East Fork La Moine River Watershed (II) Total Maximum Daily Load

DRAFT Stage 1 Report

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Acronyms and Abbreviations

AFO	animal feeding operation
AWQMN	Ambient Water Quality Monitoring Network
BOD	biochemical oxygen demand
CAFO	confined animal feeding operation
CWA	Clean Water Act
DO	dissolved oxygen
IEPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
MGD	millions of gallons per day
MS4	municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
SOD	sediment oxygen demand
STP	sewage treatment plant
TKN	total Kjeldahl nitrogen
TMDL	total maximum daily load
TSS	total suspended solids
U.S. EPA	United States Environmental Protection Agency
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WQS	water quality standards
WWTP	wastewater treatment plant

1. Introduction

The Clean Water Act and U.S. Environmental Protection Agency (U.S. EPA) regulations require that Total Maximum Daily Loads (TMDLs) be developed for waters that do not support their designated uses. In simple terms, a TMDL is a plan to attain and maintain water quality standards in waters that are not currently meeting standards. This TMDL study addresses the 223-square mile East Fork La Moine River watershed located in west central Illinois (Figure 1). Several waters in the East Fork La Moine River watershed have been placed on the State of Illinois 303(d) list and require the development of a TMDL. Two previous TMDL studies have been completed in the watershed: the Upper La Moine River Watershed TMDL Final Stage 1 Report (IEPA 2017) and the East Fork La Moine River Watershed TMDL Report (IEPA 2007). Relevant information from the more recent Upper La Moine River watershed report is included herein where applicable.

The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also includes a margin of safety, which reflects uncertainty as well as the effects of seasonal variation. By following the TMDL process, states can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (U.S. EPA 1991). The Illinois EPA will be working with stakeholders to implement the necessary controls to improve water quality in the impaired waterbodies and meet water quality standards. The controls for nonpoint sources (e.g., agriculture) will be strictly voluntary.

1.1 Water Quality Impairments

This project addresses two impaired segments along the East Fork La Moine River on the State of Illinois §303(d) list (Table 1 and Figure 1). Drowning Fork (DGLC-01) is also included on the §303(d) list; however, total phosphorus, sedimentation/siltation, and total suspended solids are not being addressed as part of this project because Illinois does not have applicable numeric standards for these pollutants.

Table 1. East Fork La Moine River watershed impairments and pollutants (2016 Illinois 303(d) Draft List)

Name	Segment ID	Segment Length (Miles)	Watershed Area (Sq. Miles)	Designated Uses	Cause of Impairment
East Fork La Moine River	IL_DGL-05	22.27	83	Aquatic Life	**Dissolved Oxygen**
	IL_DGL-08	4.48	145	Aquatic Life	**Dissolved Oxygen**
Drowning Fork	IL_DGLC-01	18.83	55	Aquatic Life	Phosphorus (Total) [a], Sedimentation/Siltation [a], Total Suspended Solids (TSS) [a]

a. These causes of impairment are not being addressed as part of this project.
BOLD – TMDLs are addressed in this Stage 1 report

