Middle Kaskaskia River/Carlyle Lake Watershed Total Maximum Daily Load

Stage 3 Report for Public Review

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Acronyms and Abbreviations

AFOs	animal feeding operations
AQI	Aesthetic Quality Index
AWQMN	Ambient Water Quality Monitoring Network
BMP	best management practice
CAFO	confined animal feeding operation
CSA	critical source areas
CWA	Clean Water Act
DAF	design average flow
DMF	design maximum flow
HSG	hydrologic soil group
IDOA	Illinois Department of Agriculture
IEPA	Illinois Environmental Protection Agency
Ill. Adm. Code	Illinois Administrative Code
IPCB	Illinois Pollution Control Board
KWA	Kaskaskia Watershed Association
LA	load allocation
MOS	margin of safety
MS4	municipal separate storm sewer system
MST	microbial source tracking
NOAA	National Oceanic and Atmospheric Administration
NLRS	Nutrient Loss Reduction Strategy
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service

RC	reserve capacity
TMDL	total maximum daily load
TP	total phosphorus
TSI	Trophic State Index
USACE	U.S. Army Corps of Engineers
U.S. EPA	United States Environmental Protection Agency
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WLA	wasteload allocation
WQS	water quality standards
WTP	water treatment plant
WWTP	wastewater treatment plant

Units of Measure

cfu	colony forming units (fecal coliform)
lbs.	pounds
mgd	millions of gallons per day
mg/L	milligrams per liter
mL	milliliter

Executive Summary

The Clean Water Act (CWA) and U.S. Environmental Protection Agency (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 them.

This TMDL study addresses approximately 946 square miles in the Middle Kaskaskia River/Carlyle Lake watershed located in central Illinois. Carlyle Lake at the outlet of the Middle Kaskaskia River drains a watershed of approximately 2,590 square miles. The Upper Kaskaskia and Lake Fork watershed and East Fork Kaskaskia River and Farina Lake watershed (totaling 1,644 square miles) are addressed in separate TMDL reports.

Two stream segments and one lake segment within the project are receiving TMDLs. Two segments receive a fecal coliform TMDL, and the one lake segment received a total phosphorus TMDL. The sources of pollutants in the watershed include National Pollutant Discharge Elimination System permitted facilities such as wastewater treatment facilities. In addition, nonpoint pollution resulting from several key sources including stormwater runoff, onsite wastewater treatment systems, and animal feeding operations.

A TMDL identifies the total allowable load that a waterbody can assimilate (the loading capacity) and still meet water quality standards or targets. The loading capacity for each stream is determined using a load duration curve framework. TMDLs are presented in Section 7. A TMDL is equal to the loading capacity for a waterbody, and that loading capacity is distributed among load allocations to nonpoint and background sources and wasteload allocations to point sources. The required pollutant reductions vary between 37% and 96%, depending on the waterbody and pollutant.

An implementation plan is provided in Section 8 which includes potential implementation activities to address sources of pollutants. This plan, when combined with the entire TMDL study, is provided to meet U.S. EPA's Nine Minimum Elements for CWA section 319 funding requirements and includes an analysis of critical areas, extent of needed implementation, schedule, milestones, partners, and estimated costs.

The State of Illinois uses a three-stage approach to develop TMDLs:

> **Stage 1 –** Watershed characterization, historical dataset evaluation, data analysis, methodology selection, data gap identification
>
> **Stage 2** – Data collection to fill in data gaps, if necessary
>
> **Stage 3 –** Model calibration, TMDL scenarios, and implementation plan

This final report represents a compilation of Stage 1, 2, and 3.

1. Introduction

The Clean Water Act (CWA) 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 them. This TMDL study addresses the approximately 946 square miles of Middle Kaskaskia River/Carlyle Lake watershed located in central Illinois (Figure 1). The Upper Kaskaskia River watershed and East Fork Kaskaskia River watershed drain to the Middle Kaskaskia River/Carlyle Lake watershed but are being addressed in separate TMDL studies.

Several waters in the Middle Kaskaskia River/Carlyle Lake watershed have been placed on the State of Illinois 303(d) list and require the development of a TMDL. This project addresses two impaired segments along the mainstem of the Kaskaskia River and Carlyle Lake. Concurrent with this TMDL study in the Middle Kaskaskia watershed, TMDL studies are being conducted in the Upper Kaskaskia and Lake Fork watershed, Lower Kaskaskia watershed, East Fork Kaskaskia and Farina Lake watershed, and Crooked Creek / Lost Creek watershed.

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 (MOS), which reflects uncertainty, as well as the effects of seasonal variation, and a reserve capacity (RC) to account for future loading. 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 State of Illinois uses a three-stage approach to develop TMDLs:

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>
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>
> **Stage 3** – Model calibration, TMDL scenarios, and implementation plan

The full Stage 1 report is included in Appendix A and includes an initial summary of the water quality impairments, watershed characterization, pollutant source summary, analysis of water quality data, and information on the approach taken to develop TMDLs. Relevant information from the Stage 1 report has been included in this full Stage 3 document.

As part of the Stage 2 TMDL development process, additional monitoring was gathered by Illinois State Water Survey on behalf of the Illinois Environmental Protection Agency (IEPA) in 2019; Appendix B includes data collected as part of Stage 2. This Stage 3 report includes a brief summary of Stage 2 data collection efforts and the outcome of those efforts.

An implementation plan is also provided that addresses fecal coliform and phosphorus in the watershed. This plan, when combined with the entire TMDL study, is provided to meet U.S. EPA's Nine Minimum Elements for CWA section 319 funding requirements and includes an analysis of critical areas, extent of needed implementation, schedule, milestones, partners, and estimated costs. IEPA 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

Two TMDLs were developed to address two impaired segments of the Kaskaskia River (IL_O-08 and IL_O-38) and one TMDL was developed to address Carlyle Lake (Table 1 and Figure 1). One segment of the Kaskaskia River (IL_O-33) was delisted in the 2020/2022 Integrated Report Cycle; see Appendix C for the justification. There are other impaired waters in the Middle Kaskaskia River/Carlyle Lake watershed that are not being addressed by this TMDL study.

