**Michigan Department of Environmental Quality**
**Water Bureau**
**May 2008**

# Total Maximum Daily Load for Dissolved Oxygen for the Cass River Tuscola County

## INTRODUCTION

Section 303(d) of the federal Clean Water Act and the United States Environmental Protection Agency's (USEPA's) Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations, Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting Michigan's Water Quality Standards (WQS) pursuant to Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA). The TMDL process establishes the allowable loadings of pollutants for a water body based on the relationship between pollution sources and in-stream water quality conditions. TMDLs provide states a basis for determining the pollutant reductions necessary from both point and nonpoint sources (NPS) to restore and maintain the quality of their water resources. The purpose of this TMDL is to identify the sources of dissolved oxygen (DO) standard nonattainment in the Cass River in the vicinity of Caro (Figure 1), and to quantify reductions in these sources necessary for attainment of the standard. The Cass River is designated as a warmwater stream with a DO standard of 5 milligrams per liter (mg/l) as a minimum.

The Cass River TMDL reach is defined on the 2008 Section 303(d) list (LeSage and Smith, 2008) as extending from East Dayton Road upstream (Figure 1, Station 1). The Cass River DO TMDL reach is located in Tuscola County (Figure 1).

Table 1 defines the extent and length of the TMDL reach. Note that the reach start is a downstream location, while the end location is an upstream location. A total of four river miles are addressed by this TMDL. The reach length has been increased from one to four miles to reflect the monitoring performed at Deckerville Road (i.e., four river miles upstream of East Dayton Road).

Table 1. Cass River DO TMDL Reach.

| River | Reach Start | Reach End | Distance (mi.) |
|---|---|---|---|
| Cass River | East Dayton Road (T12N, R9E, Section 2) | Deckerville Road (T13N, R10E, Section 9) | 4 |

Cass River has a drainage area of approximately 621 square miles at East Dayton Road. Summer season 50 percent and 95 percent exceedance flows (cubic feet per second [cfs]) for the Cass River at this location are 42 cfs and 14 cfs, respectively. All low flows were computed from a United States Geological Survey (USGS) Grand River flow gage (04151500) located in Frankenmuth, Michigan.

## PROBLEM STATEMENT

Cass River TMDL reach appears on the 2008 Section 303(d) list as:

**Water Body Name**: Cass River **AUID**: 040802050205, 040802050207
**Impaired designated use**: Warmwater Fishery
**Cause**: Organic Enrichment (Sewage) Biological Indicators
**Size**: 4 miles
**Location Description**: East Dayton Road Upstream

Continuous and instantaneous measurements of DO were conducted in the Cass River in the summer of 2001 (Staron, 2007). The monitoring showed that significant periods of dry weather nonattainment of the DO warmwater WQS occur in the Cass River. The cause of the impairment (sewage) was entered incorrectly in the 2008 Sections 303(d), 305(b), and 314 Integrated Report (Integrated Report) (LeSage and Smith, 2008) and will be corrected. The cause of the impairment is abundant plant growth within the TMDL reach due to organic enrichment from agricultural NPS within the watershed.

## NUMERIC TARGETS

Rule 100 (designated uses) of the WQS requires that the Cass River be protected for warmwater fish, other indigenous aquatic life and wildlife, agriculture, navigation, industrial water supply, public water supply at the point of intake, partial body contact recreation, total body contact recreation from May 1 to October 31, and fish consumption. The impaired designated use for the Cass River addressed by this TMDL is the warmwater fish use according to the 2008 Integrated Report. The DO standard was developed to provide protection of this designated use. Attainment of the warmwater DO standard of 5 mg/l as a daily minimum will be the target of this TMDL. The DO WQS is defined as follows:

> R 323.1064 Dissolved oxygen in Great Lakes, connecting waters, and inland streams.
>
> Rule 64. (1) A minimum of 7 milligrams per liter of dissolved oxygen in all Great Lakes and connecting waterways shall be maintained, and, except for inland lakes as prescribed in R 323.1065, a minimum of 7 milligrams per liter of dissolved oxygen shall be maintained at all times in all inland waters designated by these rules to be protected for coldwater fish. In all other waters, except for inland lakes as prescribed by R 323.1065, a minimum of 5 milligrams per liter of dissolved oxygen shall be maintained. These standards do not apply for a limited warmwater fishery use subcategory or limited coldwater fishery use subcategory established pursuant to R 323.1100(11) or during those periods when the standards specified in subrule (2) of this rule apply.
>
> (2) Surface waters of the state which do not meet the standards set forth in subrule (1) of this rule shall be upgraded to meet those standards. The department may issue permits pursuant to R 323.2145 which establish schedules to achieve the standards set forth in subrule (1) of this rule for point source discharges to surface waters which do not meet the standards set forth in subrule (1) of this rule and which commenced discharge before December 2, 1986. For point source discharges which commenced before December 2, 1986, the dischargers may demonstrate to the department that the dissolved oxygen standards specified in subrule (1) of this rule are not attainable through further feasible and prudent reductions in their discharges or that the diurnal variation between the daily average and daily minimum dissolved oxygen concentrations in those

waters exceeds 1 milligram per liter, further reductions in oxygen-consuming substances from such discharges will not be required, except as necessary to meet the interim standards specified in this subrule, until comprehensive plans to upgrade these waters to the standards specified in subrule (1) of this rule have been approved by the department and orders, permits, or other actions necessary to implement the approved plans have been issued by the department. In the interim, all of the following standards apply:

(a) For surface waters of the state designated for use for coldwater fish, except for inland lakes as prescribed in R 323.1065, the dissolved oxygen shall not be lowered below a minimum of 6 milligrams per liter at the design flow during the warm weather season in accordance with R 323.1090(2) and (3). At the design flows during other seasonal periods, as provided in R 323.1090(3), a minimum of 7 milligrams per liter shall be maintained. At flows greater than the design flows, dissolved oxygen shall be higher than the respective minimum values specified in this subdivision.

(b) For surface waters of the state designated for use for warmwater fish and other aquatic life, except for inland lakes as prescribed in R 323.1065, the dissolved oxygen shall not be lowered below a minimum of 4 milligrams per liter, or below 5 milligrams per liter as a daily average, at the design flow during the warm weather season in accordance with R 323.1090(3) and (4). At the design flows during other seasonal periods as provided in R 323.1090(3), a minimum of 5 milligrams per liter shall be maintained. At flows greater than the design flows, dissolved oxygen shall be higher than the respective minimum values specified in this subdivision.

(c) For surface waters of the state designated for use for warmwater fish and other aquatic life, but also designated as principal migratory routes for anadromous salmonids, except for inland lakes as prescribed in R 323.1065, the dissolved oxygen shall not be lowered below 5 milligrams per liter as a minimum during periods of migration.

(3) The department may cause a comprehensive plan to be prepared to upgrade waters to the standards specified in subrule (1) of this rule taking into consideration all factors affecting dissolved oxygen in these waters and the cost effectiveness of control measures to upgrade these waters and, after notice and hearing, approve the plan. After notice and hearing, the department may amend a comprehensive plan for cause. In undertaking the comprehensive planning effort the department shall provide for and encourage participation by interested and impacted persons in the affected area. Persons directly or indirectly discharging substances which contribute towards these waters not meeting the standards specified in subrule (1) of this rule may be required after notice and order to provide necessary information to assist in the development or amendment of the comprehensive plan. Upon notice and order, permit, or other action of the department, persons directly or indirectly discharging substances which contribute toward these waters not meeting the standards specified in subrule (1) of this rule shall take the necessary actions consistent with the approved comprehensive plan to control these discharges to upgrade these waters to the standards specified in subrule (1) of this rule.

**SOURCE ASSESSMENT**

Potential sources of DO demanding pollutants to the Cass River (such as carbonaceous biochemical oxygen demand [CBOD], ammonia nitrogen, sediments, and indirectly, nutrients)

include point and NPS. CBOD and ammonia can be oxidized in the water column, depleting levels of DO. Decay of deposited organic sediments can also negatively affect in-stream DO concentrations. This process is known as sediment oxygen demand (SOD). Nutrients such as phosphorus and nitrogen can stimulate plant growths, which in turn can reduce DO levels through respiration.

In this TMDL, sources have been split into two categories; point sources (e.g., National Pollutant Discharge Elimination System [NPDES] permits) and NPS. There is one NPDES permitted point source discharge to the Cass River watershed in the vicinity of the TMDL reach. The Michigan Department of Transportation (MDOT) has an individual statewide permit covering storm water (Table 2). The Cass City Wastewater Treatment Plant discharges approximately 13 river miles upstream of the TMDL reach. The effluent from this facility is of very high quality and is not expected to cause DO exceedances within the Cass River.