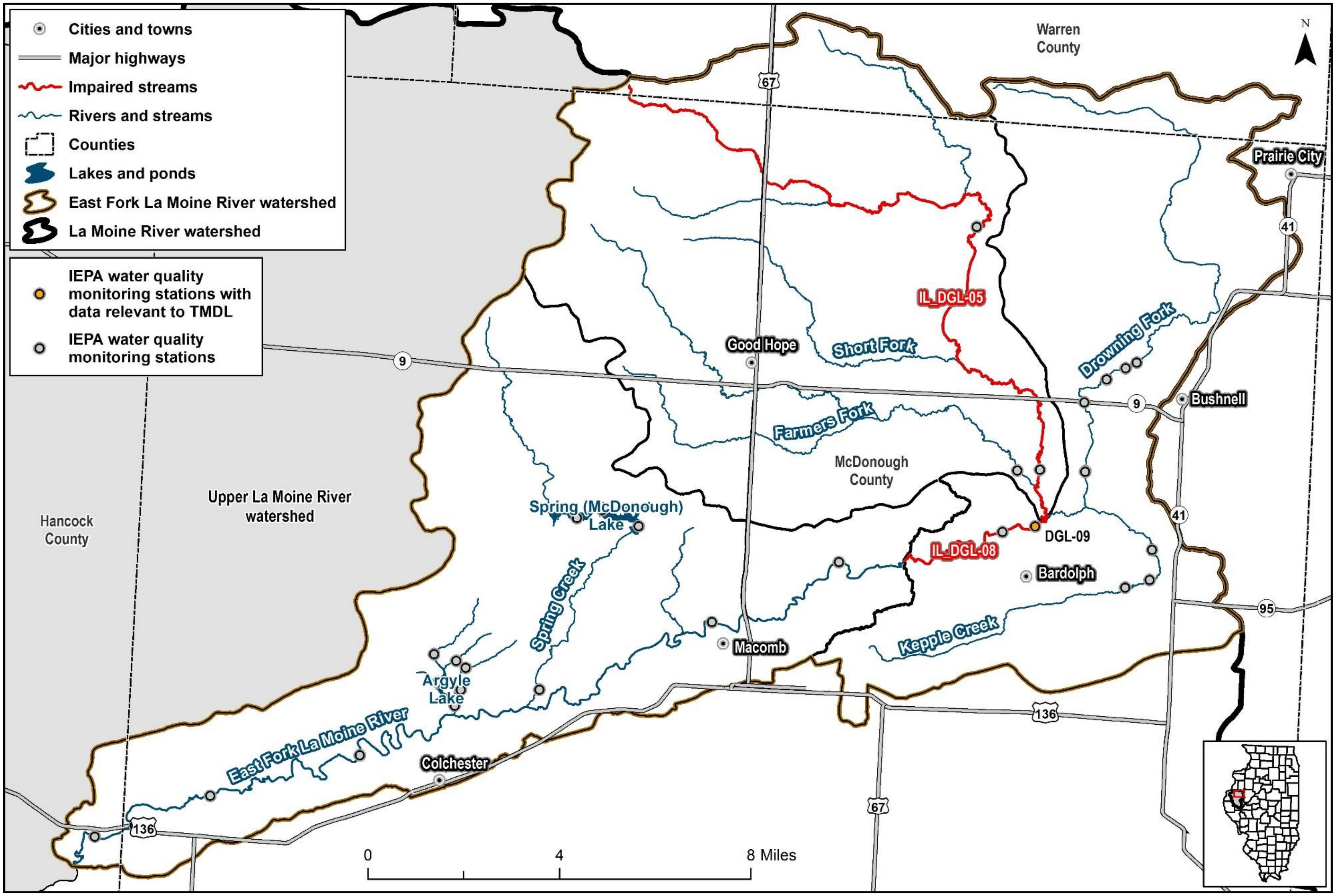

Figure 1. East Fork La Moine River, TMDL project area.
Monitoring stations on impaired waterbodies with water quality data used in impairment assessment are labeled.

1.2 TMDL Endpoints

This section presents information on the water quality standards (WQS) that are used for TMDL endpoints. WQS are designed to protect beneficial uses. The authority to designate beneficial uses and adopt WQS is granted through Title 35 of the Illinois Administrative Code. Designated uses to be protected in surface waters of the state are defined under Section 303, and WQS are designated under Section 302 (Water Quality Standards). Designated uses and WQS are discussed below.

1.2.1 Designated Uses

Illinois EPA uses rules and regulations adopted by the Illinois Pollution Control Board (IPCB) to assess the designated use support for Illinois waterbodies. The following are the use support designations provided by the IPCB that apply to waterbodies in the East Fork La Moine River watershed:

General Use Standards—These standards protect aquatic life, wildlife, agricultural uses, primary contact (where physical configuration of the waterbody permits it, any recreational or other water use in which there is prolonged and intimate contact with the water involving considerable risk of ingesting water in quantities sufficient to pose a significant health hazard, such as swimming and water skiing), secondary contact (any recreational or other water use in which contact with the water is either incidental or accidental and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, commercial and recreational boating, and any limited contact incident to shoreline activity), and most industrial uses. These standards are also designed to ensure the aesthetic quality of the state's aquatic environment.

1.2.2 Water Quality Standards and TMDL Endpoints

Environmental regulations for the State of Illinois are contained in the Illinois Administrative Code, Title 35. Specifically, Title 35, Part 302 contains water quality standards promulgated by the IPCB. This section presents the standards applicable to impairments in the watershed. Water quality standards are the endpoints to be used for TMDL development (Table 2).

Table 2. Summary of water quality standards for the Lower Kaskaskia River watershed

Parameter	Units	Water Quality Standard
Dissolved Oxygen [a]	mg/L	March–July > 5.0 min. and > 6.0 7-day mean Aug–Feb > 3.5 min, > 4.0 7-day mean, and > 5.5 30-day mean

a. Applies to the dissolved oxygen concentration in the main body of all streams, in the water above the thermocline of thermally stratified lakes and reservoirs, and in the entire water column of unstratified lakes and reservoirs.

Aquatic life use assessments in streams are typically based on the interpretation of biological information, physicochemical water data, and physical-habitat information from the Intensive Basin Survey, Ambient Water Quality Monitoring Network, or Facility-Related Stream Survey programs. The primary biological measures used are the fish Index of Biotic Integrity (Karr et al. 1986; Smogor 2000, 2005), the macroinvertebrate Index of Biotic Integrity (Tetra Tech 2004), and the Macroinvertebrate Biotic Index (IEPA 1994). Physical habitat information used in assessments includes quantitative or qualitative measures of stream bottom composition and qualitative descriptors of channel and riparian conditions. Physicochemical water data used include measures of conventional parameters (e.g., dissolved oxygen, pH, and temperature), priority pollutants, non-priority pollutants, and other pollutants (U.S. EPA 2002). In a minority of streams for which biological information is unavailable, aquatic life use assessments are based primarily on physicochemical water data.

When a stream segment is determined to be not supporting aquatic life use, generally one exceedance of an applicable Illinois water quality standard (related to the protection of aquatic life) results in identifying the parameter as a potential cause of impairment. Additional guidelines used to determine potential causes of impairment include site-specific standards (35 Ill. Adm. Code 303, Subpart C) or adjusted standards (published in the IPCB's Environmental Register at https://pcb.illinois.gov/Resources/EnvironmentalRegister).

2. Watershed Characterization

The East Fork La Moine River watershed is located in west central Illinois (Figure 1). The headwaters of the watershed are north of Bushnell and Good Hope, IL, and the downstream end of the watershed is at the confluence of the East Fork and Upper La Moine rivers and the start of the La Moine River. The Upper La Moine River Watershed TMDL Final Stage 1 report was recently developed for the Upper La Moine River watershed, and the project area includes the East Fork La Moine River watershed (IEPA 2017, https://www2.illinois.gov/epa/Documents/iepa/water-quality/watershed-management/tmdls/reports/upper-la-moine-river/upper-la-moine-stage-1-combined.pdf). Much of the information presented in the report is applicable to the current TMDL project. There have been no known changes in the project area; therefore, the existing Upper La Moine River watershed report provides much of the basis for the watershed characterization and source assessment below.

