East Fork Kaskaskia River and Farina Lake Watershed Total Maximum Daily Load

Final Stage 1 Report

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Acronyms and Abbreviations

AFOs	animal feeding operations
AQI	Aesthetic Quality Index
AWQMN	Ambient Water Quality Monitoring Network
BOD	biochemical oxygen demand
CAFO	confined animal feeding operation
CWA	Clean Water Act
DO	dissolved oxygen
fIBI	fish Index of Biotic Integrity
Illinois EPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
lbs	pounds
L	liter
mg	milligram
µg	microgram
mIBI	macroinvertebrate Index of Biotic Integrity
MCL	Maximum Contaminant Level
MGD	millions of gallons per day
MS4	municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
NVSS	nonvolatile suspended solids
SOD	sediment oxygen demand
STEPL	Spreadsheet Tool for Estimating Pollutant Load
STP	sewage treatment plant
TMDL	total maximum daily load
TSI	Trophic Status Index
U.S. EPA	United States Environmental Protection Agency
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 East Fork Kaskaskia River and Farina Lake watershed in central Illinois. The project area is approximately 536 square miles and includes impairments in the East Fork and North Fork Kaskaskia River watershed (Figure 1). Two previous TMDL studies were completed in the project area: the North Fork Kaskaskia River TMDL (Limno-Tech 2006), which covers the northern half of the project area, and the East Fork Kaskaskia Watershed TMDL (Baetis Environmental Services, Inc. 2007), which covers the southern portion of the project area. Relevant information from the studies is included herein where applicable.

1.1 TMDL Development Process

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. It should be noted that the controls for nonpoint sources (e.g., agriculture) will be strictly voluntary.

1.2 Water Quality Impairments

Several waters in the East Fork Kaskaskia River Farina Lake project area have been placed on the State of Illinois §303(d) list (Table 1 and Figure 1). Of the waters being addressed by this TMDL study, Farina Lake was determined to be unimpaired for copper (see italics in Table 1 and Appendix A – Unimpaired Stream Data Analysis). In addition, total phosphorus impairments in streams are not being addressed as part of this project.

Table 1. East Fork Kaskaskia River and Farina Lake watershed impairments and pollutants (2016 Illinois 303(d) Draft List [IEPA 2016])

Name	Segment ID	Segment Length (Miles)	Watershed Area (Sq. Miles)	Designated Uses	Cause of Impairment
East Fork Kaskaskia River	IL_OK-02	18.72	78	Aquatic Life	**Dissolved Oxygen**, Phosphorus (Total) [a]
North Fork Kaskaskia River	IL_OKA-01	11.83	78	Aquatic Life	**Atrazine, Terbufos,** Phosphorus (Total) [a]
Kinmundy Old Lake	IL_ROZY	20 ac (surface area)	0.5	Aesthetic Quality	**Phosphorus (Total)**
Farina Lake	IL_SOB	4 ac (surface area)	0.05	Aquatic Life	*Copper*, **Dissolved Oxygen, pH, Terbufos**

a. These causes of impairment are not being addressed as part of this project.
Italics – Based on evaluation of the last ten years of available data (2007-2016), it was determined that Farina Lake (IL_SOB) is not impaired for copper (see Appendix A – Unimpaired Stream Data Analysis). A TMDL is not provided for this cause of impairment.
Bold – Impairments are addressed in this Stage 1 report.

1.3 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.

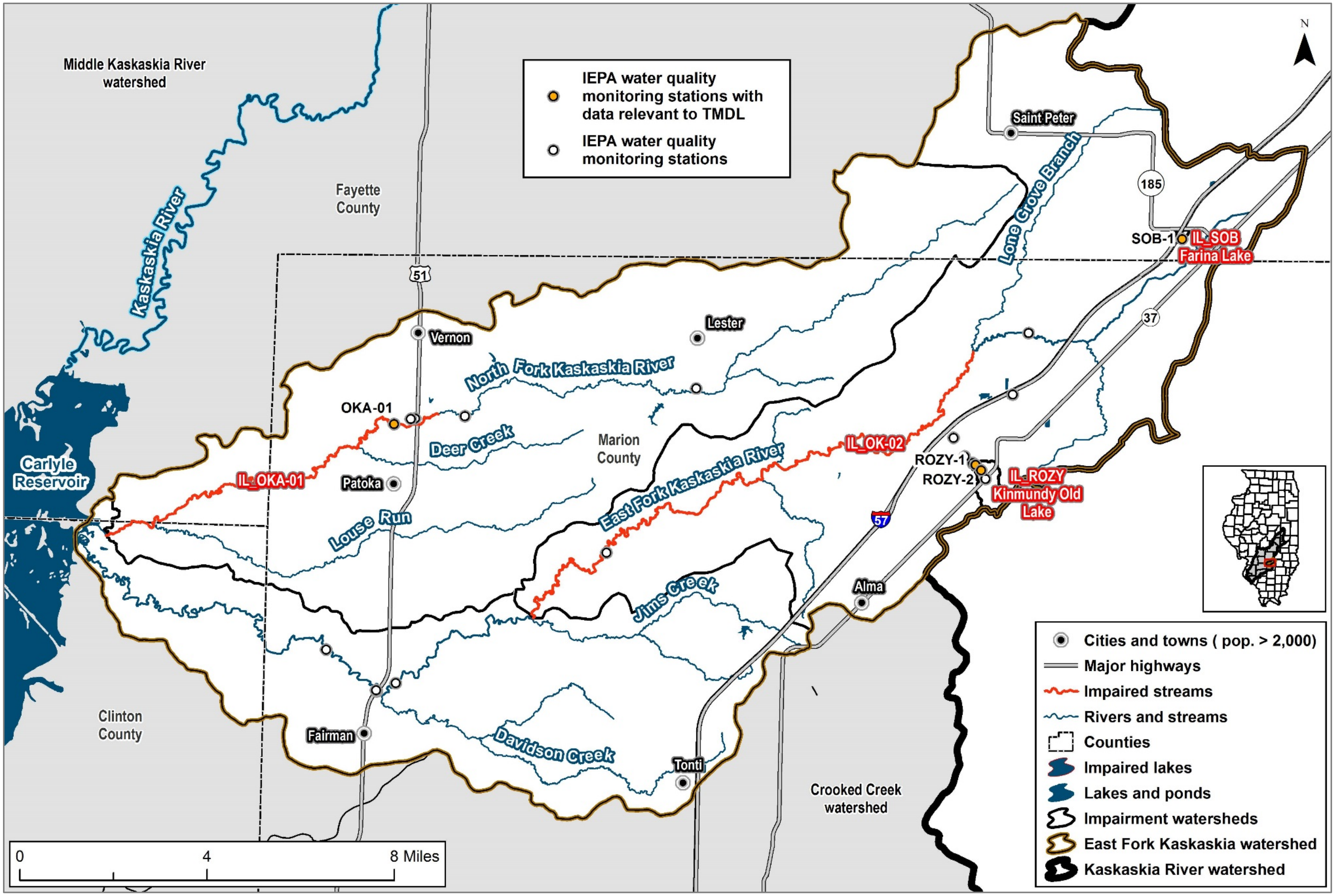

Figure 1. East Fork Kaskaskia Farina Lake TMDL project area.

1.3.1 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 Kaskaskia Farina Lake watershed:

General Use Standards – These standards protect for 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.

1.3.2 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 study area. Water quality standards are the endpoints to be used for TMDL development in the East Fork Kaskaskia Farina Lake project area (Table 2).