Table 1. Impairments in the Middle Kaskaskia River watershed addressed in this TMDL report

Name	Segment ID	Impaired Designated Uses	Cause(s)	Action
Carlyle Lake	IL_ROA	Aesthetic Quality	**Phosphorus**	**TMDL (phosphorus)**
Kaskaskia River	IL_O-08	Primary Contact Recreation	**Fecal Coliform**	**TMDL (fecal coliform)**
	IL_O-33	Aquatic Life	Dissolved Oxygen	Delisted*
	IL_O-38	Primary Contact Recreation	**Fecal Coliform**	**TMDL (fecal coliform)**

TMDLs presented in this report are **bolded in yellow**
*Delisted in the 2020/2022 Cycle Integrated Report

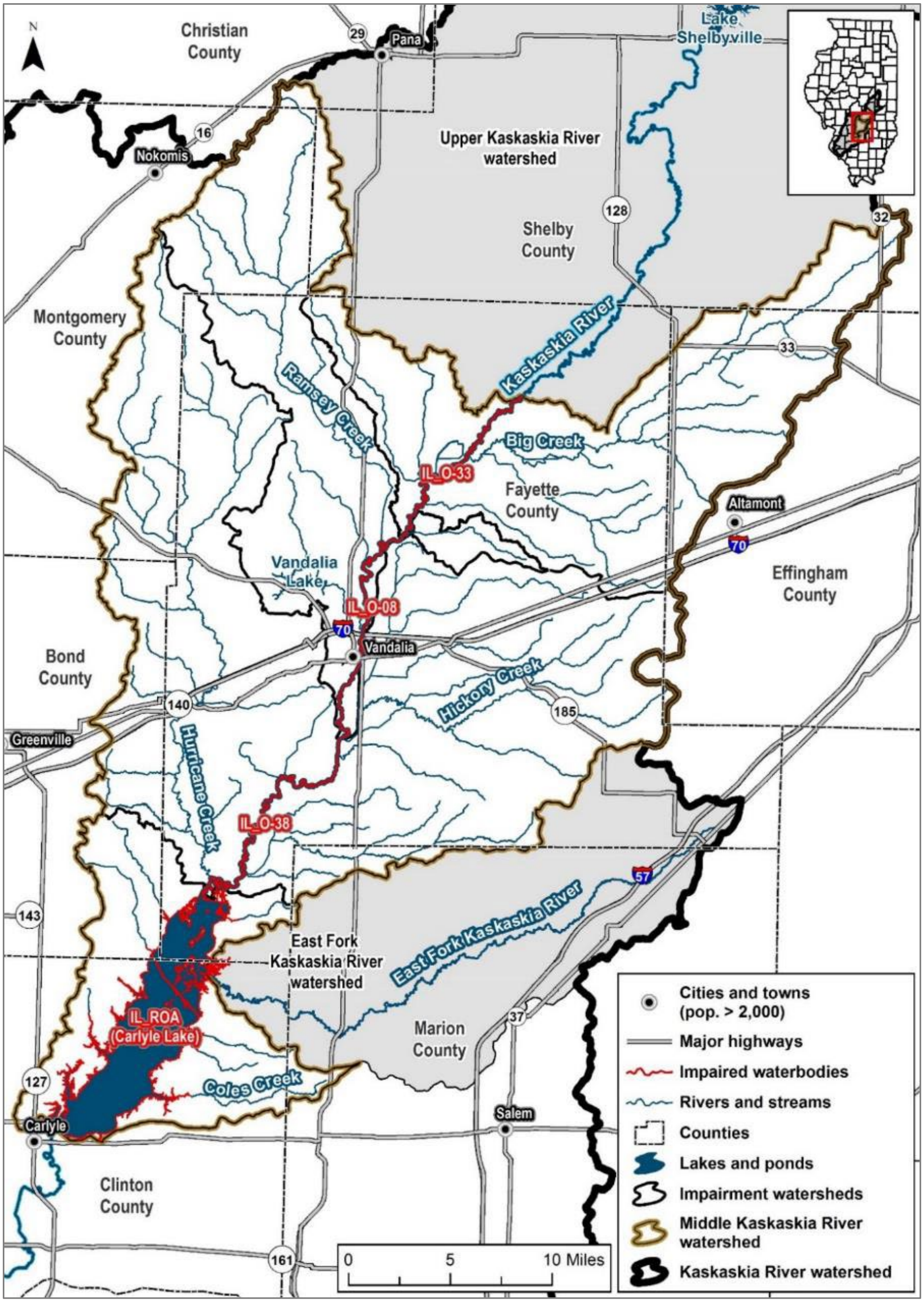

Figure 1. Middle Kaskaskia River/Carlyle Lake watershed, TMDL project area.

Note: IL_O-33 is not addressed in this TMDL document. See Appendix C for more information.

2. Water Quality Standards and 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.

2.1 Designated Uses

IEPA 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 designation provided by the IPCB that apply to waterbodies in the Middle Kaskaskia River 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.

In addition to these IEPA designated uses, the Army Corps of Engineers also identifies the following primary purposes of Carlyle Lake (USACE 2017): flood risk management, navigation, water supply, water quality, fish and wildlife conservation, and recreation. These purposes are not directly applicable to TMDL development; however, they are noted as important to management of the lake.

Carlyle Lake is also designated as a public and food processing water supply. This designation, however, is not applicable to the impairments addressed in this TMDL.

2.2 Water Quality Standards

Environmental regulations for the State of Illinois are contained in the Illinois Administrative Code (Ill. Adm. 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 and TMDL endpoints to be used for TMDL development in the Middle Kaskaskia River watershed are listed in Table 2.

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

Parameter	Units	Water Quality Standard
Fecal Coliform [a]	#/100 mL	400 in <10% of samples [b]
		Geometric mean < 200 [c]
Phosphorus (Total)	mg/L	0.05 for lakes

mg/L - milligram per liter
mL - milliliter
a. Fecal coliform standards are applicable for the recreation season only (May through October).
b. Standard shall not be exceeded by more than 10% of the samples collected during a 30-day period.
c. Geometric mean based on minimum of 5 samples taken over not more than a 30-day period.

According to Illinois WQS, primary contact means *...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* (35 Ill. Adm. Code 301.355). Additional recreational activities that may be impacted include small craft sailing and jet ski operations. The assessment of primary *contact* use is based on fecal coliform bacteria data. The General Use Water Quality Standard for fecal coliform bacteria specifies that during the months of May through October, based on a minimum of five samples taken over not more than a 30-day period, fecal coliform bacteria counts shall not exceed a geometric mean of 200/100 mL, nor shall more than 10% of the samples during any 30-day period exceed 400/100 mL (35 Ill. Adm. Code 302.209). This standard protects primary contact use of Illinois waters by humans.