2.1 Jurisdictions and Population

Relevant information on jurisdictions and population can be found in the Upper La Moine River Watershed TMDL Final Stage 1 report (IEPA 2017). The project area is located in Hancock, McDonough, and Warren counties. The city of Macomb is the largest urban area in the watershed.

2.2 Climate

In general, the climate of the region is continental with hot, humid summers and cold winters. Relevant information on climate can be found in the Upper La Moine River Watershed TMDL Final Stage 1 report (IEPA 2017).

2.3 Land Use and Land Cover

Relevant information on land use and land cover can be found in the Upper La Moine River Watershed TMDL Final Stage 1 report (IEPA 2017). Cultivated crops make up the majority of the land cover in the East Fork La Moine River watershed. There are several small cities and towns in the watershed, with much of the development located in the city of Macomb.

2.4 Topography

Relevant information on topography can be found in the Upper La Moine River Watershed TMDL Final Stage 1 report (IEPA 2017).

2.5 Soils

Relevant information on soils can be found in the Upper La Moine River Watershed TMDL Final Stage 1 report (IEPA 2017). Soils are primarily a mixture of silt loam with moderate infiltration rates when thoroughly wetted and silty clay loams with low infiltration rates when thoroughly wetted.

2.6 Hydrology

Relevant information on hydrologic conditions can be found in the Upper La Moine River Watershed TMDL Final Stage 1 report (IEPA 2017). There are no active U.S. Geological Survey (USGS) flow gage sites in the watershed.

2.7 Watershed Studies and Information

This section describes several of the studies that have been completed in the watershed:

- **The La Moine River Basin: An Inventory of the Region's Resources** (IDNR 2005)

  This report includes an inventory of physical and biological resources in the La Moine River basin. Information on the history of the area as well as landforms, land cover and natural areas, and wildlife is discussed.

- **East Fork La Moine River Watershed TMDL Report** (IEPA 2007) (https://www2.illinois.gov/epa/Documents/epa.state.il.us/water/tmdl/report/lamoine-east-fork/lamoine-east-final-tmdl.pdf)

  The completed East Fork La Moine River TMDL Report contains TMDL allocations for the East Fork La Moine River (manganese impairment) and Argyle and Spring (McDonough) lakes (total phosphorus impairments). The report was completed over ten years ago and new information in the Upper La Moine River Watershed TMDL Final Stage 1 report is considered more applicable for this TMDL.

- **Upper La Moine River Watershed TMDL Final Stage 1 Report** (IEPA 2017) (https://www2.illinois.gov/epa/Documents/iepa/water-quality/watershed-management/tmdls/reports/upper-la-moine-river/upper-la-moine-stage-1-combined.pdf)

  The completed Upper La Moine River watershed report contains relevant information and data for this TMDL. Causes of impairments included ammonia (total), chloride, dissolved oxygen, manganese and total phosphorus.

A detailed summary of recent watershed studies and additional relevant information for this section can be found in the Upper La Moine River Watershed TMDL Final Stage 1 Report (IEPA 2017).

3. Watershed Source Assessment

Source assessments are an important component of water quality management plans and TMDL development. This section provides a summary of potential sources that contribute to dissolved oxygen impairments along the East Fork La Moine River.

3.1 Pollutants of Concern

Pollutants of concern evaluated in this source assessment include parameters influencing dissolved oxygen. Dissolved oxygen in streams can be affected by biochemical oxygen demand, phosphorus, ammonia, and sediment oxygen demand in addition to non-pollutant causes such as lack of reaeration. These pollutants can originate from an array of sources including point and nonpoint sources. Eutrophication (high levels of algae) is also often linked directly to low dissolved oxygen conditions, and therefore nutrients are also a pollutant of concern. Point sources typically discharge at a specific location from pipes, outfalls, and conveyance channels. Nonpoint sources are diffuse sources that have multiple routes of entry into surface waters, particularly overland runoff. This section provides a summary of potential point and nonpoint sources that contribute to the impaired waterbodies.

3.2 Point Sources

Point source pollution is defined by the Federal Clean Water Act (CWA) §502(14) as:

> ...any discernible, confined and discrete conveyance, including any ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation (CAFO), or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agriculture storm water discharges and return flow from irrigated agriculture.

Under the CWA, all point sources are regulated under the National Pollutant Discharge Elimination System (NPDES) program. A municipality, industry, or operation must apply for an NPDES permit if an activity at that facility discharges wastewater to surface water. Point sources can include facilities such as municipal wastewater treatment plants (WWTPs), industrial facilities, CAFOs, or regulated stormwater including municipal separate storm sewer systems (MS4s). There are no CAFOs or regulated MS4s in the East Fork La Moine River watershed.

NPDES facilities in the study area include municipal wastewater treatment plants. Nutrients and oxygen-demanding substances can be found in these discharges and may contribute to low dissolved oxygen impairments. There are three individual NPDES permitted facilities in the East Fork La Moine River watershed (Table 3). Average and maximum design flows and downstream impairments are included in the facility summaries. Bardolph STP (ILG580020) drains to a small tributary of DLG-08 and may be contributing to impairment because of close proximity to the impaired reach. Bushnell West STP (IL0024384) drains to Drowning Fork (DGLC-01), which is listed as impaired for total phosphorus. The remaining facility, Good Hope STP (ILG580194), drains to an unimpaired upstream tributary of DGL-05 and is not likely contributing to impairment. All three facilities have existing dissolved oxygen permit limits that meet the general use water quality standard.