Table 2. Summary of water quality standards for the East Fork Kaskaskia Farina Lake watershed

Parameter	Units	General Use Water Quality Standard
Atrazine	µg/L	If fewer than 10 samples, not to exceed the chronic 9 µg/L nor acute 82 µg/L standard. If greater than 10 samples, not to exceed the chronic standard and fewer than two observations exceed the acute standard.
Terbufos	µg/L	If fewer than 10 samples, not to exceed the chronic 0.002 µg/L nor acute 0.024 µg/L standards. If greater than 10 samples, not to exceed the chronic standard and fewer than two observations exceed the acute 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 If fewer than 10 samples, not to exceed two violations of the standard. If greater than 10 samples, not to exceed one violation of the standard.
pH	s.u.	Within the range of 6.5 - 9.0 (s.u.)
Phosphorus (Total)	mg/L	0.05

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

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 (fIBI; Karr et al. 1986; Smogor 2000, 2005), the macroinvertebrate Index of Biotic Integrity (mIBI; Tetra Tech 2004) and the Macroinvertebrate Biotic Index (MBI; 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 and www.epa.gov/waterscience/criteria/wqcriteria.html). 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 WQS (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 http://www.ipcb.state.il.us/ecll/environmentalregister.asp).

Aesthetic Quality

The Aesthetic Quality Index (AQI; Table 3) is the primary tool used to assess *aesthetic quality* for freshwater lakes. The AQI represents the extent to which pleasure boating, canoeing, and aesthetic enjoyment are attained at a lake. The Trophic State Index (TSI; Carlson 1977), the percent-surface-area macrophyte coverage during the peak growing season (June through August), and the median concentration of nonvolatile suspended solids (NVSS) are used to calculate the AQI score. Higher AQI scores indicate increased impairment (Table 4).

Assessments of aesthetic quality use are based primarily on physical and chemical water quality data collected by the Illinois EPA through the Ambient Lake Monitoring Program or the Illinois Clean Lakes Program, or by non-Illinois EPA persons under an approved quality assurance project plan. The physical and chemical data used for aesthetic quality use assessments include Secchi disk transparency, chlorophyll *a*, total phosphorus (epilimnetic samples only), nonvolatile suspended solids (epilimnetic samples only), and percent surface area macrophyte coverage. Data are collected a minimum of five times per year (April through October) from one or more established lake sites. Data are considered usable for assessments if meeting the following minimum requirements: 1) At least four out of seven months (April through October) of data are available, 2) At least two of these months occurs during the peak growing season of June through August (this requirement does not apply to nonvolatile suspended solids), and 3) Usable data are available from at least half of all lake sites in any given lake each month. A whole-lake TSI value is calculated for the median Secchi disk transparency, median total phosphorus (epilimnetic sample depths only), and median chlorophyll *a* values. A minimum of two parameter-specific TSI values are required to calculate a parameter-specific use support determination. An assessment is then made based on the parameter specific use support determinations. The 0.05 mg/L Illinois General Use Water Quality Standard for total phosphorus in lakes (35 Ill. Adm. Code 302.205) has been incorporated into the weighting criteria used to assign point values for the AQI.

Table 3. Aesthetic Quality Index

Evaluation Factor	Parameter	Weighting Criteria	Points
1. Median Trophic State Index (TSI)	For data collected May-October: Median lake TSI value calculated from total phosphorus (samples collected at one foot depth), chlorophyll *a*, and Secchi disk transparency	Actual Median TSI Value	Actual Median TSI Value
2. Macrophyte Coverage	Average percentage of lake surface area covered by macrophytes during peak growing season (June through August). Determined by: a. Macrophyte survey conducted during same water year as the chemical data used in the assessment; <u>or</u> b. Average value reported on the VLMP Secchi Monitoring Data form	a. <5 b. ≥5<15 c. ≥15<25 d. ≥25	a. 0 b. 5 c. 10 d. 15
3. Nonvolatile Suspended Solids (NVSS) Concentration	Median lake surface NVSS concentration for samples collected at one foot depth (reported in mg/L)	a. <3 b. ≥3<7 c. ≥7<15 d. ≥15	a. 0 b. 5 c. 10 d. 15

Table 4. Guidelines for Assessing Aesthetic Quality Use in Illinois Freshwater Lakes

Degree of Use Support	Guidelines
Fully Supporting (Good)	Total AQI points are <60
Not Supporting (Fair)	Total AQI points are ≥60<90
Not Supporting (Poor)	Total AQI points are ≥90

2. Watershed Characterization

The East Fork Kaskaskia Farina Lake watershed is located in central Illinois (Figure 1). The headwaters begin in Fayette and Marion counties. East Fork Kaskaskia flows west until its confluence with the Kaskaskia River at Carlyle Lake. The Kaskaskia River eventually joins the Mississippi River south of St. Louis, Missouri. Much of the information presented in previous TMDL reports (Limno-Tech 2006, Baetis Environmental Services, Inc. 2007) is applicable to the East Fork Kaskaskia Farina Lake project area. There have been no known changes in the project area; therefore, the two previous TMDLs provide much of the basis for the watershed characterization and source assessment for the East Fork Kaskaskia Farina Lake TMDL.

2.1 Jurisdictions and Population

Relevant information on jurisdictions and population can be found in the North Fork Kaskaskia River TMDL (Limno-Tech 2006) and the East Fork Kaskaskia Watershed TMDL (Baetis Environmental

Services, Inc. 2007). The project area is primarily located in Marion County with portions of Fayette, Clinton, and Bond counties.

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 North Fork Kaskaskia River TMDL (Limno-Tech 2006) and the East Fork Kaskaskia Watershed TMDL (Baetis Environmental Services, Inc. 2007).

2.3 Land Use and Land Cover

Relevant information on land use and land cover can be found in the North Fork Kaskaskia River TMDL (Limno-Tech 2006) and the East Fork Kaskaskia Watershed TMDL (Baetis Environmental Services, Inc. 2007). The majority of land cover in the watershed is agricultural. Primary crops are soy, corn, and wheat.

2.4 Topography

Relevant information on topography can be found in the North Fork Kaskaskia River TMDL (Limno-Tech 2006) and the East Fork Kaskaskia Watershed TMDL (Baetis Environmental Services, Inc. 2007).

2.5 Soils

Relevant information on soils can be found in the North Fork Kaskaskia River TMDL (Limno-Tech 2006) and the East Fork Kaskaskia Watershed TMDL (Baetis Environmental Services, Inc. 2007). Bluford-Ava-Hickory and Cisne-Hoyleton-Darmstadt are the predominant soil associations in the watershed, both derived from glacial till.

2.6 Hydrology

Relevant information on hydrologic conditions can be found in the North Fork Kaskaskia River TMDL (Limno-Tech 2006) and the East Fork Kaskaskia Watershed TMDL (Baetis Environmental Services, Inc. 2007). There is one USGS flow gage site on the East Fork Kaskaskia near Sandoval, IL (05592900).

2.7 Watershed Studies and Information

Relevant information for this section can be found in the following reports and studies:

- **Kaskaskia River Watershed, An Ecosystem Approach to Issues and Opportunities** (Southwestern Illinois RC&D, Inc. 2002)

  The plan encompasses the larger Kaskaskia River watershed from Champaign County to Randolph County in southwestern Illinois, covering over 10 percent of the state of Illinois. The purpose of the plan was to begin a coordinated restoration process in the Kaskaskia River watershed based on sound ecosystem principles. The plan made recommendations on sustainability, diversity, health, variety, connectivity, and the ecosystem's ability to thrive and reproduce in order to promote the sustainability of the ecosystem and strengthen the economic base and the quality of life of residents in the region.

- **East Fork Kaskaskia River/Farina Lake Watershed Simazine TMDL** (IEPA 2015)

This previous TMDL provides information on Farina Lake and its simazine impairment.

- **North Fork Kaskaskia River TMDL** (Limno-Tech 2006)

  This previous TMDL provides watershed characterization for the northern half of the East Fork Kaskaskia River TMDL project area. TMDLs were developed for manganese, dissolved oxygen, and fecal coliform.

- **East Fork Kaskaskia Watershed TMDL** (Baetis Environmental Services, Inc. 2007)

  This previous TMDL provides information for the watershed characterization for the southern half of the East Fork Kaskaskia River TMDL project area. TMDLs were developed for manganese, pH, iron, and fecal coliform.