Due to limited state resources, fecal coliform bacteria are not normally sampled at a frequency necessary to apply the General Use standard, i.e., at least five times per month during May through October, and very little data available from others are collected at the required frequency. Therefore, assessment guidelines are based on application of the standard when sufficient data is available to determine standard exceedances; but, in most cases, attainment of primary contact use is based on a broader methodology intended to assess the likelihood that the General Use standard is being attained.

To assess primary contact use, IEPA uses all fecal coliform bacteria from water samples collected in May through October, over the most recent five-year period (i.e., 2012 through 2016 for this report). Based on these water samples, geometric means and individual measurements of fecal coliform bacteria are compared to the concentration thresholds in Table 3 and Table 4. To apply the guidelines, the geometric mean of fecal coliform bacteria concentration is calculated from the entire set of May through October water samples, across the five years. No more than 10% of all the samples may exceed 400/100 ml for a waterbody to be considered Fully Supporting.

Table 3. Guidelines for Assessing Primary Contact Use in Illinois Streams and Inland Lakes

Degree of Use Support	Guidelines
Fully Supporting	No exceedances of the fecal coliform bacteria standard in the last five years, and the geometric mean of all fecal coliform bacteria observations in the last five years ≤200 cfu/100 ml, and ≤10% of all observations in the last five years exceed 400 cfu/100 ml.
Not Supporting	At least one exceedance of the fecal coliform bacteria standard in the last five years (when sufficient data is available to assess the standard); or, The geometric mean of all fecal coliform bacteria observations in the last five years >200 cfu/100 ml, or >10% of all observations in the last five years exceed 400 cfu/100 ml.

Source: IEPA 2021 (Table C-16).

Table 4. Guidelines for Identifying Potential Causes of Impairment of Primary Contact Use in Illinois Streams and Freshwater Lakes

Potential Cause	Basis for Identifying Cause - Numeric Standard
Fecal coliform	When *Primary Contact* Use is assessed as Not Supporting based on the criteria in Table C-16, Fecal Coliform is listed as the cause.

Source: IEPA 2021 (Table C-17).

The Aesthetic Quality Index (AQI; Table 5) 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 are used to calculate the AQI score. Higher AQI scores indicate increased impairment (Table 6).

Assessments of aesthetic quality use are based primarily on physical and chemical water quality data collected by the IEPA through the Ambient Lake Monitoring Program or the Illinois Clean Lakes Program, or by non-IEPA 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 (TP; epilimnetic[1] 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 lakes sites in any given lake each month. A whole-lake TSI value is calculated for the median Secchi disk transparency, median TP (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 TP in lakes (35 Ill. Adm. Code 302.205) has been incorporated into the weighting criteria used to assign point values for the AQI. Table 7 lists the guidelines for identifying potential causes of aesthetic quality use impairment.

Table 5. 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

Source: IEPA 2021 (Table C-25).

[1] Within the epilimnion of the lake, which is the upper-most layer in a stratified lake.

Table 6. Guidelines for Assessing Aesthetic Quality Use in Illinois Freshwater Lakes

Degree of Use Support	Guidelines
Fully Supporting	Total AQI points <60
Not Supporting	Total AQI points ≥60

Source: IEPA 2021 (Table C-26).

Table 7. Guidelines for Identifying Potential Causes of Impairment of Aesthetic Quality Use in Illinois Freshwater Lakes

Potential Cause	Basis for Identifying Cause(1) - Criteria based on Water Quality Standards(2)
Sludge	The presence of sludge that violates the narrative standard(4)
Bottom Deposits	The presence of bottom deposits that violates the narrative standard(4)
Floating Debris	The presence of floating debris that violates the narrative standard(4)
Visible Oil	The presence of visible oil that violates the narrative standard(4)
Odor	The presence of odor that violates the narrative standard(4)
Specific Odor Causing Pollutant	If identified, the specific pollutant causing odor that violates the narrative standard(4)
Aquatic Algae	The presence of aquatic algae that violates the narrative standard(4)
Aquatic Plants (Macrophytes)	The presence of aquatic macrophytes that violates the narrative standard(4)
Phosphorus (Total)	In lakes ≥ 20 acres, total phosphorus exceeds 0.05 mg/L(3), or In lakes < 20 acres, when the narrative standard(4) is not attained due in part to aquatic plant or algal growth, phosphorus (total) is listed as a contributing cause(3)
Color	The presence of color that violates the narrative standard(4)
Turbidity	The presence of turbidity that violates the narrative standard(4)

Source: IEPA 2021 (Table C-26).

1. In general, a single exceedance of the criteria results in listing the parameter as a potential cause of impairment. Determination of causes is normally based on the most recent year of data from the Ambient Lake Monitoring Program (ALMP) or Source Water Assessment Program.

2. From Illinois General Use Water Quality Standards 35 Illinois Administrative Code, Part 302, Subpart B. Water Quality Standards are available at: https://pcb.illinois.gov/SLR/IPCBandIEPAEnvironmentalRegulationsTitle35.

3. The total phosphorus standard at 35 Ill. Adm. Code 302.205 applies to lakes of 20 acres or larger. In smaller lakes, phosphorus (total) is listed when the narrative standard in 35 Ill. Adm. Code 302.203 is not attained due to aquatic plant or algal growth.

4. The Offensive Condition narrative standard in 35 Ill. Adm. Code 302.203.

2.3 TMDL Endpoints

Two fecal coliform TMDLs were developed for each of the impaired segments of the Kaskaskia River (IL_O-08 and IL_O-38). One TMDL each was set to a target of 200 colony forming units per 100 milliliters (cfu/100 mL), which is the value of the geometric mean standard, and one TMDL each was set to a target of 400 cfu/100mL, which is the value of the instantaneous standard.

The TP TMDL for Carlyle Lake (IL_ROA) was set to a target of 0.05 mg/L as phosphorus, which is the TP standard for lakes to protect the aesthetic quality use.