Table 3. Individual NPDES permitted facilities in impairment watersheds

IL Permit ID	Facility Name	Type of Discharge	Receiving Water	Downstream Impairment(s)	Average Design Flow (MGD)	Maximum Design Flow (MGD)
IL0024384	*Bushnell West STP*	*STP*	*Drowning Fork*	*DGL-08*	*0.25*	*0.625*
ILG580020	**Bardolph STP [a]**	**STP**	**Unnamed tributary of East Fork La Moine River**	**DGL-08**	**0.07**	**0.175**
ILG580194	*Good Hope STP*	*STP*	*Town Fork*	*DGL-05, DGL-08*	*0.057*	*0.075*

Italics – NPDES facility draining to unimpaired segment.
BOLD – NPDES facility draining to impaired segment.
MGD – Million gallons per day
STP – Sewage treatment plant
a. Although Bardolph STP does not discharge directly to an impaired segment, the facility discharges to a small tributary of DGL-08 and could be contributing to impairment.

3.3 Nonpoint Sources

The term nonpoint source pollution is defined as any source of pollution that does not meet the legal definition of point sources. Nonpoint source pollution typically results from overland stormwater runoff that is diffuse in origin, as well as background conditions. It should be noted that stormwater collected and conveyed through a regulated MS4 is considered a controllable point source. As part of the water resource assessment process, Illinois EPA was not able to identify specific sources contributing to dissolved oxygen impairments (Table 4).

Table 4. Potential sources in project area based on the draft 2016 305(b) list

Watershed	Segment	Sources
East Fork La Moine River	IL_DGL-05	Source unknown
	IL_DGL-08	Source unknown

Nonpoint sources potentially contributing to low dissolved oxygen conditions include stormwater and agricultural runoff, onsite wastewater treatment systems, animal agriculture activities, and sediment oxygen demand. Typical pollutants of concern include phosphorus (leading to eutrophication), ammonia, and carbonaceous biochemical oxygen demand. Sediment oxygen demand, often a result of decaying organic matter, can significantly contribute to low dissolved oxygen conditions. Channelization and hydrologic modification are non-pollutant sources. Channelization can result in low dissolved oxygen conditions due to lack of in-stream structures that would reaerate the water column.

3.3.1 Animal Feeding Operations (AFOs)

Animal feeding operations that are not classified as CAFOs are known as animal feeding operations (AFOs) in Illinois. Non-CAFO AFOs are considered nonpoint sources by U.S. EPA. AFOs in Illinois do not have state permits. However, they are subject to state livestock waste regulations and may be inspected by the Illinois EPA, either in response to complaints or as part of the agency's field inspection responsibilities to determine compliance by facilities subject to water pollution and livestock waste regulations. The animals raised in AFOs produce manure that is stored in pits, lagoons, tanks, and other storage devices. The manure is then applied to area fields as fertilizer. When stored and applied properly, this beneficial re-use of manure provides a natural source for crop nutrition. It also lessens the need for fuel and other natural resources that are used in the production of fertilizer. AFOs, however, can pose environmental concerns, including the following:

- Manure can leak or spill from storage pits, lagoons, tanks, etc.
- Improper application of manure can contaminate surface or ground water.
- Manure over application can adversely impact soil productivity.

Livestock are potential sources of nutrients to streams, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas. Watershed specific data are not available for livestock populations.

2012 Census of Agriculture animal population estimates and additional relevant information for this section can be found in the Upper La Moine River Watershed TMDL Final Stage 1 Report (IEPA 2017).

3.3.2 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems (e.g., septic systems) that are properly designed and maintained should not serve as a source of contamination to surface waters. However, onsite systems do fail for a variety of reasons. Common soil-type limitations that contribute to failure include seasonally high water tables, compact glacial till, bedrock, and fragipan. When these septic systems fail hydraulically (surface breakouts) or hydrogeologically (inadequate soil filtration) there can be adverse effects to surface waters (Horsley and Witten, Inc. 1996). Septic systems contain all the water discharged from homes and business and can be significant sources of pollutants. County health departments were contacted for information on septic systems and unsewered communities. A response was received from McDonough County. The county estimates that 50 percent of installed systems in the county have been inspected. The county does not have a total count of installed systems or unsewered communities and could not provide information on failure rates or results of compliance testing.

Additional relevant information for this section can be found in the Upper La Moine River Watershed TMDL Final Stage 1 Report (IEPA 2017).

3.3.3 Stormwater and Agricultural Runoff

During wet-weather events (snowmelt and rainfall), pollutants are incorporated into runoff and can be delivered to downstream waterbodies. The resultant pollutant loads are linked to the land uses and practices in the watershed. Agricultural and developed areas can have significant effects on water quality if proper best management practices are not in place.

In addition to pollutants, alterations to a watershed's hydrology as a result of land use changes, ditching, and stream channelization can detrimentally affect habitat and biological health. Imperviousness associated with developed land uses and agricultural field tiling can result in increased peak flows and runoff volumes and decreased base flow as a result of reduced ground water discharge. Drain tiles also transport agricultural runoff directly to ditches and streams, whereas runoff flowing over the land surface may infiltrate to the subsurface and may flow through riparian areas.

4. Water Quality

An important step in the TMDL development process is the review of water quality conditions, particularly data and information used to list segments. Examination of water quality monitoring data is a key part of defining the problem that the TMDL is intended to address.