3. Watershed Source Assessment

Source assessments are an important component of water quality management plans and TMDL development. As part of the water resource assessment process, Illinois EPA identified several sources as contributing to the East Fork Kaskaskia River watershed impairments (Table 5). Descriptions of these and other sources are provided in the following sections.

Table 5. Potential sources in project area based on the Draft 2016 305(b) list

Watershed	Segment	Pollutant	Sources
East Fork Kaskaskia River	IL_OK-02	Dissolved oxygen	Source unknown and crop production (crop land or dry land)
North Fork Kaskaskia River	IL_OKA-01	Atrazine, Terbufos	Agriculture, unknown, crop production (crop land or dry land)
Kinmundy Old Lake	IL_ROZY	Phosphorus (Total)	Source unknown, crop production (crop land or dry land), runoff from forest/grassland/parkland
Farina Lake	IL_SOB	Dissolved oxygen, pH, Terbufos	Crop production (crop land or dry land), pesticide application

3.1 Pollutants of Concern

Pollutants of concern evaluated in this source assessment include phosphorus, atrazine, terbufos, and parameters influencing dissolved oxygen and pH such as biochemical oxygen demand, phosphorus, and ammonia. 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 potentially 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 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, concentrated feeding operations (CAFOs), or regulated storm water including municipal separate storm sewer systems (MS4s). There are no permitted CAFOs in the watershed.

3.2.1 NPDES Facilities (Non-CAFO or stormwater)

There are seven individual NPDES permitted facilities in the East Fork Kaskaskia Farina Lake project area (Table 6) however, none of the facilities dicharge directly to an impaired segment. Average and maximum design flows and downstream impairments are included in the facility summaries.

Table 6. Individual NPDES permitted facilities discharging to impaired segments

IL Permit ID	Facility Name	Type of Discharge	Receiving Water	Downstream Impairment(s)	Average Design Flow (MGD)	Maximum Design Flow (MGD)
IL0060585	*Marathon Pipeline Company*	*Hydrostatic test water*	*Unnamed tributary to North Fork Kaskaskia River*	*OKA-01*	*1.44*	*--*
IL0075001	*Kinmundy Energy Center*	*Misc. equipment and floor drain wastewater*	*Unnamed tributary to Louse Run*	*OKA-01*	*0.026*	*--*
IL0076422	*Alma STP*	*STP outfall*	*Unnamed tributary to East Fork Kaskaskia River*	*OK-02*	*0.05*	*0.199*
ILG580007	*St. Peter STP*	*STP outfall*	*Unnamed tributary to Lone Grove Branch*	*OK-02*	*0.042*	*0.17*
ILG580022	*Patoka STP*	*STP outfall*	*Unnamed tributary to North Kaskaskia River*	*OKA-01*	*0.072*	*0149*
ILG580047	*Farina STP*	*STP outfall*	*East Fork Kaskaskia River*	*OK-02*	*0.105*	*0.62*
ILG580123	*KINMUNDY STP*	*STP outfall*	*Unnamed tributary to Schneider Springs Branch*	*OK-02*	*0.146*	*0.442*

Italics – NPDES facility draining to unimpaired segment.
STP – Sewage treatment plant
MGD – Million gallons per day

3.2.2 Municipal Separate Storm Sewer Systems

Regulated stormwater runoff can contribute to impairments in the project area. As development increases in the watershed, additional pressure will be placed on receiving waters due to stormwater. Impervious areas associated with developed land uses can result in higher peak flow rates, higher runoff volumes, and larger pollutant loads. Stormwater runoff often contains sediment and nutrients, among other pollutants.

Under the NPDES program, municipalities serving populations over 100,000 people are considered Phase I MS4 communities. In the impairment watersheds, there are no Phase I communities. Municipalities serving populations under 100,000 people are considered Phase II communities. In Illinois, Phase II communities are allowed to operate under the statewide General Storm Water Permit (ILR40), which requires dischargers to file a Notice of Intent acknowledging that discharges shall not cause or contribute to a violation of water quality standards.

To assure pollution is controlled to the maximum extent practical, regulated entities operating under the General Storm Water Permit (ILR40) are required to implement six control measures including public education, public involvement, illicit discharge and detection programs, control of construction site runoff, post construction stormwater management in new development and redevelopment, and pollution prevention/good housekeeping for municipal operations. Foster Township MS4 (ILR400052) is the only entity operating under the General Storm Water Permit and is located in the both the North Fork Kaskaskia River (OKA-01) and East Fork Kaskaskia River (OK-02) impairment subwatersheds.

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.

3.3.1 Agricultural and Stormwater 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, specifically contributing to high biochemical oxygen demand and nutrients that can affect the dissolved oxygen conditions in streams.

In addition to pollutants, alterations to a watershed's hydrology as a result of land use changes 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.

Atrazine is an herbicide that is commonly used in the U.S. to control broadleaf weeds. In the Mississippi North Central River watershed, atrazine is applied on most corn fields. In Illinois, the use of atrazine is common, having been applied on 67 percent of corn crops in 2014 for a total of 8,622,000 pounds (USDA 2015). Atrazine is typically applied in the spring or summer and can be applied pre- or post-emergent. Transport mechanisms include overland runoff, discharge from drainage tiles, and contaminated dust that is delivered to the waterway through wet and dry atmospheric deposition. Atrazine is also transported easily in water, in the dissolved phase.

Terbufos is an orthophosphate pesticide that is applied to the surface of agricultural soil to combat pests. Application requires soil integration and occurs during planting, post plant emergent (applied in bands along row), and at crop cultivation. The typical application rate of terbufos to corn is 1.0 lb active ingredient per acre and the maximum is 1.3 lbs active ingredient per acre per year. U.S. EPA use data indicates that from 1987 to 1996 the average nationwide domestic use of terbufos was 7.5 million pounds per year. Terbufos and its two major degradation products, terbufos sulfoxide and terbufos sulfone, have the potential to run off of agricultural fields and into surface waters (U.S. EPA 2006).

The majority of land cover in the East Fork Kaskaskia Farina Lake watershed is cropland. Atrazine and terbufos application on these cultivated areas contributes loading by runoff and through infiltration into shallow groundwater or drain tiles. Therefore, the location and quantity of atrazine and terbufos applied to the landscape can greatly affect the resulting concentrations in nearby waterbodies. It is also possible that the two pollutants can be released from manufacturing, formulation, transport, and disposal.

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 1996). Septic systems contain all the water discharged from homes and business and can be significant sources of pollutants.

Relevant information for this section can be found in the North Fork Kaskaskia River TMDL (Limno-Tech 2006) and the East Fork Kaskaskia Watershed TMDL (Baetis Environmental Services, Inc. 2007). County health departments were contacted for information on septic systems and unsewered communities. From 2009–2016, between 49 and 90 new private sewage disposal permits were issued in Fayette County. This number, however, is not indicative of the number of sewage systems previously installed.

3.3.3 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 bacteria and 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. However, county wide data available from the 2012 Census of Agriculture were downloaded and area weighted to estimate the animal population in the project area. An estimated 6,615 animals are in the project area.

3.3.4 Internal Loading

Internal phosphorus loading from lake bottom sediments can be a substantial component of the phosphorus budget in lakes. The sediment phosphorus originates as an external phosphorus load that settles out of the water column to the lake bottom. There are multiple mechanisms by which phosphorus can be released back into the water column as internal loading:

- Low oxygen concentrations (also called anoxia) in the water overlying the sediment can lead to phosphorus release. In a shallow lake that undergoes intermittent mixing of the water column throughout the growing season, the released phosphorus can mix with surface waters throughout the summer and become available for algal growth. In deeper lakes with a more stable summer stratification period, the released phosphorus remains in the bottom water layer until the time of fall mixing, when it mixes with surface waters.
- Bottom-feeding fish such as carp and black bullhead forage in lake sediments. This physical disturbance can release phosphorus into the water column.
- Wind energy in shallow areas can mix the water column and disturb bottom sediments, which leads to phosphorus release.
- Other sources of physical disturbance, such as boating in shallow areas, can disturb bottom sediments and lead to phosphorus release.

