensive analysis. Livestock producers can request an evaluation of their operation, which is conducted by a two-person assessment team. Following the assessment, OFAER participants receive a confidential report that highlights the specific areas on their operation that can be improved in terms of environmental soundness and has recommendations for such improvements. Both of the programs are available to persons operating farms in the Beaver Creek-GLSM watershed.

The Ohio Department of Agriculture is responsible for the Livestock Environmental Permitting Program. Concentrated animal feeding facilities (CAFFs) are permitted and monitored through this program. Further information is available at **http://www.ohioagriculture.gov/pubs/divs/lepp/lepp-index.stm**.

8.3.6 Local Health Departments

Under OAC 3701-29, local health departments are responsible for code enforcement, operational inspections, and nuisance investigations of household sewage treatment systems serving 1, 2, or 3 family dwellings. The Ohio Department of Health works with locals health departments and provides technical assistance and training.

8.3.7 Local Zoning and Regional Planning

Each township in these watersheds has their own local zoning with the exception of Jefferson Township. There is no special zoning other than agricultural districts.

8.3.8 Phase II Storm Water Communities

Phase II storm water communities must develop storm water management plans that include controls for the six minimum control measures outlined by the US EPA (**www.epa.state.oh.us/dsw/storm/ms4.html**). In the Beaver Creek and Grand Lake St. Marys watershed, the City of Celina is designated a Phase II community.

8.3.9 Local Watershed Groups

The Grand Lake/Wabash Watershed Alliance (GLWWA) stewards the complete Beaver Creek-GLSM stream system. The Grand Lake Watershed Project began with local funding in 1998. They hired a watershed coordinator and received a Section 319 Grant to do several agriculture best management practices in the watershed. In 2000, the group received a watershed coordinator grant from ODNR and began to develop a watershed action plan. In 2003, a similar coordinator grant was given to the Wabash Watershed Alliance, and the two coordinators worked on watershed issues together for a couple of years. With the departure of the Wabash Coordinator in late 2005, the two groups merged to form the Grand Lake/Wabash Watershed Alliance, and are continuing to work on projects and planning.

The watershed organization has produced a watershed action plan under the watershed coordinator program for a portion of the watershed. The Grand Lake St. Marys Watershed Action Plan, addressing agriculture and residential issues, was fully endorsed by Ohio DNR and Ohio EPA in 2005. A plan for the remaining portion of the Wabash watershed is being prepared for submission to the state in July 2008. Multiple action items contained in the watershed plan parallel topics and recommendations contained in this report. The Grand Lake Wabash Watershed Alliance Plan will be updated upon approval of the TMDL report.

8.3.10 Easements and Land Preservation

The preservation and protection of high quality riparian acres is advanced by multiple private and public entities throughout the watershed. Franklin Township’s wetlands along Beaver Creek upstream of the Lake are not protected under a perpetual conservation easement; however, there are restrictions on land uses. The City of Celina is planning to construct wetlands along Coldwater Creek as mitigation for the new west bank walkway, and have asked the Mercer SWCD to hold a conservation easement on those wetlands.

8.3.11 Education and Outreach Program

Educational materials can be updated to include information on causes, sources and solutions to nonpoint pollution in the Beaver Creek-GLSM watershed. The primary focus would be building public awareness about the value of a healthy watershed and the importance of reducing/eliminating these sources of pollution. Funding for nonpoint source education is available through competitive grants from ODNR Division of Soil and Water Conservation and the Ohio Environmental Education Fund. Links to the two Agency's environmental program web sites are:
http://www.dnr.state.oh.us/soilandwater/education.htm and **http://www.epa.state.oh.us/oeef/**.

8.4 Process for Evaluation and Revision

The effectiveness of actions implemented based on the TMDL recommendations should be validated through ongoing monitoring and evaluation. Information derived from water quality analyses can guide changes to the implementation strategy to more effectively reach the TMDL goals. Additionally, monitoring is required to determine if and when formerly impaired segments meet applicable water quality standards.