3. Watershed Characterization

The Middle Kaskaskia River/Carlyle Lake watershed is in central Illinois (Figure 1). The headwaters for the watershed begin north of Vandalia City, IL. The Kaskaskia River then flows through Carlyle Lake at the downstream end of the watershed. Carlyle Lake is a very popular recreational area, has five swimming beaches, and is frequented by jet skiers, swimmers, kayakers and other small watercraft. The TMDL watershed covers 946 square miles; major tributaries of the river include Big Creek, Ramsey Creek, Hickory Creek, and Hurricane Creek.

3.1 Jurisdictions and Population

Counties with land located in the watershed area include Bond, Christian, Clinton, Effingham, Fayette, Marion, Montgomery, and Shelby. The city of Vandalia is the only major government unit with jurisdiction in the Middle Kaskaskia River/Carlyle Lake watershed area. The cities of Altamont, Nokomis, Greenville, and Carlyle border the watershed, with the city of Carlyle located along the downstream end of Carlyle Lake. Populations are area weighted to the watershed in Table 8. All county population estimates, with the exception of Fayette County, were adjusted to account for major cities within the counties but outside the watershed area. Fayette County had not major city outside of the Middle Kaskaskia River\Carlyle Lake project area.

Table 8. Area weighted county populations in watershed

County	Percent (%) of County in Project Area	Area-Weighted Population in Project Area [a]		Change (%)
		2000	2010	
Bond	15.4%	1,649	1,662	1%
Christian	0.3%	57	55	-4%
Clinton	16.1%	3,722	4,005	8%
Effingham	14.2%	3,104	3,109	0%
Fayette	82.4%	17,959	18,237	2%
Marion	2.6%	573	549	-4%
Montgomery	13.4%	2,289	1,970	-14%
Shelby	3.6%	638	629	-1%
	TOTAL	***29,991***	***30,216***	***1%***

a. Area-weighted populations are calculated based on 2000 and 2010 U.S. Census Bureau data. Area-weighted populations were adjusted to exclude the populations of all cities located 100% outside of the Middle Kaskaskia watershed area.

3.2 Climate

Climate data are available from the National Oceanic and Atmospheric Administration (NOAA) Global Historical Climatology Network Database; station USC00111290 is located at the southern end of Carlyle Lake near Carlyle, IL, along the southern boundary of the watershed. Daily data from 1962-2016 for temperature, precipitation and snowfall are summarized in Table 9. In general, the climate of the region is continental with hot, humid summers and cold winters. The average high winter temperature is 40° F and the average high summer temperature is 86° F. The annual average precipitation is approximately 41-inches, including approximately 11-inches of snowfall. In general, larger volumes of precipitation tend to occur between the months of April and September.

Table 9. Climate summary for Carlyle Lake (1962–2016)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average High (ºF)	37	41	53	65	75	84	87	86	79	68	54	42
Average Low (ºF)	19	23	34	45	55	64	67	65	57	45	35	25
Mean Temperature (ºF)	25	28	39	51	60	69	72	69	61	50	40	30
Average Precipitation (in)	2.2	2.2	3.6	4.2	4.4	4.5	3.8	3.0	3.4	3.0	3.5	3.1
Average Snowfall (in)	3.5	2.9	1.7	0.2	0.0	0.0	0.0	0.0	0.0	0	0.7	2.2

Source: NOAA Global Historical Climatology Network Database

3.3 Land Use and Land Cover

Land use in the watershed is heavily influenced by agriculture (Figure 2). Urban area is located near the city of Vandalia and several small towns in the watershed. Land use in the watershed includes agriculture – cultivated crops and pasture/hay (63%), forest (24%), and urban (8%). Corn and soybeans are the most common crops, with much smaller areas of spring wheat, alfalfa, and other crops. Table 10 presents area and percent by land cover type as provided in the 2011 National Land Cover Database.

Table 10. Watershed land use summary

Land Use / Land Cover Category	Acres	Percentage
Cultivated Crops	292,084	48.3%
Deciduous Forest	144,502	23.9%
Hay/Pasture	86,656	14.3%
Developed, Open Space	35,643	5.9%
Open Water	28,869	4.8%
Developed, Low Intensity	8,196	1.4%
Woody Wetlands	3,615	0.6%
Herbaceous	2,472	0.4%
Developed, Medium Intensity	1,528	0.3%
Emergent Herbaceous Wetlands	1,228	0.2%
Developed, High Intensity	357	<0.1%
Evergreen Forest	104	<0.1%
Barren Land	60	<0.1%

Source: 2011 National Land Cover Database (Multi-Resolution Land Consortium 2015)