4. Water Quality

Background information on water quality monitoring can be found in the North Fork Kaskaskia River TMDL (Limno-Tech 2006) and the East Fork Kaskaskia Watershed TMDL (Baetis Environmental Services, Inc. 2007). In the East Fork Kaskaskia River Farina Lake watershed, water quality data were found for numerous stations that are part of the Illinois EPA Ambient Water Quality Monitoring Network (AWQMN). Monitoring stations with data relevant to the impaired segments are presented in Figure 1 and Table 7. Parameters sampled in the streams include field measurements (e.g., water temperature) 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, with the exception of Farina Lake (SOB). 2017 monitoring data were collected on Farina Lake and are included here. Data that are greater than 10 years old are not included. Each data point was reviewed to ensure the use of quality data in the analysis below. Many sites have historical data that are greater than 10 years old. Data were obtained directly from Illinois EPA.

Table 7. East Fork Kaskaskia Lake Fork watershed water quality data

Waterbody	Impaired Segment	AWQMN Sites	Location	Period of Record
East Fork Kaskaskia River	IL_OK-02	OK-02	2 mile west of Alma	*2006*–2007
North Fork Kaskaskia River	IL_OKA-01	**OKA-01**	County Rd 250E Br 1.5 mile north of Patoka	*1999*–2007, 2012
Kinmundy Old Lake	IL_ROZY	**ROZY-1**	No location information	2011 (5 days), 2016 (1 day)
		ROZY-2	No location information	2011 (5 days), 2016 (1 day)
Farina Lake	IL_SOB	**SOB-1**	No location information	2012, 2017

BOLD – Indicates station with data relevant to impairment
Italics – Data are more than 10 years old

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. This section provides a brief review of available water quality information provided by the Illinois EPA.

4.1 East Fork Kaskaskia River (OK-02)

East Fork Kaskaskia River (OK-02) is listed as being impaired for aquatic life due to low levels of dissolved oxygen. There were no dissolved oxygen data available for OK-02; additional data collection is needed to verify the dissolved oxygen impairment on segment OK-02.

4.2 North Fork Kaskaskia River (OKA-01)

North Fork Kaskaskia River (OKA-01) is listed as impaired for aquatic life due to atrazine and terbufos. There is one Illinois EPA sampling site located on segment OKA-01 (sampling site OKA-01).

Seven terbufos samples were collected on OKA-01 (Table 8 and Figure 2). All samples exceeded the acute standard for terbufos, confirming impairment. Seven atrazine samples were collected on OKA-01 (Table 8 and Figure 3). One sample exceeded the chronic standard and no samples exceeded the acute standard, confirming impairment.

Table 8. Data summary, North Fork Kaskaskia River (OKA-01)

Sample Site	No. of samples	Minimum (µg/L)	Average (µg/L)	Maximum (µg/L)	CV (standard deviation/ average)	Number of exceedances of general use water quality standard
Atrazine						
OKA-01	7	0.02	5.31	32.00	11.81	1
Sample Site	**No. of samples**	**Minimum (µg/L)**	**Average (µg/L)**	**Maximum (µg/L)**	**CV (standard deviation/ average)**	**Number of exceedances of general use water quality standard**
Terbufos						
OKA-01	7	0.01	0.09	0.23	0.44	7

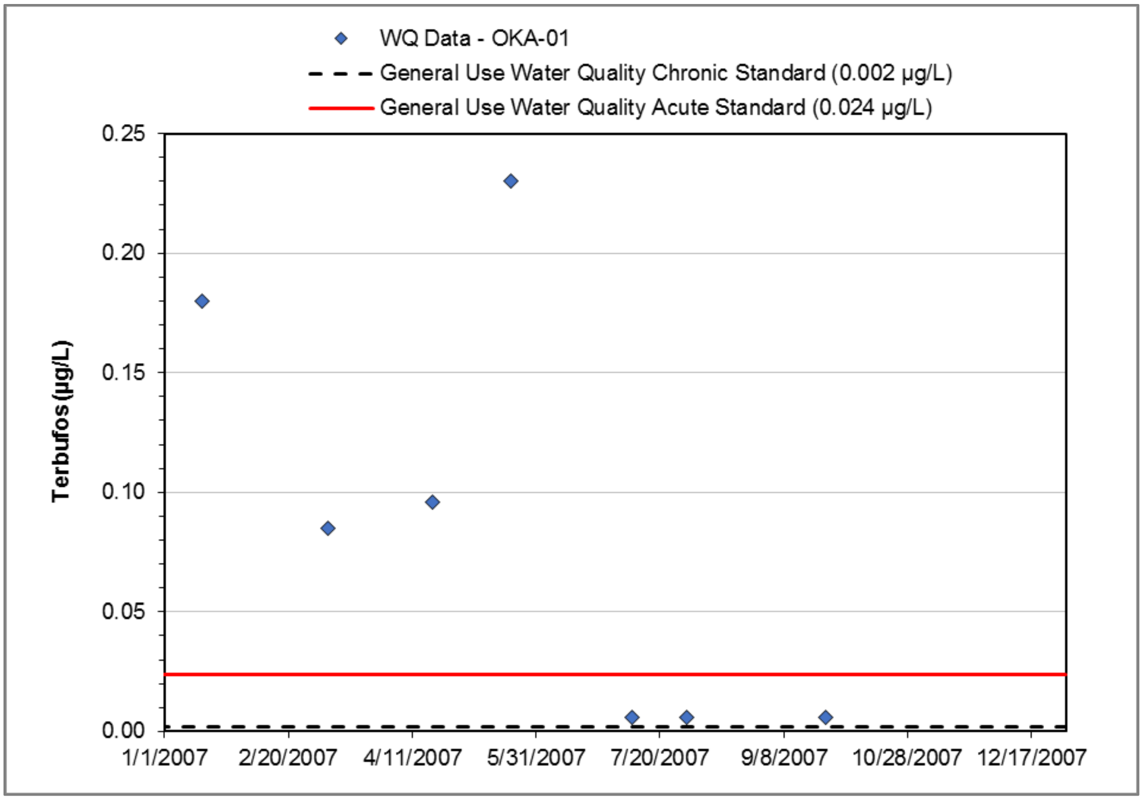

Figure 2. Water quality time series for terbufos, North Fork Kaskaskia River (OKA-01).