Background information on water quality monitoring can be found in the recently completed Upper La Moine River Watershed TMDL Final Stage 1 Report (IEPA 2017). In the East Fork La Moine River watershed, water quality data are available that are a part of the Illinois EPA Ambient Water Quality Monitoring Network (AWQMN). Parameters sampled in the streams include field measurements (e.g., dissolved oxygen) as well as those that require lab analyses (e.g., nutrients).

The most recent 10 years of data collection, 2007–2016, were used to evaluate impairment status for East Fork La Moine River segments DGL-05 and DGL-08. Each data point was reviewed to ensure the use of quality data in the analysis below. Data were obtained directly from Illinois EPA.

The East Fork La Moine River is listed as impaired along two segments—DGL-05 and DGL-08. Both segments are impaired for aquatic life due to low dissolved oxygen. Sample site DGL-09 is the only Illinois EPA sampling site with relevant data on DGL-08. There are no data available for DGL-05. Continuous monitoring data were collected on segment DGL-08 in 2012 and 2017. Dissolved oxygen in July 2012 violated the standard, and the dissolved oxygen impairment on DGL-08 is confirmed (Figure 2). Additional data collection is recommended to confirm impairment along DGL-05.

As described above, there are three NPDES-permitted facilities in the watershed, two that are likely contributing to the impairment on DLG-08 (see Table 1). Dissolved oxygen data were paired with phosphorus data and chlorophyll-*a* data along DGL-08 to determine if eutrophication is potentially contributing to low dissolved oxygen conditions. Phosphorus versus dissolved oxygen data collected from 2007 and 2012 do not indicate a negative correlation (Figure 3); however, the data are too limited to draw conclusions. Chlorophyll-*a* versus dissolved oxygen data from 2007 and 2012 do not show a correlation (Figure 4).

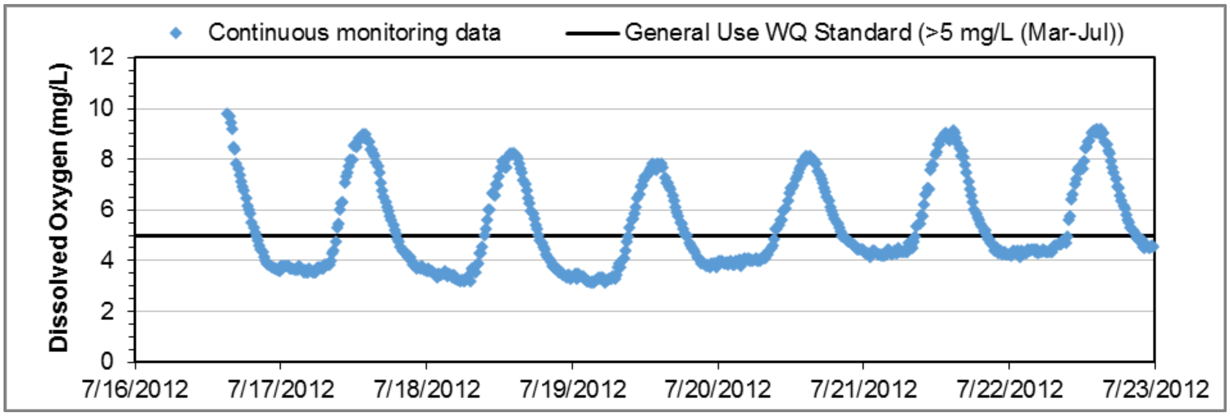

Figure 2. Continuous dissolved oxygen time series, East Fork La Moine River DGL-08 (site DGL-09).