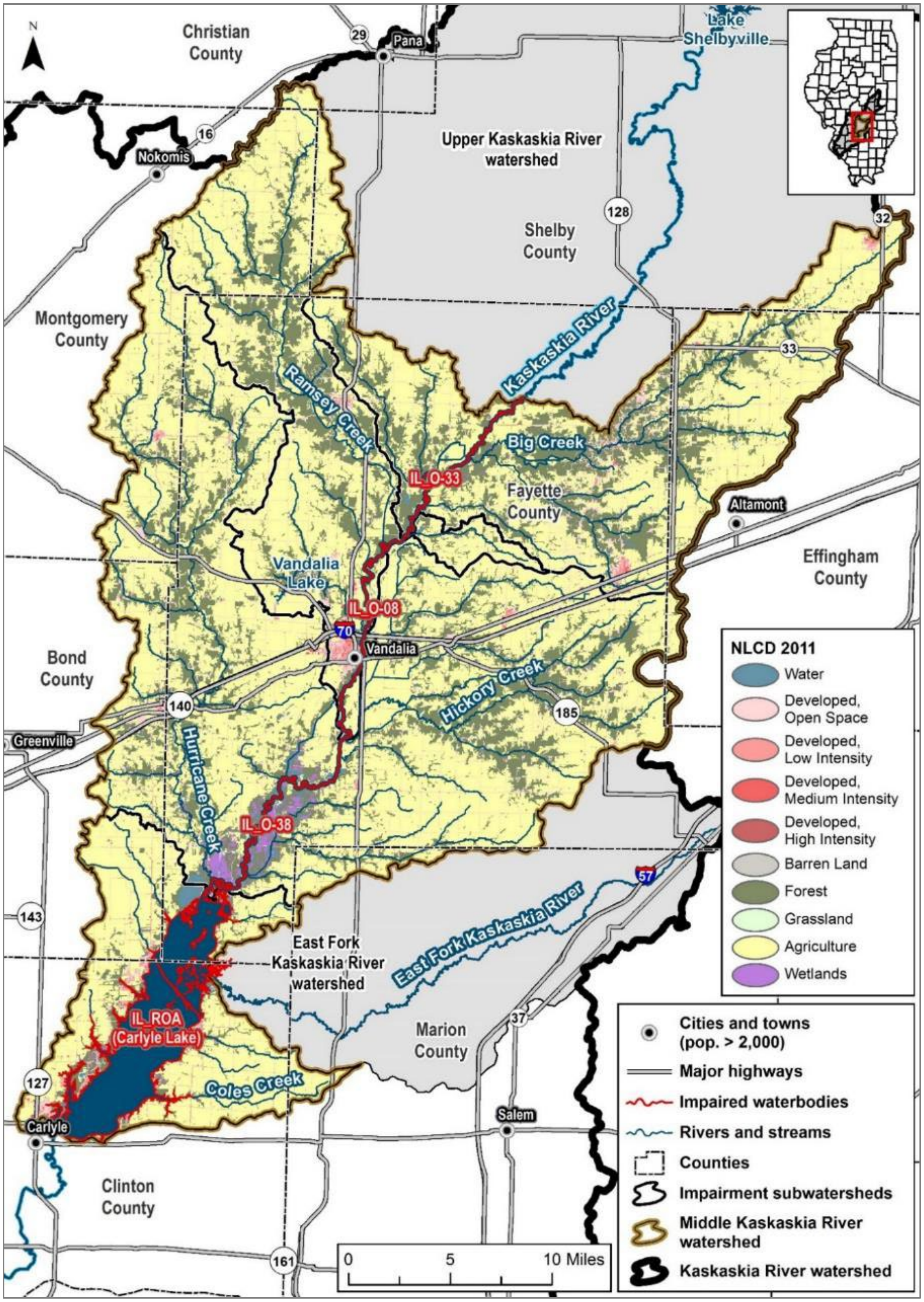

Figure 2. Middle Kaskaskia River/Carlyle Lake watershed land cover (2011 National Land Cover Database).

Note: IL_O-33 is not addressed in this TMDL document. See Appendix C for more information.

3.4 Topography

Topography is an important factor in watershed management because stream types, precipitation, and soil types can vary dramatically by slope and elevation. The Middle Kaskaskia River/Carlyle Lake watershed varies in elevation from 802- to 438-feet (Figure 3). The Kaskaskia River water elevation varies from 492-feet to 447-feet and is 54-miles long upstream of the inlet to Carlyle Lake, resulting in a river gradient of 0.8-feet per mile. The highest elevations in the watershed are in the headwaters of Ramsey Creek and Hurricane Creek. The watershed topography consists of gently rolling terrain with steeper areas surrounding tributary streams. In the floodplain of Kaskaskia River, the topography is mostly flat (Carlyle Lake Watershed Technical and Planning Committees 2000).

3.5 Soils

The National Cooperative Soil Survey publishes soil surveys for each county in the United States, and these data were obtained from the Natural Resources Conservation Service (NRCS). These soil surveys contain predictions of soil behavior for selected land uses. The surveys also highlight limitations and hazards inherent in the soil, general improvements needed to overcome the limitations, and the impact of selected land uses on the environment. The soil surveys are designed for many different uses, including land use planning, the identification of special practices needed to ensure proper performance, and mapping of hydrologic soil groups (HSGs).

HSGs refer to the grouping of soils according to their runoff potential. Soil properties that influence the HSGs include depth to seasonal high water table, infiltration rate and permeability after prolonged wetting, and depth to a slower permeable layer (e.g., finer grained). There are four groups of HSGs: Group A, B, C, and Group D. Table 11 describes those HSGs found in the Middle Kaskaskia River/Carlyle Lake watershed. Figure 4 and Table 12 summarizes the composition of HSGs in the watershed. Soils are predominantly C, C/D and D in the watershed. The high proportion of C, C/D and D type soils coupled with agricultural land uses indicate the likelihood of tile drainage.