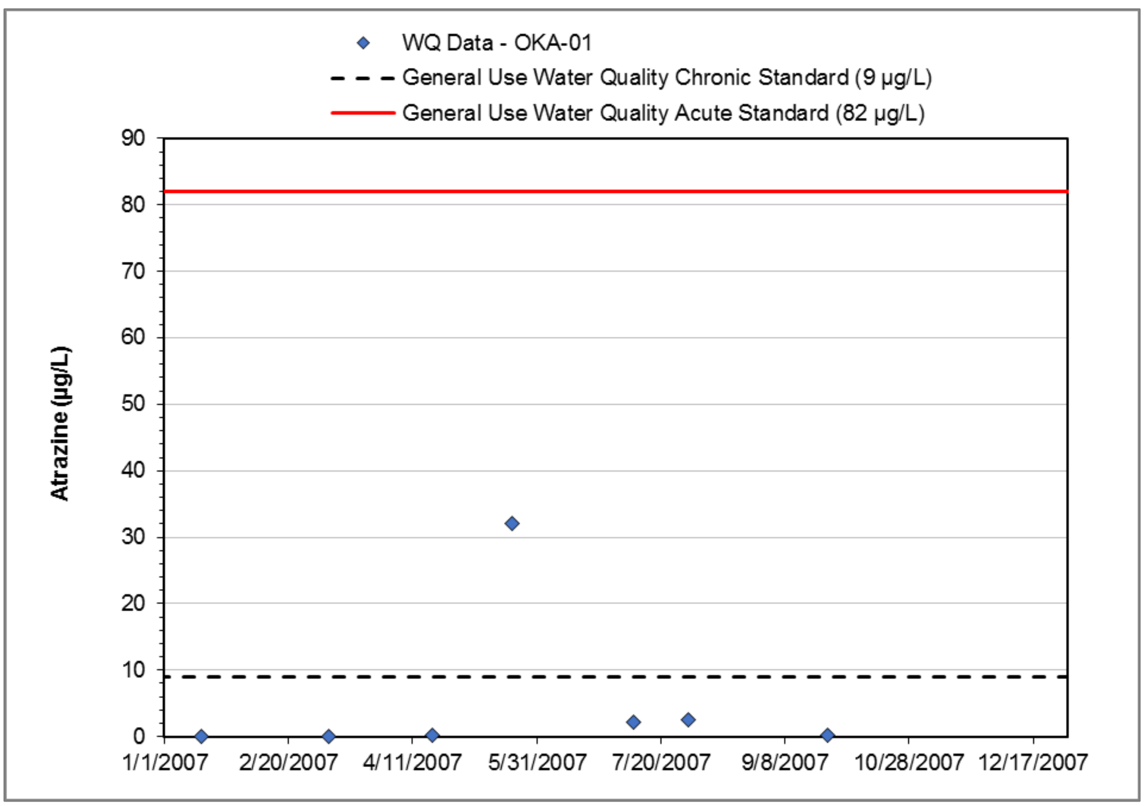

Figure 3. Water quality time series for atrazine, North Fork Kaskaskia River (OKA-01).

4.3 Kinmundy Old Lake (ROZY)

Kinmundy Old Lake (ROZY) is listed as impaired for aesthetic quality due to phosphorus. Kinmundy Old Lake is 20 acres in surface area and is therefore assessed for impairment in the state of Illinois for phosphorus. There are two sampling sites (ROZY-1 and ROZY-2; Table 9 and Figure 4). All 24 samples exceeded the general use water quality standard, confirming impairment. Chlorophyll *a* data are also available (Figure 5).

Table 9. Data summary, Kinmundy Old Lake (ROZY)

Sample Site	No. of samples	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Standard Deviation	Number of exceedances of general use water quality standard 0.05 mg/L
Total Phosphorus						
ROZY-1	18	0.1	0.3	1.6	0.5	18
ROZY-2	6	0.1	0.1	0.3	0.1	6

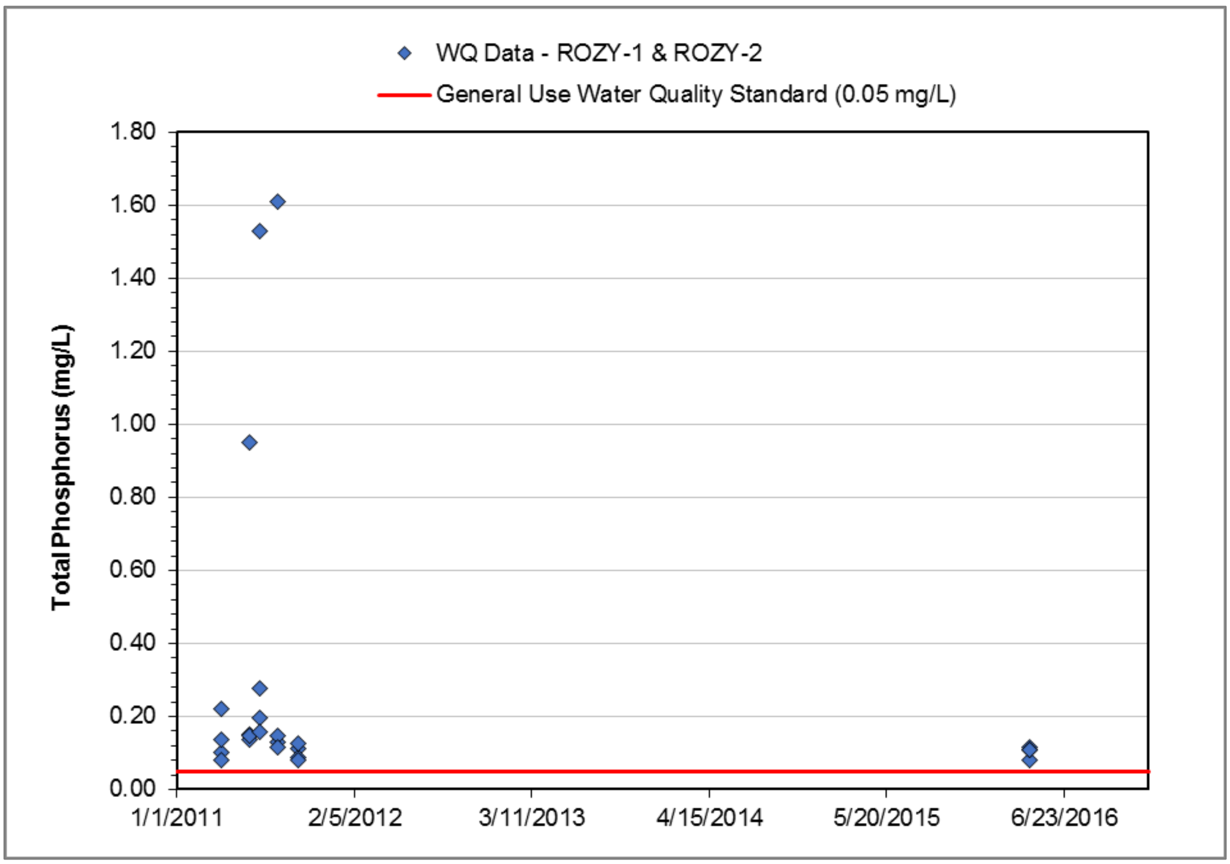

Figure 4. Water quality times series for total phosphorus, Kinmundy Old Lake (ROZY).