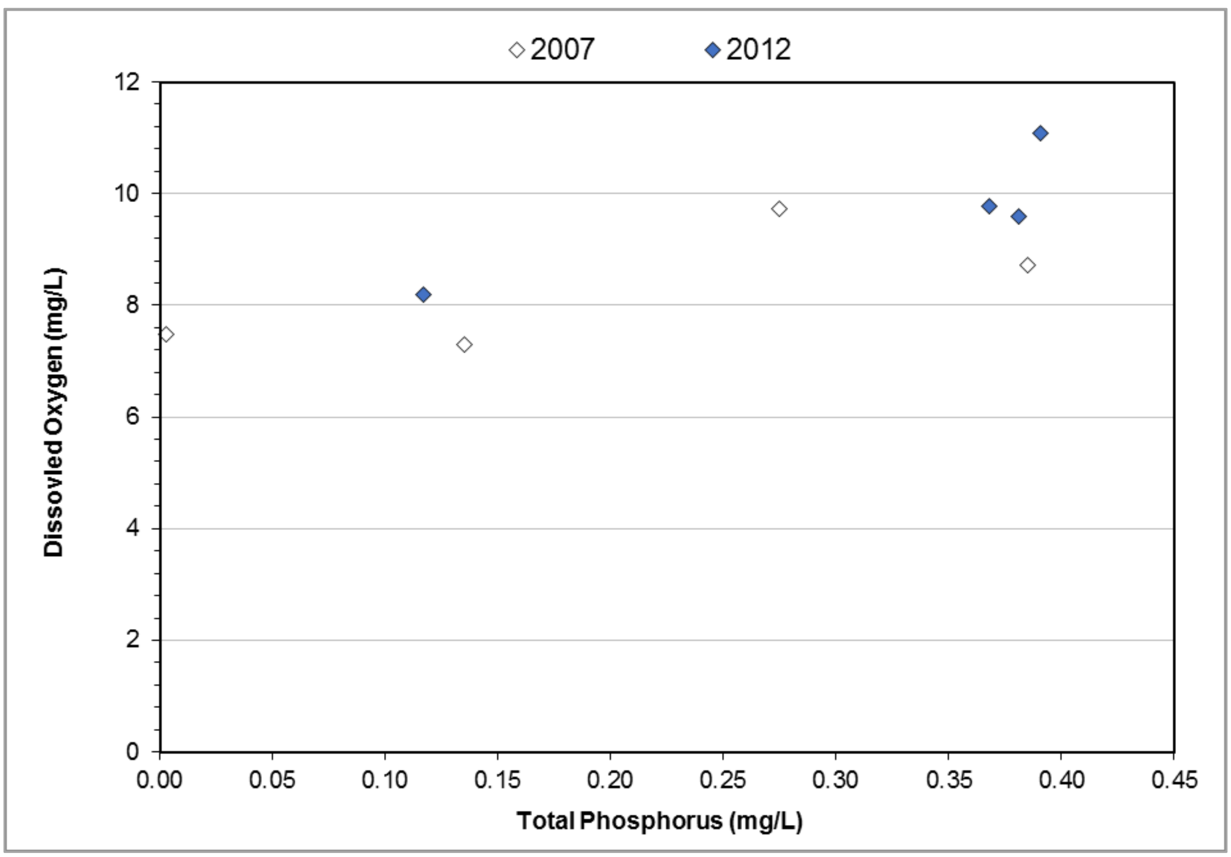

Figure 3. Total phosphorus versus dissolved oxygen, 2007 and 2012, East Fork La Moine River, DGL-08 segment.

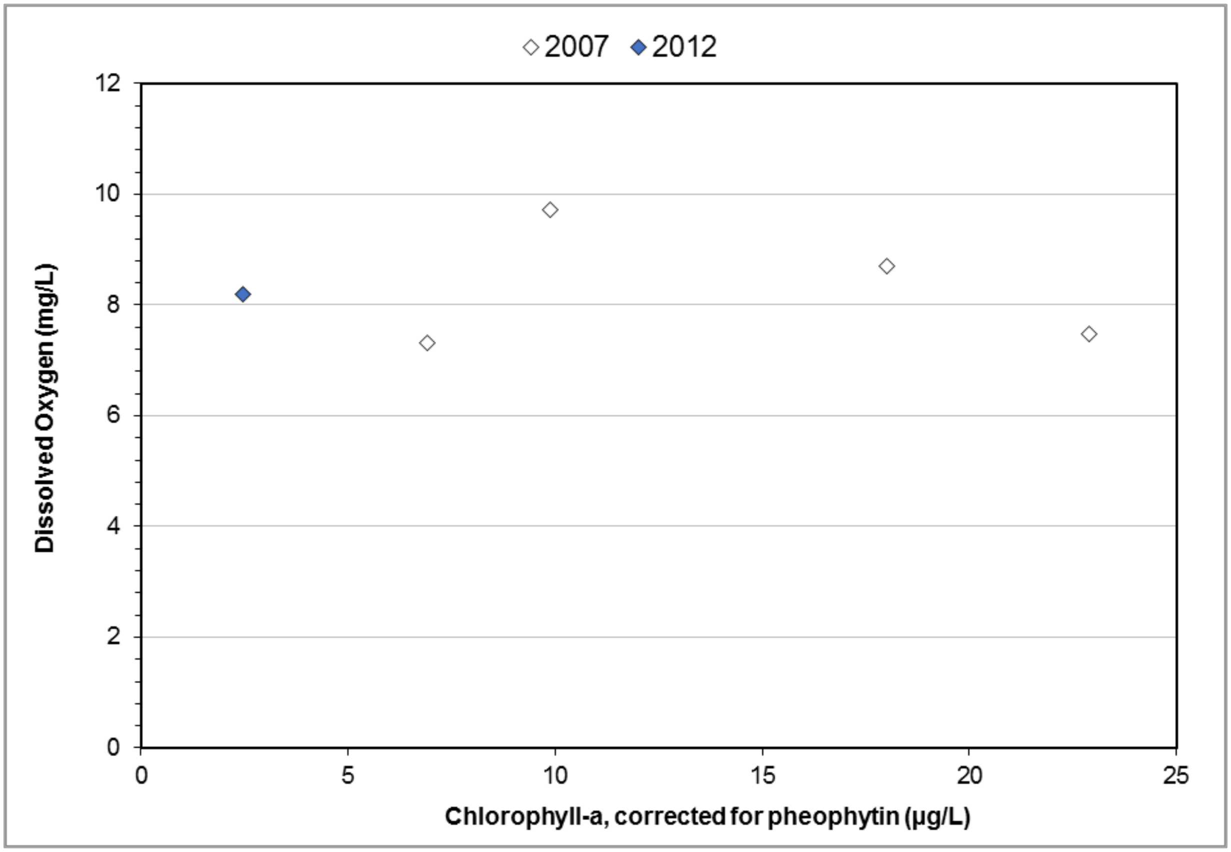

Figure 4. Chlorophyll-*a* versus dissolved oxygen, 2007 and 2012, East Fork La Moine River, DGL-08 segment.

5. TMDL Methods and Data Needs

The first stage of this project is an assessment of available data, followed by evaluation of their credibility. The types of data available, their quantity and quality, and their spatial and temporal coverage relative to impaired segments or watersheds drive the approaches used for TMDL model selection and analysis. Credible data are those that meet specified levels of data quality, with acceptance criteria defined by measurement quality objectives, specifically their precision, accuracy, bias, representativeness, completeness, and reliability. The following sections describe the methods that are proposed to derive TMDLs and the additional data needed to develop credible TMDLs.