Table 2. NPDES Permitted Point Source Discharges to the Cass River TMDL Watershed. Source: Michigan Department of Environmental Quality (MDEQ), Water Bureau's (WB's) NPDES Permit Management System.

| Facility | Permit No. | County | Receiving Water | Latitude | Longitude |
|---|---|---|---|---|---|
| Individual Permit | | | | | |
| MDOT MS4 | MI0057364 | Statewide | --- | * | * |

* Exact outfall locations are unknown.

Table 3 contains estimates of the Cass River conventional pollutant loads from the MDOT MS4 general NPDES permitted point source. Storm water loads in Table 3 were estimated based on commercial land use data contained in the Long-Term Hydrologic Impact Assessment (L-THIA) Web-based software created and maintained by Purdue University and the USEPA (Purdue University and USEPA, 2001). This geographic information system-based application uses the event mean concentration and curve number procedures to calculate annual pollutant loads based on land use, soil type, and meteorological data. The L-THIA application is supported by staff of the USEPA, Region 5.

The L-THIA has been developed as a straightforward analysis tool that provides estimates of changes in runoff, recharge, and NPS pollution resulting from past or proposed land use changes. It gives long-term average annual runoff for a land use configuration, based on actual long-term climate data for that area. By using many years of climate data in the analysis, L-THIA focuses on the average impact, rather than an extreme year or storm. L-THIA results do not predict what will happen in a specific year. As a quick and easy approach, L-THIA results are intended to provide insight into the relative hydrologic impacts of different land use scenarios. The results can be used to generate community awareness of potential long-term problems and to support physical planning aimed at minimizing disturbance of critical areas. It is an ideal tool to assist in the evaluation of potential effects of land use change and to identify the best location of a particular land use so as to have minimum impact on the natural environment of the area. Concern over urban sprawl has focused on several land use change issues, including the failure to account for hydrologic aspects of land use change that can result in flooding, stream degradation, erosion, and loss of groundwater supply. The L-THIA was developed to provide a quick, accessible tool to use in assessing the long-term impacts of land use change. This site suitability analysis tool makes use only of information that is readily available from municipal databases. Appendix A presents a short description of L-THIA model background geographical information system (GIS) data (Purdue University and USEPA, 2001).

Table 3. Estimated Daily and Annual Conventional Pollutant Loads from the MDOT MS4 NPDES Permitted Point Source.

| Pollutant | Daily Load (lbs/day) | Annual Load (lbs/yr) |
|---|---|---|
| Biochemical Oxygen Demand (BOD) | 96.7 | 35,300 |
| Total Suspended Solids (TSS) | 233 | 85,200 |
| Ammonia Nitrogen | 5.63 | 2,060 |
| Total Phosphorus (TP) | 1.34 | 490 |

Potential NPS of pollutants were evaluated based on land use in the drainage basin. Land use proportions were derived using the L-THIA application and are presented in Table 4. It is possible that the urban land use proportions (e.g., commercial and residential) are in fact higher than indicated in Table 4 due to increasing residential development in this area. However, these possible increases in residential and/or commercial development are not expected to significantly affect the TMDL as the overall residential and commercial land use in the watershed is relatively minor when compared to other uses, e.g., agriculture.

Table 4. Cass River Basin Land Use Categories as Percentages.

| Land Use Category | Percent Land Use Category |
|---|---|
| Water/Wetlands | 0.2 |
| Commercial | 0.2 |
| Agriculture | 63.1 |
| High Density Residential | 0.1 |
| Low Density Residential | 0.5 |
| Grass/Pasture | 10.1 |
| Forest | 25.8 |

The 2001 summer DO survey indicated that certain pollutants contribute toward DO standard nonattainment in the Cass River. Land use-related inputs of various oxygen demanding pollutants (e.g., ammonia, BOD, TP) appear to cause the DO depressions in the Cass River, and likely contribute toward DO standard nonattainment primarily through respiration from abundant plant growths observed throughout the TMDL reach (Staron, 2007). As previously stated, the cause of the impairment (sewage) was entered incorrectly in the 2008 Integrated Report. The cause of the impairment is abundant plant growth due to organic enrichment from agricultural NPS within the watershed.