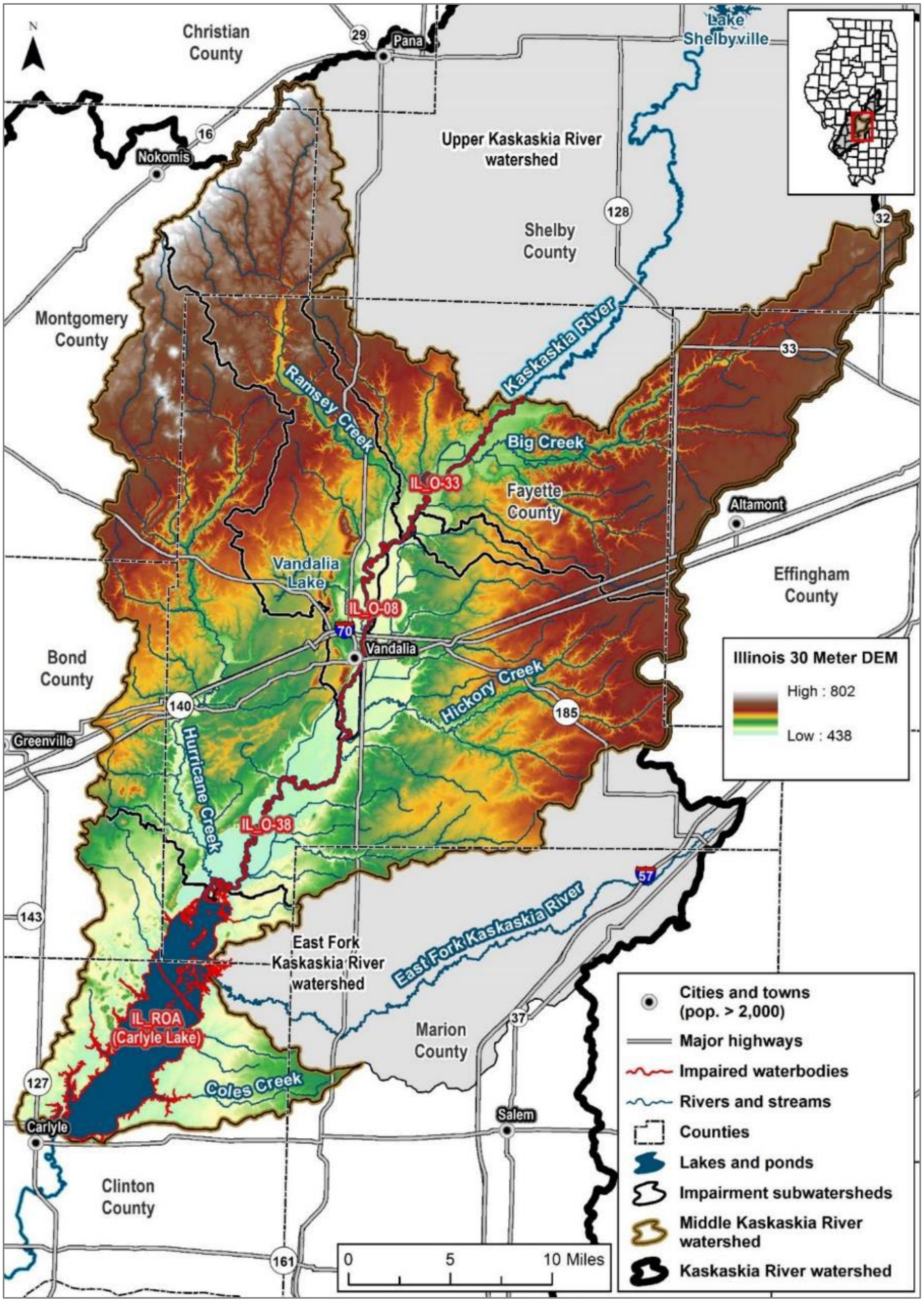

Figure 3. Middle Kaskaskia River/Carlyle Lake watershed elevations (Illinois State Geological Survey 2003).

Note: IL_O-33 is not addressed in this TMDL document. See Appendix C for more information.

Table 11. Hydrologic soil group descriptions

HSG	Group Description
A	Sand, loamy sand or sandy loam types of soils. Low runoff potential and high infiltration rates even when thoroughly wetted. Consist chiefly of deep, well to excessively drained sands or gravels with a high rate of water transmission.
B	Silt loam or loam. Moderate infiltration rates when thoroughly wetted. Consist chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
C	Soils are sandy clay loam. Low infiltration rates when thoroughly wetted. Consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
D	Soils are clay loam, silty clay loam, sandy clay, silty clay or clay. Group D has the highest runoff potential. Low infiltration rates when thoroughly wetted. Consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.
A/D B/D C/D	Dual Hydrologic Soil Groups. Certain wet soils are placed in group D based solely on the presence of a water table within 24 inches of the surface even though the saturated hydraulic conductivity may be favorable for water transmission. If these soils can be adequately drained, then they are assigned to dual hydrologic soil groups (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and the water table depth when drained. The first letter applies to the drained condition and the second to the undrained condition.

Table 12. Percent composition of hydrologic soil groups in watershed

Hydrologic Soil Group (HSG)	Acres	Percentage
B	41,917	6.9%
B/D	26,590	4.4%
C	249,614	41.2%
C/D	128,345	21.2%
D	130,517	21.6%
No Data	28,337	4.7%

Source: Soil Survey Graphic (SSURGO) Database (Natural Resources Conservation Service 2011)

A commonly used soil attribute is the K-factor, or the soil erodibility index. The distribution of K-factor values in the Middle Kaskaskia River watershed range from 0.26 to 0.53, with an average value of 0.39 (Figure 5). The higher the K-factor, the more susceptible the soil is to erosion.