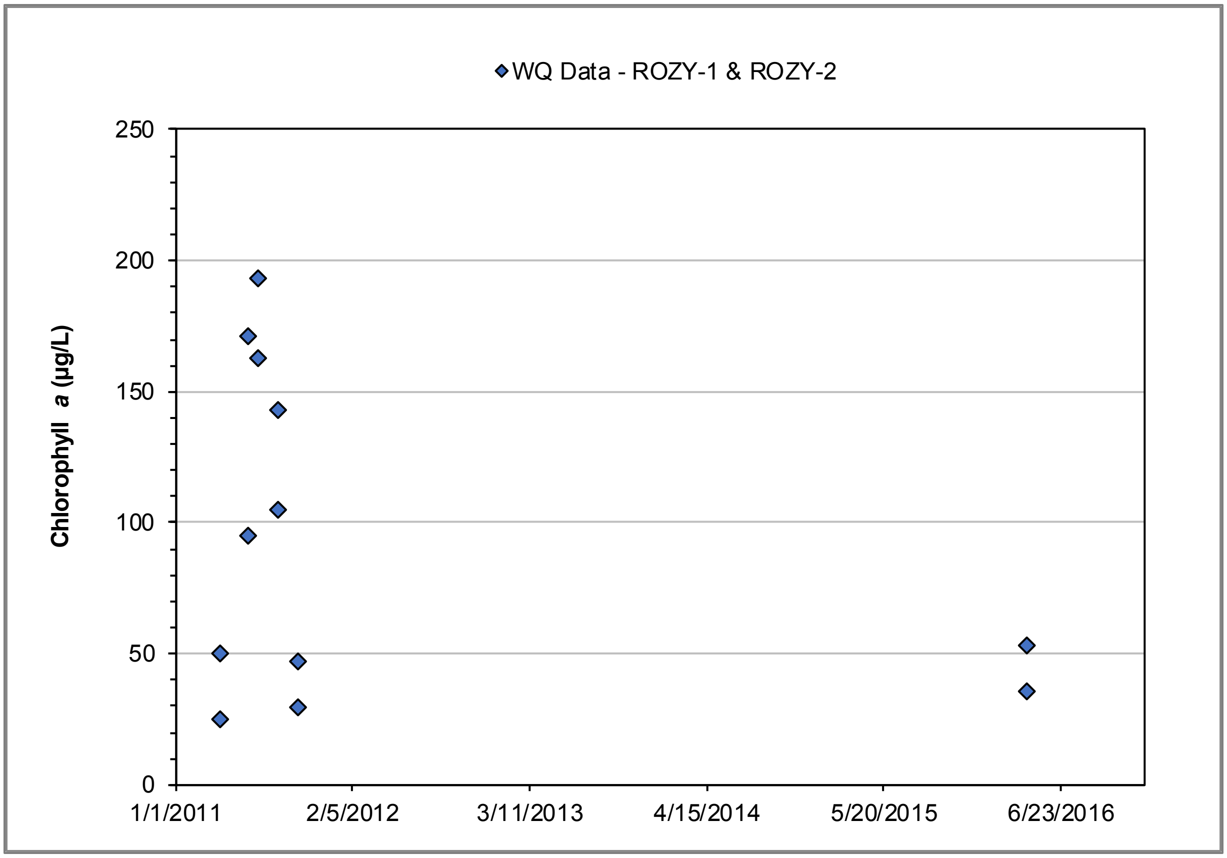

Figure 5. Water quality times series for chlorophyll *a*, Kinmundy Old Lake (ROZY).

4.4 Farina Lake (SOB)

Farina Lake (SOB) is listed as impaired for aquatic life due to dissolved oxygen, pH, and terbufos. The lake is a borrow pit that pumps water from East Fork Kaskaskia. One water quality sampling site (sampling site SOB-1) was identified in the lake.

133 dissolved oxygen measurements were collected from Farina Lake (Figure 6). Of these measurements, the dissolved oxygen standard applies to the 67 measurements that were collected above the thermocline or during periods when Farina Lake was unstratified (Table 10). Six violations of the general use water quality standard for dissolved oxygen were observed in June and October 2012 and May 2017, confirming the dissolved oxygen impairment. 133 pH samples were collected in 2012 and 2017 (Table 10 and Figure 7). 12 violations of the general use water quality standard for pH were observed in June and August 2012 and October 2017, confirming the pH impairment. Five data points were collected for terbufos, and exceedances of the general use water quality standard confirm the terbufos impairment (Table 10 and Figure 8).

Existing phosphorus data suggest that the lake is eutrophic; however, Farina Lake is under 20 acres in surface area and was therefore not assessed by IEPA for total phosphorus.

Table 10. Data summary, Farina Lake (SOB)

Sample Site	No. of samples	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	CV (standard deviation/ average)	Number of violations of general use water quality standard (>5 mg/L (Mar–Jul) and >3.5 mg/L (Aug–Feb))
Dissolved oxygen						
SOB-1	67	0.3	7.6	13.3	0.3	6
Sample Site	**No. of samples**	**Minimum (s.u.)**	**Average (s.u.)**	**Maximum (s.u.)**	**CV (standard deviation/ average)**	**Number of samples outside the range of the general use water quality standard (6.5–9.0 s.u.)**
pH						
SOB-1	133	6.2	7.4	9.1	0.1	12
Sample Site	**No. of samples**	**Minimum (µg/L)**	**Average (µg/L)**	**Maximum (µg/L)**	**CV (standard deviation/ average)**	**Number of exceedances of general use water quality standard (0.024 µg/L)**
Terbufos						
SOB-1	5	0.05	0.12	0.18	0.06	4