Estimates of land use-related NPS annual loads of BOD (CBOD + nitrogenous BOD), TSS, TP, and total nitrogen to the Cass River were estimated using the L-THIA application. Estimates of NPS loads to the Cass River appear in Table 5. These loads impact all Cass River tributaries upstream of East Dayton Road, are based on non-site-specific data, and represent a best approximation using software default event mean concentrations and curve number values.

Table 5. Estimated Daily and Annual NPS Land Use Conventional Pollutant Loads.

| Pollutant | Daily Load (lbs/day) | Annual Load (lbs/yr) |
|---|---|---|
| BOD | 1,490 | 544,000 |
| TSS | 35,300 | 12,900,000 |
| Total Nitrogen | 1,480 | 540,000 |
| TP | 427 | 156,000 |

## LINKAGE ANALYSIS

The observed DO standard nonattainment in the Cass River can be attributed to a number of factors. These factors were assessed using mathematical DO models of the reach of concern. The model chosen was the O'Connor-DiToro multi-reach, steady-state DO model (O'Connor and DiToro, 1970), based on the modified Streeter-Phelps equation. This model has the capability of simulating diurnal DO variation resulting from plant photosynthesis and respiration. The respiration term includes DO depletion due to SOD. The O'Connor-DiToro model is considered appropriate for use in this TMDL as it can represent the system without being unnecessarily complex or too data-intensive. Modeling was conducted in accordance with guidance described in the Great Lakes and Environmental Assessment Section Procedure 80 (MDEQ, 1995). The models were calibrated to data collected in the summer of 2001.

**Plant Respiration**: The presence of aquatic plants in a water body can have a very significant effect on levels of DO. Plants, such as rooted macrophytes and algae, utilize photosynthesis during daylight hours to convert carbon dioxide and water into glucose, a process that releases oxygen. The oxygen is released to the surrounding water increasing levels of DO. Throughout the day and night, plants also respire aerobically. This process removes DO from the water column. DO concentrations vary throughout the day in response to photosynthesis and respiration. Since the photosynthetic contribution of DO occurs only with sunlight, and respiration is relatively constant, levels of DO are most often lowest just before sunrise. Plant growth can be encouraged by the addition of nutrients, such as phosphorus, to a water body. This increased growth causes increases in photosynthesis and respiration rates, resulting in exaggerated daytime DO concentration peaks and potentially problematic early morning lows.

Phosphorus is an important nutrient of concern when considering DO problems in aquatic systems, such as the Cass River. Phosphorus can exist in dissolved and particulate forms. When dissolved, some of the phosphorus is available for use by aquatic plants and increased growth can result. Phosphorus, in the particulate form in river sediments, can be released to the water column as dissolved phosphorus under certain conditions, contributing to increased plant growth. Solids that run off of land into water bodies or that are discharged directly to a stream typically have particulate phosphorus associated with them. Substantial loads of TSS can therefore result in substantial inputs of phosphorus available for plant use in a stream.

Abundant growths of rooted and detached macrophytes were noted in the Cass River during the survey conducted in the summer of 2001 (Staron, 2007). Nutrient levels, including phosphorus and ammonia, capable of causing abundant aquatic plant growth, were noted in the 2001 DO survey, and the biological assessment survey conducted in 2006 (Staron, 2007; Cooper, 2007). This plant growth results in high rates of photosynthesis and respiration. Very high DO diurnal variations (ranging from 1.4 to 3.9 mg/l) were measured in 2001 (Staron, 2007), and early morning DO standard nonattainment (as low as 4.0 mg/l) was noted within the TMDL reach.

Dry weather chemistry sampling conducted in 2001 and 2006, showed that TP concentrations exceeded 0.06 mg/l.

**SOD**: In 2001, minimal sediment deposition was observed in the Cass River at Station 1 indicating that SOD is likely not a primary factor in DO standard nonattainment in the Cass River (although it may contribute, depending on the reach). DO modeling utilizing the O'Connor-DiToro multi-reach, steady-state DO model (O'Connor and DiToro, 1970) supports this assertion. Modeling results indicate that low DO levels within the TMDL reach are caused primarily by high diurnal variation due to abundant plant growth.