TMDLs are proposed for segments with verified impairments and known pollutants (Table 5). The Qual2K model is proposed to evaluate the confirmed low dissolved oxygen impairments where point sources are present (DLG-08). If point sources are not present, as is the case for DLG-05, and if there is a correlation with eutrophication (i.e., phosphorus concentration or high levels of algae and/or plant growth), a duration curve approach is suggested to develop a phosphorus TMDL. The phosphorus target will be derived from the relationship between phosphorus and dissolved oxygen in the impaired stream. TMDLs are not proposed for dissolved oxygen impairments that are not affected by point sources and do not show a correlation with eutrophication. In these cases, it is assumed that the cause of impairment is non-pollutant based (e.g., the effect of lack of re-aeration in low-gradient streams or the effect of hydromodification).

Table 5. Proposed model summary

Name	Segment ID	Designated Uses	TMDL Parameter(s)	Proposed Model	Proposed Pollutant
East Fork La Moine River	IL_DGL-05	Aquatic Life	Dissolved Oxygen	Load duration curve or 4C classification	Phosphorus or non-pollutant
	IL_DGL-08	Aquatic Life	Dissolved Oxygen	Qual2K	Biochemical oxygen demand, ammonia, total phosphorus

5.1 Load Duration Curve Approach

The primary benefit of duration curves in TMDL development is to provide insight regarding patterns associated with hydrology and water quality concerns. The duration curve approach is particularly applicable because water quality is often a function of stream flow. For instance, sediment concentrations typically increase with rising flows as a result of factors such as channel scour from higher velocities. Other parameters, such as chloride, may be more concentrated at low flows and more diluted by increased water volumes at higher flows. The use of duration curves in water quality assessment creates a framework that enables data to be characterized by flow conditions. The method provides a visual display of the relationship between stream flow and water quality.

Allowable pollutant loads have been determined through the use of load duration curves. Discussions of load duration curves are presented in *An Approach for Using Load Duration Curves in the Development of TMDLs* (U.S. EPA 2007). 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 (in cubic feet per second) by the water quality standard/target for a contaminant (mg/L), then multiplying by conversion factors to yield results in the proper unit (i.e., pounds per day). The resulting points are plotted to create a load duration curve.

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 load duration curve.

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 exceedances at the right side of the graph occur during low flow conditions, and may be derived from sources such as illicit sewer connections. Exceedances on the left side of the graph occur during higher flow events, and may be

derived from sources such as runoff. Using the load duration curve approach allows Illinois EPA to determine which implementation practices are most effective for reducing loads on the basis of flow regime.

Water quality duration curves are created using the same steps as those used for load duration curves except that concentrations, rather than loads, are plotted on the vertical axis. Flows are categorized into the following five hydrologic zones (U.S. EPA 2007):

- 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

The duration curve approach helps to identify the issues surrounding the impairment and to roughly differentiate among sources. Table 6 summarizes the general relationship among the five hydrologic zones and potentially contributing source areas (the table is not specific to an individual pollutant). For example, the table indicates that impacts from point sources are usually most pronounced during dry and low flow zones because there is less water in the stream to dilute their loads. In contrast, impacts from stormwater are most pronounced during moist and high flow zones due to increased overland flow from stormwater source areas during rainfall events.

Table 6. Relationship between 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
Stormwater: Impervious		H	H	H	
Stormwater: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	

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

The load reduction approach also considers critical conditions and seasonal variation in the TMDL development as required by the Clean Water Act and U.S. EPA's implementing regulations. Because the approach establishes loads on the basis of a representative flow regime, it inherently considers seasonal variations and critical conditions attributed to flow conditions. An underlying premise of the duration curve approach is correlation of water quality impairments to flow conditions. The duration curve alone does not consider specific fate and transport mechanisms, which may vary depending on watershed or pollutant characteristics.

5.2 Qual2K

Qual2K is a steady-state water quality model that simulates eutrophication kinetics and conventional water quality parameters and is maintained by U.S. EPA. Qual2K simulates up to 15 water quality constituents in branching stream systems. A stream reach is divided into a number of computational elements, and for each computational element, a hydrologic balance in terms of stream flow (e.g., m^3/s), a heat balance in terms of temperature (e.g., degrees C), and a material balance in terms of concentration (e.g., mg/l) are written. Both advective and dispersive transport processes are considered in the material balance. Mass is gained or lost from the computational element by transport processes, wastewater discharges, and withdrawals. Mass can also be gained or lost by internal processes such as release of mass from benthic sources or biological transformations.

The program simulates changes in flow conditions along the stream by computing a series of steady-state water surface profiles. The calculated stream-flow rate, velocity, cross-sectional area, and water depth serve as a basis for determining the heat and mass fluxes into and out of each computational element due to flow. Mass balance determines the concentrations of constituents at each computational element. In addition to material fluxes, major processes included in the mass balance are transformation of nutrients, algal production, benthic and carbonaceous demand, atmospheric reaeration, and the effect of these processes on the dissolved oxygen balance. The nitrogen cycle is divided into four compartments: organic nitrogen, ammonia nitrogen, nitrite nitrogen, and nitrate nitrogen. The primary internal sink of dissolved oxygen in the model is biochemical oxygen demand (BOD). The major sources of dissolved oxygen are algal photosynthesis and atmospheric reaeration.

The model is applicable to dendritic streams that are well mixed. It assumes that the major transport mechanisms, advection and dispersion, are significant only along the main direction of flow (the longitudinal axis of the stream or canal). It allows for multiple waste discharges, withdrawals, tributary flows, and incremental inflow and outflow.