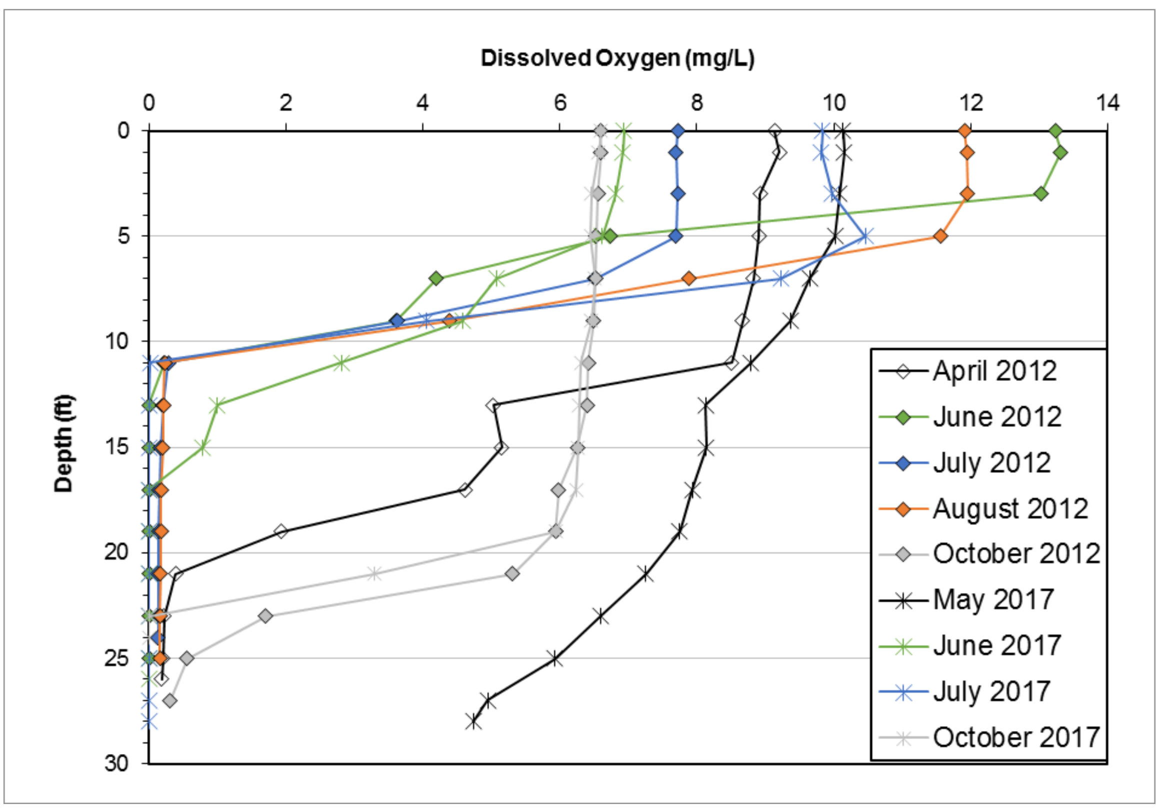

Figure 6. Dissolved oxygen depth profile data, Farina Lake SOB

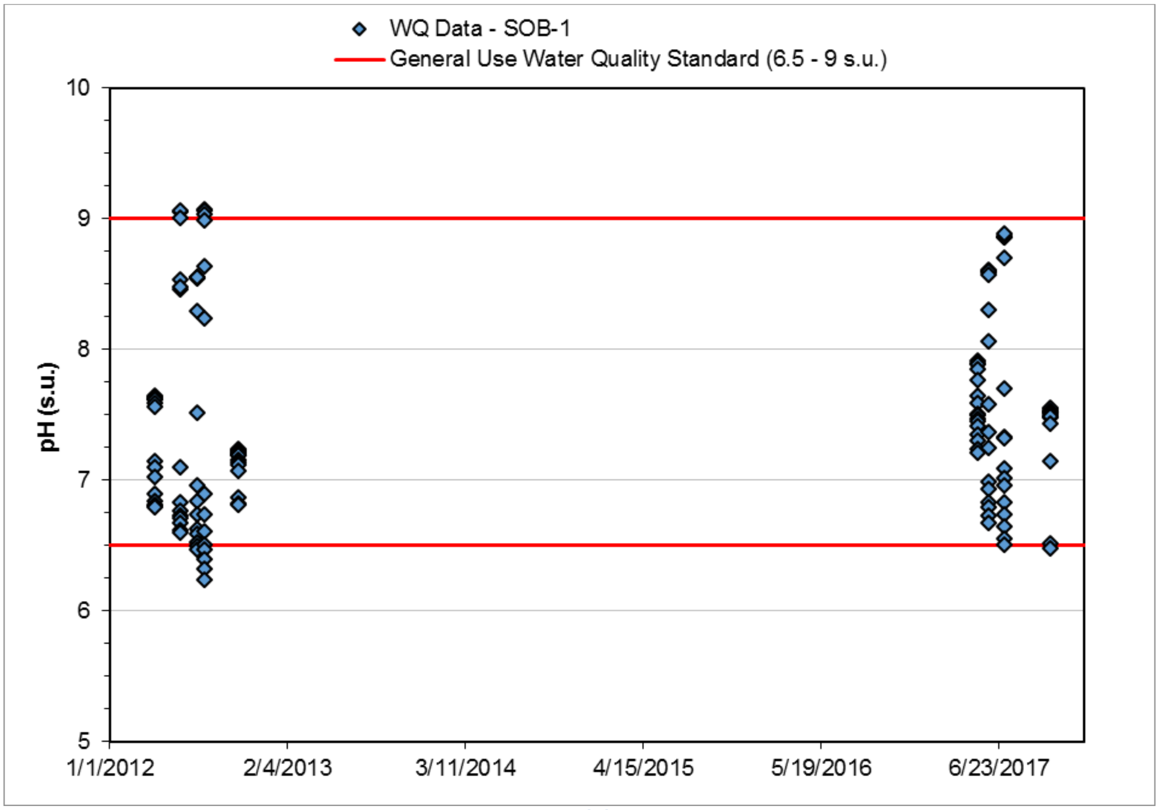

Figure 7. pH water quality time series, Farina Lake SOB

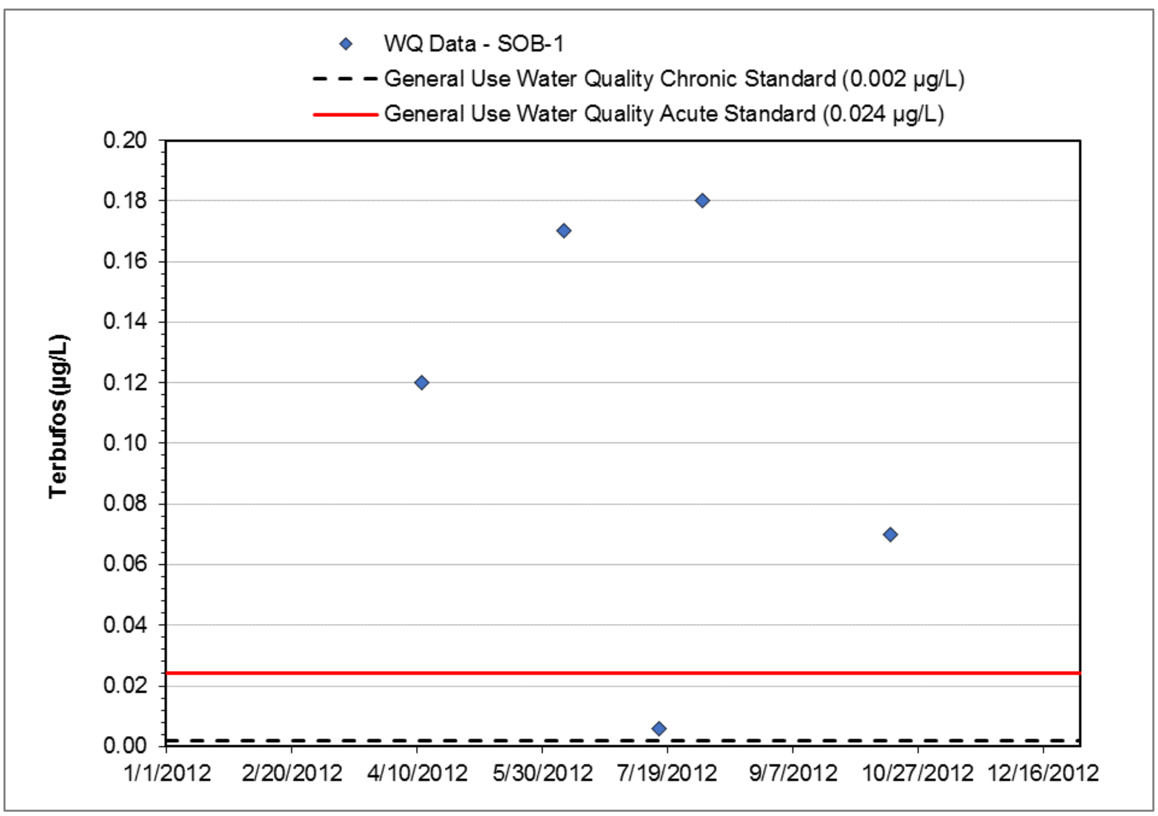

Figure 8. Water quality time series for terbufos, Farina Lake (SOB).

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 will be used to derive TMDLs and the additional data needed to develop credible TMDLs.

5.1 Stream Impairments

TMDLs are proposed for segments with verified impairments and known pollutants (Table 11). A duration curve approach is suggested to evaluate the relationships between hydrology and water quality and to calculate the stream TMDLs for atrazine and terbufos. For the dissolved oxygen impairment (pending impairment verification), which is not affected by point sources, it is assumed that the cause of impairment is either eutrophication or non-pollutant based (e.g., the effect of lack of re-aeration in low-gradient streams).

Table 11. Proposed model summary, streams

Name	Segment ID	Designated Uses	TMDL Parameter(s)	Proposed Model	Proposed Pollutant
East Fork Kaskaskia River	IL_OK-02	Aquatic life	Dissolved Oxygen	Load duration curve or 4C classification (pending impairment verification)	Phosphorus or non-pollutant
North Fork Kaskaskia River	IL_OKA-01	Aquatic life	Atrazine	Load duration curve	Atrazine
			Terbufos	Load duration curve	Terbufos

5.1.1 Load Duration Curve

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 between sources. Table 12 summarizes the general relationship between the five hydrologic zones and potentially contributing source areas (the table is not specific to any 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 12. 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
Onsite 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 Lake Impairments

Table 13. Proposed model summary, lakes

Name	Segment ID	Designated Uses	TMDL Parameter(s)	Proposed Model	Proposed Pollutant
Kinmundy Old Lake	IL_ROZY	Aesthetic Quality	Phosphorus	Bathtub	Phosphorus
Farina Lake	IL_SOB	Aquatic life	Dissolved Oxygen, pH	Bathtub	Phosphorus
			Terbufos	Lake volume calculation [a]	Terbufos

a. This approach was used in the previously approved East Fork Kaskaskia/Farina Lake Watershed Simazine TMDL (IEPA 2015)

5.2.1 Bathtub Model

The Bathtub model is proposed to support TMDL development for Kinmundy Old Lake and Farina Lake. Bathtub is a steady state model that predicts eutrophication response in lakes based on empirical formulas developed for nutrient balance calculations and algal response (Walker 1987). The model was developed and is maintained by the U.S. Army Corps of Engineers. The 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. There are sufficient phosphorus and chlorophyll *a* data to calibrate Bathtub models for both lakes. It is assumed that a phosphorus TMDL will address dissolved oxygen and pH impairments.