## LOADING CAPACITY DEVELOPMENT

The Loading Capacity (LC) represents the maximum daily loading of oxygen demanding substances, or other parameters that can indirectly cause oxygen demand (sediments, nutrients), that can be assimilated by the water body while still achieving WQS. As indicated in the Numeric Target section, the target for this DO TMDL is the WQS of 5 mg/l minimum. DO TMDL development also defines the environmental conditions that will be used when defining allowable levels.

The "critical condition" is the set of environmental conditions (e.g., flow) used in developing the TMDL that result in attaining WQS and has an acceptably low frequency of occurrence. The critical conditions for the applicability of WQS in Michigan are given in Rule 323.1090 (Applicability of WQS). Rule 323.1090 requires that the WQS apply at all flows equal to or exceeding the water body design flow. The critical conditions for the control of point sources in Michigan are given in R 323.1082 (Mixing Zones). In general, the lowest monthly 95 percent exceedance flow and 90 percent occurrence temperature for streams are used as design conditions for developing conventional pollutant loadings.

The LC is the sum of individual Waste Load Allocations (WLAs) for point sources and Load Allocations (LAs) for NPS and natural background levels. In addition, the LC must include a margin of safety (MOS), either implicitly or explicitly, that accounts for uncertainty in the relation between pollutant loads and the quality of the receiving water body. Conceptually, this definition is denoted by the equation:

$$LC = \sum WLAs + \sum LAs + MOS$$

The LC represents the maximum loading that can be assimilated by the receiving water while still achieving WQS. The overall loading capacity is subsequently allocated into WLAs for point and NPDES land-use sources, LAs for NPS, and the MOS.

LAs and WLAs are calculated using the best available data and information, recognizing the need for additional monitoring data subsequent to TMDL development to determine if the load reductions required by the TMDL result in WQS attainment.

DO models were used to quantify reductions in river DO sinks necessary to attain the DO standard at critical conditions. Calibration data shows that along the four-mile length of the Cass River, DO deficits are caused primarily by plant respiration. There are reaches in the Cass River where the DO deficit is influenced by some SOD. However, this influence is minor when compared to plant respiration.

In order to decrease nutrient loads, the loading of suspended sediments to the river must be reduced. It is likely that most nutrient inputs to the system are transported with the suspended sediment loads likely to accompany runoff. This is supported by wet weather water chemistry sampling conducted in other watersheds similar to the Cass River basin (Sunday, 2003). Wet weather sampling conducted in development of the Grand River at Jackson DO TMDL (Sunday, 2003) showed that on average, TP concentrations are significantly higher than orthophosphate concentrations. These data indicate that most phosphorus loads are adsorbed to solids rather than being in a dissolved form. TSS reduction is therefore the best overall strategy to improve DO in the stream.

This DO TMDL targets a 20 percent reduction in land use-related TSS loads to the Cass River in the vicinity of Caro. The 20 percent TSS load reduction was chosen, in part, due to the results of DO modeling, which indicates that plant activity in the reaches of concern should be reduced by approximately 5 to 20 percent, depending on the reach under consideration, in order to achieve the DO standard. The existence of considerable uncertainties, which make it difficult to quantify the effects of TSS loads on in-stream DO levels, make the proposed 20 percent reduction a reasonable objective.

**WLAs**

There are no NPDES point sources in the vicinity of the TMDL reach that contribute TSS loads (other than the statewide MDOT storm water permit). No TSS load reduction is targeted for the statewide MDOT storm water permit, as only a very small fraction of the overall transportation land use in the watershed consists of state-maintained roads, specifically, M-81, alternately called Caro Road. TSS loads from M-81 contribute less than one percent of the total TSS load to the Cass RiverTMDL watershed.

**LAs**

TSS inputs resulting from land use-related sediment loads will be the primary targets for reduction in the Cass River in this TMDL. Table 6 lists the land use source LAs for the Cass River. The target LA values in Table 6 represent 80 percent of the loads of the existing estimated TSS loads contributed by those land uses classified as nonurban (e.g., agriculture, forest, grass/pasture).