This section of the report provides a general strategy for continued monitoring and evaluation and lists parties who can potentially carry out such work. It highlights past efforts and those planned to be carried out in the future by the Ohio EPA and entities external to the agency. It also outlines a process by which changes to the implementation strategy can be made if needed.

8.4.1 Evaluation and Analyses

Aquatic life and recreational uses are impaired in the watershed, so monitoring that evaluates the river system with respect to these uses is a priority to the Ohio EPA. The degree of impairment of aquatic life use is exclusively determined through the analysis of biological monitoring data. Recreational use impairment is determined through bacteria counts from water quality samples. Ambient conditions causing impairment include high phosphorus and sediment concentrations (or loads) and degraded habitat. This report sets targets values for these parameters such as in-stream concentrations and loads (see Chapter 4), which should also be measured through ongoing monitoring.

A serious effort should be made to determine if and to what degree the recommended implementation actions have been carried out. This should occur within an appropriate timeframe following the completion of this TMDL report and occur prior to measuring the biological community, water quality or habitat.

Past and Ongoing Water Resource Evaluation
The Ohio EPA has conducted water quality surveys within the Beaver Creek-GLSM watershed in 1999, and in 2005 and 2006. The Ohio EPA is scheduled to perform biological, water quality, habitat, and sediment chemistry monitoring in both HUC-11 assessment units in the basin in 2018 (Ohio EPA, 2006a).

Past and continued monitoring in the watershed includes analysis of raw water from the Celina water treatment plants and effluent discharges from the NPDES-permitted facilities. Raw water is monitored for pH, temperature, conductivity, dissolved oxygen, turbidity, UV-254, ammonia, phosphorus and nitrate by the City of Celina. Effluent quality is monitored by the municipal or commercial WWTPs in the watershed including those servicing Celina, Chapel Hill, Chickasaw, Coldwater, Elks Club, Marion Local Schools, Mercer County Home, Mercer County Wagner Subdivision, Montezuma Club Island, Northwood, Pax Machine Woks, Philothea, and St. Henrys. There is also a permitted discharge from the

Celina landfill and Stoneco quarry. These data are included in the Monthly Operating Reports (MORs) that are submitted to the Ohio EPA by these facilities.

Institutions that have actively monitored water resources in the Beaver Creek and Grand Lake St. Marys watersheds for either research-based initiatives or educational purposes are Wright State University and Celina High School. Other entities conducting monitoring work include the Ohio Department of Natural Resources, Ohio Lake Management Society, and the Auglaize and Mercer County General Health Districts.

Potential and Future Evaluation

GLWWA plans to begin a volunteer monitoring program in 2007, and the watershed coordinator is currently developing a plan to train volunteers and find funding for equipment and sample analysis to sustain the program. The coordinator also intends to become a Qualified Data Collector under the Credible Data Program implemented by Ohio EPA.

Recommended approach for gathering and using available data

Early communication should take place between the Ohio EPA and the potential collaborators mentioned above to discuss research interests and objectives. Through such communication, areas of overlap should be identified and ways to make all parties' research efforts more efficient should be discussed. Ultimately, important questions can be addressed by working collectively and through pooling resources, knowledge, and data.

8.4.2 Revision to the Implementation Approach

An adaptive management approach will be taken in the Beaver Creek-GLSM watershed. Adaptive management is recognized as a viable strategy for managing natural resources (Baydack et al., 1999) and this approach is applied on federally owned lands. An adaptive management approach allows for changes in the management strategy if environmental indicators suggest that the current strategy is inadequate or ineffective. The recommendations put forth for the Beaver Creek-GLSM watershed largely center on improving failing HSTS (by repair or connecting to sewer systems), improving in-stream habitat, increasing floodplain connectivity, and the abatement of sediment and nutrients loads. If chemical water quality does not show improvement and/or water bodies are still not attaining water quality standards after the implementation plan has been carried out, then a TMDL revision would be initiated. The Ohio EPA would initiate the revision if no other parties wish to do so.

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