Due to a lack of available inflow monitoring data, watershed inputs will be derived from *Spreadsheet Tool for the Estimation of Pollutant Load* (STEPL). STEPL provides a simplified simulation of precipitation-driven runoff and sediment and nutrient delivery. STEPL can estimate loads from land uses, as well as from other sources such as stream bank erosion and failing septic systems. STEPL simulates runoff and stream flow using summary information on precipitation and rain days for the nearest weather station. STEPL has been used extensively in Region 5 for watershed plan development and in support of watershed studies. STEPL is an appropriate model to evaluate the relative contribution of various sources of pollutants and allows for the identification of the priority sources of pollutants for evaluation during implementation planning. STEPL also provides the level of detail needed for external watershed loading to Kinmundy Old Lake and Farina Lake required for Bathtub input.

5.2.2 Lake Volume Calculation

Farina Lake consists of pumping water for public water supply from the East Fork Kaskaskia River. The volume of the lake will be used to determine the allowable loading of terbufos. This method was used in the East Fork Kaskaskia/Farina Lake Simazine TMDL (IEPA 2015) and will be used in this TMDL for consistency.

$$Loading\ Capacity = Maximum\ storage\ \ X\ \ water\ quality\ standard$$

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 verify impairment, understand probable sources, calculate reductions, develop calibrated water quality models, and develop effective implementation plans. Table 14 summarizes the additional data needed for each impaired segment.

Table 14. Additional data needs

Name	Segment ID	Designated Uses	TMDL Parameters	Additional Data Needs
East Fork Kaskaskia	IL_OK-02	Aquatic life	Dissolved oxygen	To confirm impairment and to determine eutrophication relationship
North Fork Kaskaskia	IL_OKA-01	Aquatic life	Atrazine	None
			Terbufos	None
Kinmundy Old Lake	IL_ROZY	Aesthetic Quality	Phosphorus	None
Farina Lake	IL_SOB	Aquatic Life	Dissolved Oxygen, pH, terbufos	None

Specific data needs include:

Confirm DO impairment and determine relationship with eutrophication on East Fork Kaskaskia (IL_OK-02)—A series of DO measurements and chlorophyll-*a* and TP grab samples (two samples per day on three separate sampling days should be collected from the impaired segment to verify impairment and to determine the role of eutrophication, if any, in the impaired segment. Sampling should occur during the warm summer months (July–August) and during low flows, and one of each paired sample should occur in the early morning to ensure that critical conditions are captured.

Additional field based monitoring–Further in-field assessment can help to better determine the sources of impairments and develop an effective TMDL implementation plan. Additional monitoring for impaired waterbodies includes:

- Wind shield surveys
- Streambank survey and stream assessment for East Fork Kaskaskia (IL_OK-02) and associated pollutants (phosphorus or non-pollutant, pending TMDL approach)
- Lakeshore assessment for Kinmundy Old Lake and Farina Lake
- Farmer/landowner surveys
- Word of mouth and in-person conversations with local stakeholders and landowners

6. Public Participation

A public meeting was held on December 12, 2018 at the Carlyle Lake Visitor Center in Carlyle, IL to present the Stage 1 report and findings. A public notice was placed on the Illinois EPA website. There were many stakeholders present including representatives from the US Army Corps of Engineers, the Kaskaskia Watershed Association, the Original Kaskaskia Area Wilderness, Inc., and others. The public comment period closed on January 12, 2019. No written comments were provided on the draft Stage 1 report.

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Appendix A – Unimpaired Stream Data Analysis

Farina Lake (IL_SOB) is listed as impaired for copper (dissolved). According to Illinois Administrative Code, Title 35, Part 302, Subpart B, 302.208, a segment is impaired for copper if:

- The Acute Standard (AS) of $e^{(A+B\ln(H))} \times 0.960$, where A= -1.464 and B= 0.9422; H= hardness, is exceeded at any point, or
- The geometric mean of four consecutive samples over at least four days exceeds the Chronic standard (CS) $e^{(A+B\ln(H))} \times 0.960$, where A= -1.465 and B= 0.8545; H= hardness

One IEPA sampling site was identified in the lake (SOB-1). No samples of dissolved copper are available; however, total copper was below the dissolved copper standard (Figure 9). The dissolved concentration by definition is less than the total copper concentration and therefore does not exceed the standard. It is recommended that the segment be delisted for copper and no TMDL for copper be developed.

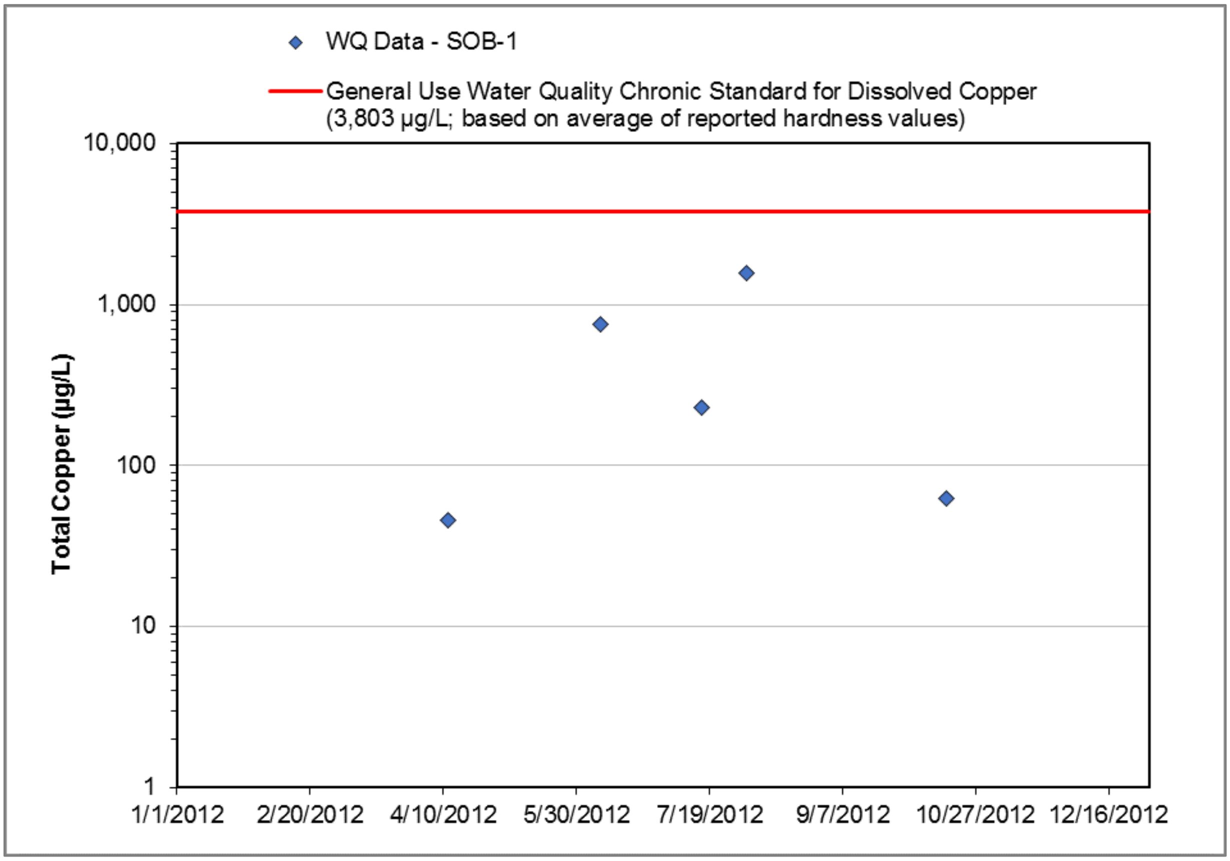

Figure 9. Water quality time series for total copper, Farina Lake (SOB).
The chronic standard of 3,803 µg/L is based on an average hardness of 90,160 CaMg mg/L, from the five samples graphed in this figure.