Table 6. Daily TSS Load Source Allocations and Numeric Targets.

| Water Body | Current Daily TSS Load (pounds/day) | Daily TSS Load Numeric Target (pounds/day) | NPDES Permitted TSS Load (pounds/day) | WLA Daily TSS Load (pounds/day) | LA Daily TSS Load (pounds/day) | Percent Reduction |
|---|---|---|---|---|---|---|
| Cass River | | | | | | |
| NPDES Sources | 233 | 233 | 233 | 233 | - | 0% |
| NPS Land Use-Related Sources | 35,300 | 28,240 | - | - | 28,240 | 20% |
| Cass River Total Daily Loads | 35,533 | 28,473 | 233 | 233 | 28,240 | 20% |

The LC for TSS (Daily TSS Load Numeric Target) is calculated as the sum of the WLA and LA, and is equal to 28,240 pounds per day.

## MOS

The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can be either implicit (i.e., incorporated into the TMDL analysis through conservative assumptions) or explicit (i.e., expressed in the TMDL as a portion of the loadings). This TMDL uses an implicit MOS due to very conservative assumptions incorporated in DO modeling. Background flows and tributary inflows are represented at the 95 percent exceedance summer low flow as determined by the MDEQ, Land and Water Management Division. The summer 95 percent exceedance flow is a stream flow that would be expected only during periods of severe drought. Stream flows would be expected to be this low for only 5 percent or less of the time during the summer season. R 323.1090 specifies that WQS apply at all flows equal to or exceeding the 12-month 95 percent exceedance low flow. This is the stream flow employed in the modeling of the critical summer season, the very minimum flow at which WQS are to be applied. Similarly, river temperatures are represented at the highest monthly 90 percent occurrence temperature for the summer season as defined in Procedure 80. This temperature would be expected to be exceeded only 10 percent of the time during the summer months. This design temperature is derived from R 323.1075 (temperature of rivers, streams, and impoundments) of the WQS. Such high temperatures result in lower DO saturation concentrations and increased rates of in-stream oxygen utilization. The conservative assumptions regarding stream flow and water temperature are the same as those employed in the determination of water quality-based effluent limits in NPDES WLAs at critical design conditions. A large degree of uncertainty in the DO modeling is also removed as the models used were calibrated to observed data. Modeling indicated that a 5 to 20 percent reduction in plant activity (and therefore TSS load) is required to achieve the DO standard, depending on the reach under consideration. Selecting the upper bound of that range (i.e., 20 percent reduction) introduces additional conservatism to the MOS.

## SEASONALITY

Monitoring and modeling indicates that design conditions occurring during the summer season represents the most critical conditions for DO standard attainment in the Cass River. Modeling of the Cass River in other seasons using appropriate 95 percent exceedance low flows and 90 percent occurrence temperatures shows no predicted instances of DO standard nonattainment.

## MONITORING

Future monitoring will be conducted as resources allow to assess whether activities implemented under the TMDL result in water quality improvements. Typically, the MDEQ, WB monitors watersheds in accordance with the five-year NPDES permit review process. The Cass River may be reevaluated in 2011 when the Cass River basin is next scheduled for monitoring, or when corrective actions have occurred to suggest WQS are being attained. Limited DO monitoring may be conducted in the meantime.

## REASONABLE ASSURANCE ACTIVITIES

A tool that may be beneficial to stakeholders in the Cass River TMDL Watershed is the *Lower Grand River Watershed Project Information and Education Guidebook.* This tool was created under a Clean Water Act Section 319 grant to the Grand Valley Metro Council and was used to motivate stakeholders and decision makers in the watershed to protect water quality. The guidebook includes a summary of activities and products for improving water quality, how to start a successful outreach program, investigating strategy targets, how to make things happen, and how to evaluate the strategy. The following Web site offers helpful information and important links to other groups: http://www.gvsu.edu/wri/isc/lower-grand-river-watershed-management-plan-312.htm.

The Tuscola Conservation District (TCD) offers programs to land owners and county residents to assist in management of local resources. The TCD participates in the Conservation Reserve Enhancement Program, a Groundwater Stewardship Program, and the Sebewaing River Watershed Project. These projects help to improve land and water quality and provide incentives for participation in various programs. In addition, the TCD offers educational programs for area schools and adult education. Additional information is available at the following Web site: http://www.tuscolacd.com/.

Tuscola County administers the Part 91, Soil Erosion and Sedimentation Control Program (SESC), of the NREPA. This program aims to reduce sedimentation in rivers, lakes, and streams by controlling sediments in runoff from construction sites greater than 1 acre, or those located within 500 feet of a water of the state. Temporary (silt fences) and permanent control measures (such as fully vegetated buffer strips) are employed. The MDEQ, WB oversees the counties' programs to ensure that they are effectively enforcing SESC regulations.