Hydraulically, Qual2K is limited to the simulation of time periods during which both the stream flow in river basins and input waste loads are essentially constant. Qual2K can operate as either a steady-state or a quasi-dynamic model, making it a very helpful water quality planning tool. When operated as a steady-state model, it can be used to study the impact of waste loads (magnitude, quality, and location) on instream water quality. By operating the model dynamically, the user can study the effects of diurnal variations in meteorological data on water quality (primarily dissolved oxygen and temperature) and also can study diurnal dissolved oxygen variations due to algal growth and respiration. However, the effects of dynamic forcing functions, such as headwater flows or point loads, cannot be modeled in Qual2K. A steady-state model is proposed.

Qual2K is an appropriate choice for certain types of dissolved oxygen and organic enrichment TMDLs that can be implemented at a moderate level of effort. Use of the Qual2K models in TMDLs is most appropriate when (1) full vertical mixing can be assumed, and (2) water quality excursions are associated with identifiable critical flow conditions. Because these models do not simulate dynamically varying flows, their use is limited to evaluating responses to one or more specific flow conditions. The selected flow condition should reflect critical conditions, which for dissolved oxygen occurs when flows are low and the ambient air temperature is warm, typically in July or August.

5.3 Additional Data Needs

Data satisfy two key objectives for Illinois EPA, enabling the agency to make informed decisions about the resource. These objectives include developing information necessary to:

- Determine if the impaired areas are meeting applicable water quality standards for their respective designated use(s)
- Support modeling and assessment activities required to allocate pollutant loadings for all impaired areas where water quality standards are not being met

Additional data may be needed to understand probable sources, calculate reductions, develop calibrated water quality models, and develop effective implementation plans. Table 7 summarizes the additional data needed for each impaired segment.

Table 7. Additional data needs

Name	Segment ID	Designated Uses	TMDL Parameters	Additional Data Needs
East Fork La Moine River	IL_DGL-05	Aquatic Life	Dissolved Oxygen	To confirm impairment and to determine relationship with eutrophication
	IL_DGL-08	Aquatic Life	Dissolved Oxygen	To support Qual2K model
All	All	All	All	Implementation plan development

Specific data needs include:

Confirm Impairment and Determine Relationship with Eutrophication on IL_DGL-05—Collect DO, chlorophyll-*a*, and TP grab samples at station DGL-05 or DGL-10; two samples per day (one per day in the early morning) on three separate sampling days, during the warm summer months (July–August) and during low flows.

Support Qual2K Model Development on East Fork La Moine River IL_DGL-08—Three monitoring stations are needed. Ideally, there would be two separate data collection periods, each time period lasting roughly one week during critical conditions (low flow, warm conditions). Although the three monitoring stations are a minimum, adding more locations along the reach of interest will help determine how heterogeneous the system is and what dynamics are occurring along the reach. Monitoring stations can be located downstream of key tributaries, at road crossings, etc. as deemed necessary.

Recommended monitoring includes:

- Site DGL-09 and a new site on East Fork La Moine River where it crosses E. 1600th Street:
  - Continuous dissolved oxygen, stream temperature, conductivity, and pH monitoring during a warm, low flow period in July; monitoring should take place over approximately two weeks.
  - Multiple samples of organic nitrogen, ammonia nitrogen, nitrate nitrogen, total Kjeldahl nitrogen (TKN), organic phosphorus, soluble reactive phosphorus, total inorganic carbon, total organic carbon, carbonaceous biochemical oxygen demand (5-day and 20-day if possible), inorganic solids, chlorophyll-*a*, and alkalinity. Depending on the monitoring station, grab samples could be collected twice per day during the first and last days of sonde deployment or throughout the week.
  - Macrophyte and attached algae survey, survey of groundwater and tributary contributions (in addition to the tributary listed below), if any.
  - Survey of channel substrate and bottom material.
- Site on the tributary that enters the impaired segment from the south, where it crosses N 1450th Street):
  - Continuous dissolved oxygen, stream temperature, conductivity, and pH monitoring during the same period as data collected on the main stem sites.
  - Multiple samples of organic nitrogen, ammonia nitrogen, nitrate nitrogen, TKN, organic phosphorus, soluble reactive phosphorus, total inorganic carbon, total organic carbon, carbonaceous biochemical oxygen demand (5-day and 20-day if possible), inorganic solids, chlorophyll-*a*, and alkalinity. Depending on the monitoring station, grab samples could be collected twice per day during the first and last days of sonde deployment or throughout the week.

- A longitudinal/synoptic survey of dissolved oxygen (DO) concentrations along the entire reach.
- Funding permitted: *in-situ* measurements of stream reaeration (via diffusion dome technique) and in-situ measurements of sediment oxygen demand (via chambers deployed on the streambed). Sediment bed surveys can be conducted potentially in lieu of sediment oxygen demand (SOD) sampling (sediment total organic carbon sampling for instance could be a rough proxy for SOD if needed). In lieu of *in-situ* measurements, literature values may be used.
- Photo documentation of the system.

Implementation Plan Development—Further in-field assessment may be needed to better determine the source of impairments in order to develop an effective TMDL implementation plan. Additional monitoring could include:

- Windshield surveys
- Streambank surveys and stream assessments for both East Fork La Moine River impaired segments and associated pollutants (phosphorus or non-pollutant for DGL-05; biochemical oxygen demand, ammonia, and phosphorus for DGL-08)
- Farmer/landowner surveys
- Word of mouth and in-person conversations with local stakeholders and landowners

6. Public Participation

<to be updated based on Stage 1 meetings>

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