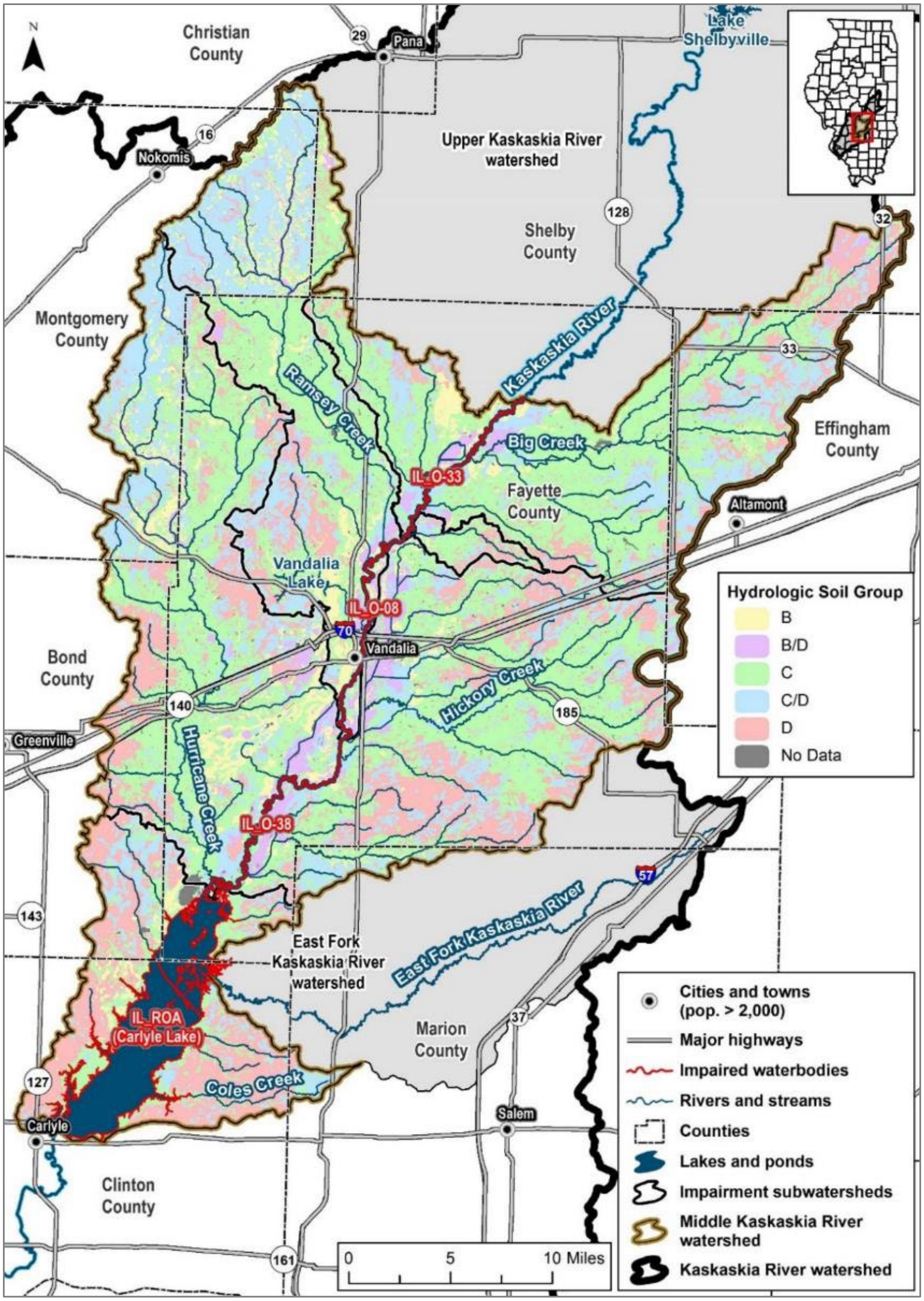

Figure 4. Middle Kaskaskia River/Carlyle Lake watershed hydrologic soil groups (Soil Surveys for Bond, Christian, Clinton, Effingham, Fayette, Marion, Montgomery and Shelby Counties, Illinois; NRCS SSURGO Database 2011).

Note: IL_O-33 is not addressed in this TMDL document. See Appendix C for more information.

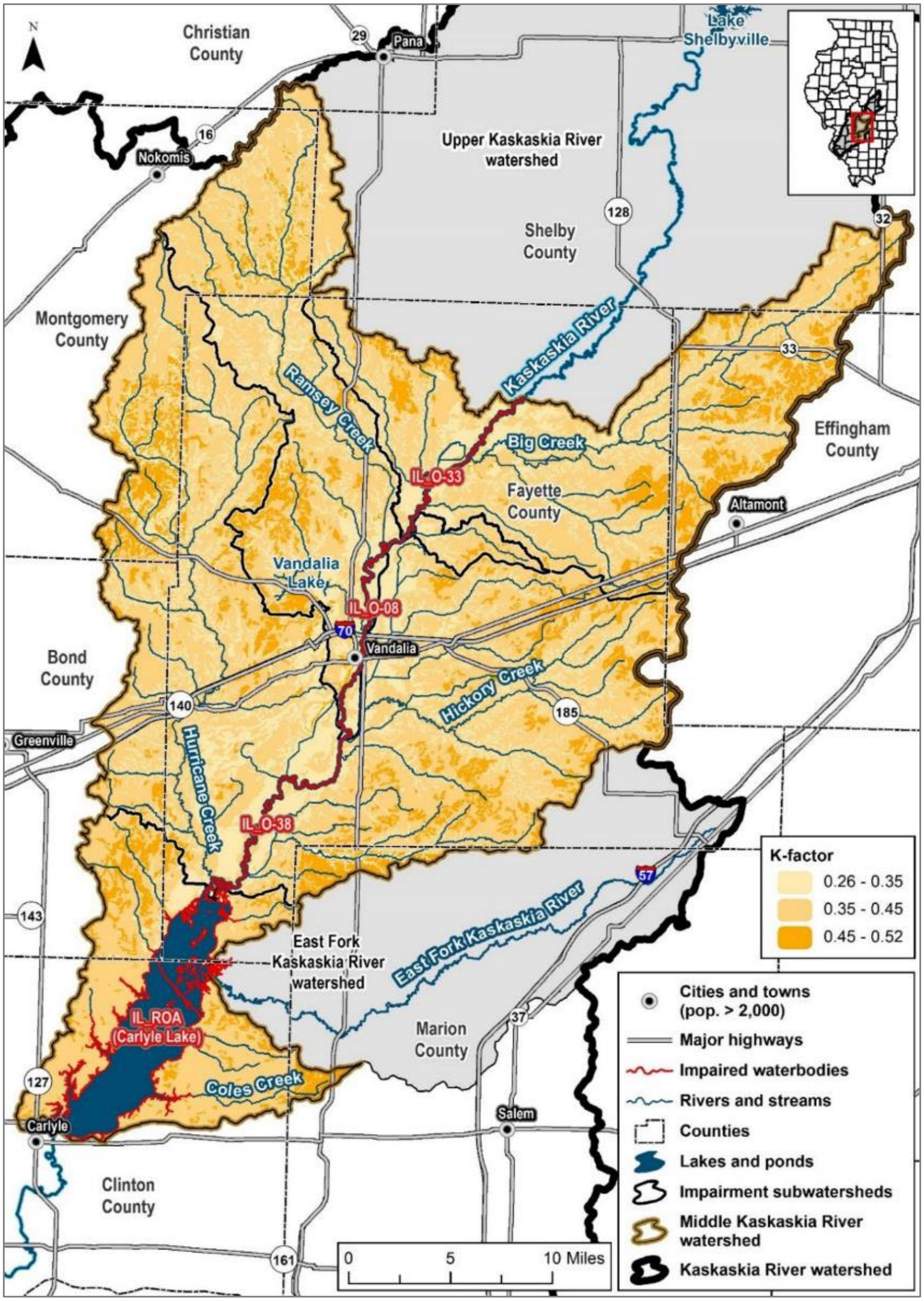

Figure 5. Middle Kaskaskia River/Carlyle Lake watershed soil K-factor values (Soil Surveys for Bond, Christian, Clinton, Effingham, Fayette, Marion, Montgomery and Shelby Counties, Illinois; NRCS SSURGO Database 2011).

Note: IL_O-33 is not addressed in this TMDL document. See Appendix C for more information.

3.6 Hydrology

Hydrology plays an important role in evaluating water quality. The hydrology of the Middle Kaskaskia River/Carlyle Lake watershed is driven by local climate conditions and the landscape. The U.S. Geological Survey (USGS) has been collecting flow and water quality data in this watershed since the early 1900s (Table 13 and Figure 9). There are four active USGS gages in the watershed.

The daily average, peak history, and monthly flow data show the inherent variability associated with hydrology. Flow duration curves provide a way to address that variability and flow related water quality patterns. Duration curves describe the percentage of time during which specified flows are equaled or exceeded. Flow duration analysis looks at the cumulative frequency of historic flow data over a specified period, based on measurements taken at uniform intervals (e.g., daily average or 15-minute instantaneous). Duration analysis results in a curve that relates flow values to the percent of time those values have been met or exceeded. Low flows are exceeded a majority of the time, whereas floods are exceeded infrequently. A flow duration curve for active USGS gage 05592500 is presented in Figure 6.