The draft TMDL was made available for public comment from May 12 through June 13, 2008. A stakeholder meeting was held on May, 21, 2008, at 1:00 p.m., at the Caro Village Hall in Caro, Michigan. Stakeholders were determined by identifying municipalities (i.e., counties, townships, and cities) in the TMDL watershed. Copies of the draft TMDL were available upon request and posted on the MDEQ's Web site. Copies of the draft TMDL were also available at the stakeholder meeting.

Prepared by: Matt Staron
Surface Water Assessment Section
Water Bureau
Michigan Department of Environmental Quality
July 18, 2008

## REFERENCES


Cooper, Jeff. 2007. Biological Survey of the Cass River Watershed and Selected Tributaries in Saginaw, Tuscola, and Sanilac Counties, Michigan. MDEQ Report #MI/DEQ/WB-07/002.

LeSage, S. and J. Smith. 2008. Water Quality and Pollution Control in Michigan: 2008 Sections 303(d),305(b), and 314 Integrated Report. MDEQ Report #MI/DEQ/WB-08/007.

MDEQ. 1995. Surface Water Quality Assessment Section Procedures Manual, Vol. II. Procedure 80: Guidance on Water Quality-Based Effluent Limit Recommendations for Oxygen Demanding Substances. Water Division, Michigan Department of Environmental Quality.

O'Connor, D.J. and D.M. DiToro. 1970. Photosynthesis and Oxygen Balance in Streams. Journal of the Sanitary Engineering Division, ASCE 96(2): 547-571.

Purdue University and USEPA. 2001. Long-Term Hydrological Impact Assessments (L-THIA) Web site, November 12, 2003. https://engineering.purdue.edu/~lthia/

Staron, Matthew. 2007. Dissolved Oxygen and Water Chemistry Sampling Study on the Cass River, Caro, Tuscola County, Michigan. MDEQ Report #MI/DEQ/WB-07/116.

Sunday, Erik. 2003. Total Maximum Daily Load for Dissolved Oxygen for the Grand River, Jackson County. MDEQ, WB.


.

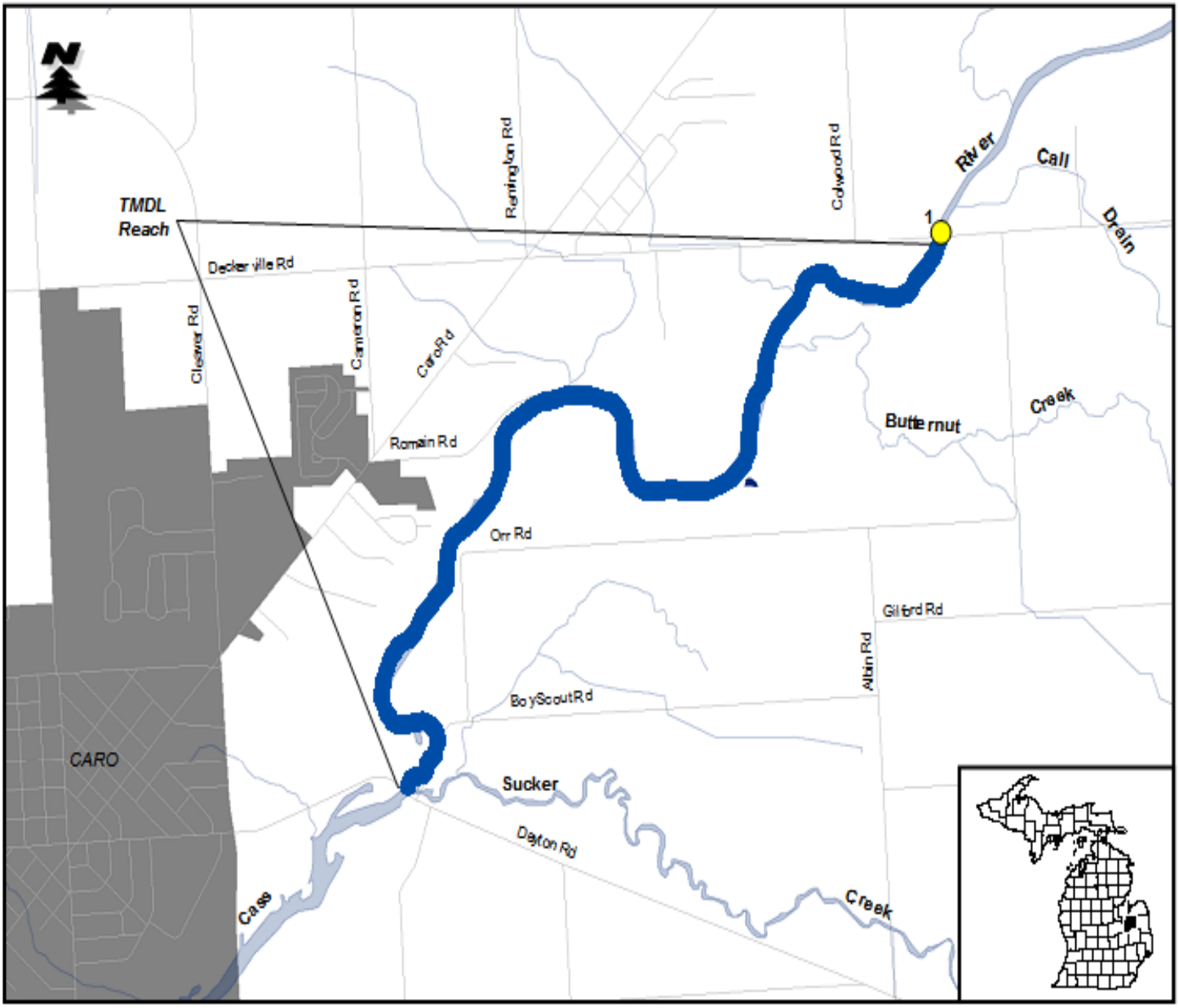


**Figure 1:** Cass River TMDL Reach and Study Sampling Site, Tuscola County, Michigan, 2001.

Appendix A. Short Description of Online L-THIA Model Background GIS Data.

| Layer Name | Type | Source | Description | Format |
|---|---|---|---|---|
| Basic Themes | | | | |
| Roads | All County Roads | TIGER | (In Indiana) roads that can be used to "geocode" a street address, placing it at a specific location on the map. From Census 2000 data set on *link no longer valid, removed 7/3/2017*. | Line |
| Railroads | Railroads | TIGER | Railroads, from Census 2000 dataset on *link no longer valid, removed 7/3/2017*. | Line |
| Streams | Streams | USGS | National Hydrography Database (NHD), medium resolution (originally digitized from 1:100,000 maps) from Census 2000 data on *link no longer valid, removed 7/3/2017*. | Line |
| Lakes_rivers | County Lakes and Rivers | USGS | Polygons from NHD medium resolution from Census 2000 data on *link no longer valid, removed 7/3/2017*. | Polygon |
| Townships | Civil Townships | TIGER | The names and boundaries of the townships in a county. | Polygon |
| Cities_towns | City and Towns | TIGER | Municipal outlines from 2000 census, for census designated places. | Polygon |
| Land Use | Land Use | USGS | 30-m resolution National Land Cover Database (based primarily on Landsat TM 1992 imagery.) | Polygon |
| Highways | Main Highways | TIGER | Statewide major highway network. Created from TIGER data. | Line |
| Rivers | Lakes and Rivers | USGS | Major water features from the NHD or statewide themes from the National Atlas (https://lta.cr.usgs.gov/national_atlas_prod). | Line |
| 8_dig_wtrsheds | Statewide Watersheds | USGS | Statewide 8-digit Hydrologic Unit Code watersheds. | Polygon |
| Counties | Counties | TIGER | Names and extents of all counties. | Polygon |
| Orthophotos | Orthophotos | USGS/ Natural Resources Conservation Service (NRCS) | (In Indiana) 1-m resolution photos by quarter of a 7.5 minute quad, from around 1998, compressed with MrSID then resampled into 2 meter .tif images. | Image (.sid) |
| Topomaps | Topographic Map Images | USGS | (In Indiana) scanned, rectified image of a USGS 7.5 minute (1:24,000 scale) topographic map. Provided by NRCS. | Image (.tif) |
| Ned_dem | Digital Elevation Model (DEM) (Elevation) | USGS | 30-m resolution National Elevation Data. | Grid |
| Stream or flow from DEM | Flowpath | Calculated | These lines represent calculated overland flow path and NOT an actual stream. | |