Table 13. USGS gages in impairment watersheds

Gage ID	Watershed Area ($mi.^2$)	Location	Period of Record	Impaired Segment
05592300	47.9	Wolf Creek near Beecher City, IL	1908-1982	-
05592350	87.3	Big Creek at Wrights Corner, IL	1961-1963	-
05592355	95.4	Big Creek near Post Oak, IL	1980-1981	-
05592360	35.3	South Fork near Pruett, IL	1980-1981	-
05592370	19.5	Ash Creek near Ramsey, IL	1980-1981	-
05592380	8.93	Bolt Creek near Ramsey, IL	1980-1981	-
05592400	97.3	Ramsey Creek near Ramsey, IL	1980-1981	-
05592500	**1,940**	**Kaskaskia River at Vandalia, IL**	**1908-2016**	**IL_O-08**
05592575	**44.2**	**Hickory Creek near Brownstown, IL**	**1988-2016**	**-**
05592600	77.6	Hickory Creek near Bluff City, IL	1977-1997	-
05592700	0.14	Hurricane Creek tributary near Witt, IL	1956-1980	-
05592800	**152**	**Hurricane Creek near Mulberry Grove, IL**	**1970-2016**	**-**
383706089210701	**2,717**	**Kaskaskia River at Carlyle Lake, IL (in-lake)**	**2017-2018**	**IL_ROA**
383715089204501	- [a]	Carlyle Lake Site 2	1991-1991 [b]	IL_ROA
384408089160001	- [a]	Carlyle Lake	1991-1992 [b]	IL_ROA

BOLD – indicates active USGS gage
a. Lake monitoring station.
b. Water quality data only, no flow data available.

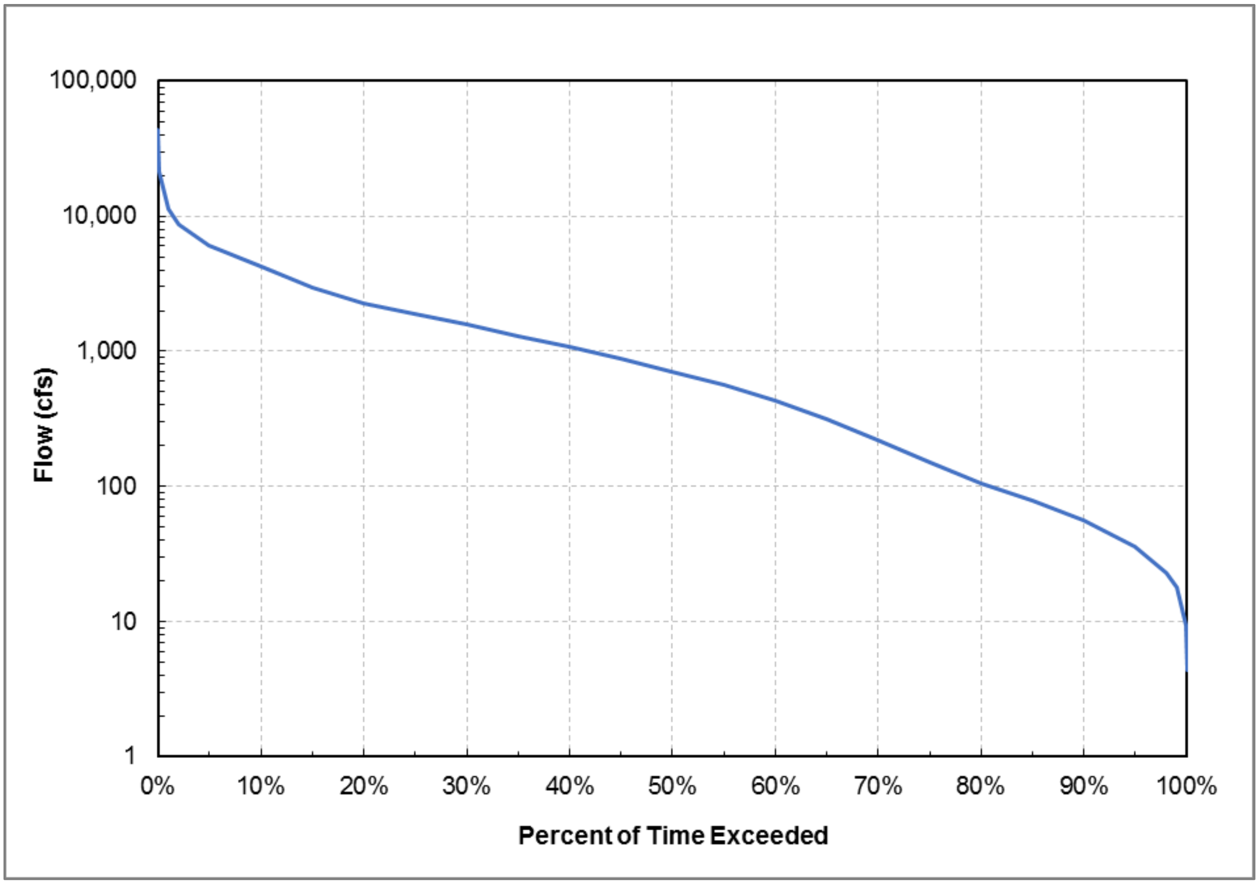

Figure 6. Flow duration curve for USGS gage 05592500, Kaskaskia River at Vandalia, IL (1908-2016).

An evaluation of annual flow at USGS gage 05592500 from 1908–2016 showed that annual flow in 2001 was nearly at the median; thus, it is assumed that 2001 is a typical year. Flow at USGS gage 05592500 is plotted with precipitation from the NOAA Global Historical Climatology Network Database Station USC00111290 (Carlyle Lake) in Figure 7. Flows in the Kaskaskia River decrease significantly during the late summer and early fall with decreasing precipitation.

There are no active flow gages on the Kaskaskia River or other incoming tributaries immediately upstream of Carlyle Lake. Flows through Carlyle Lake are monitored by USACE using the water surface elevation. A minimum and maximum water surface elevation is managed by the USACE at the dam to control flooding in and downstream of the lake and to maintain adequate water levels for recreation (USACE 2017).

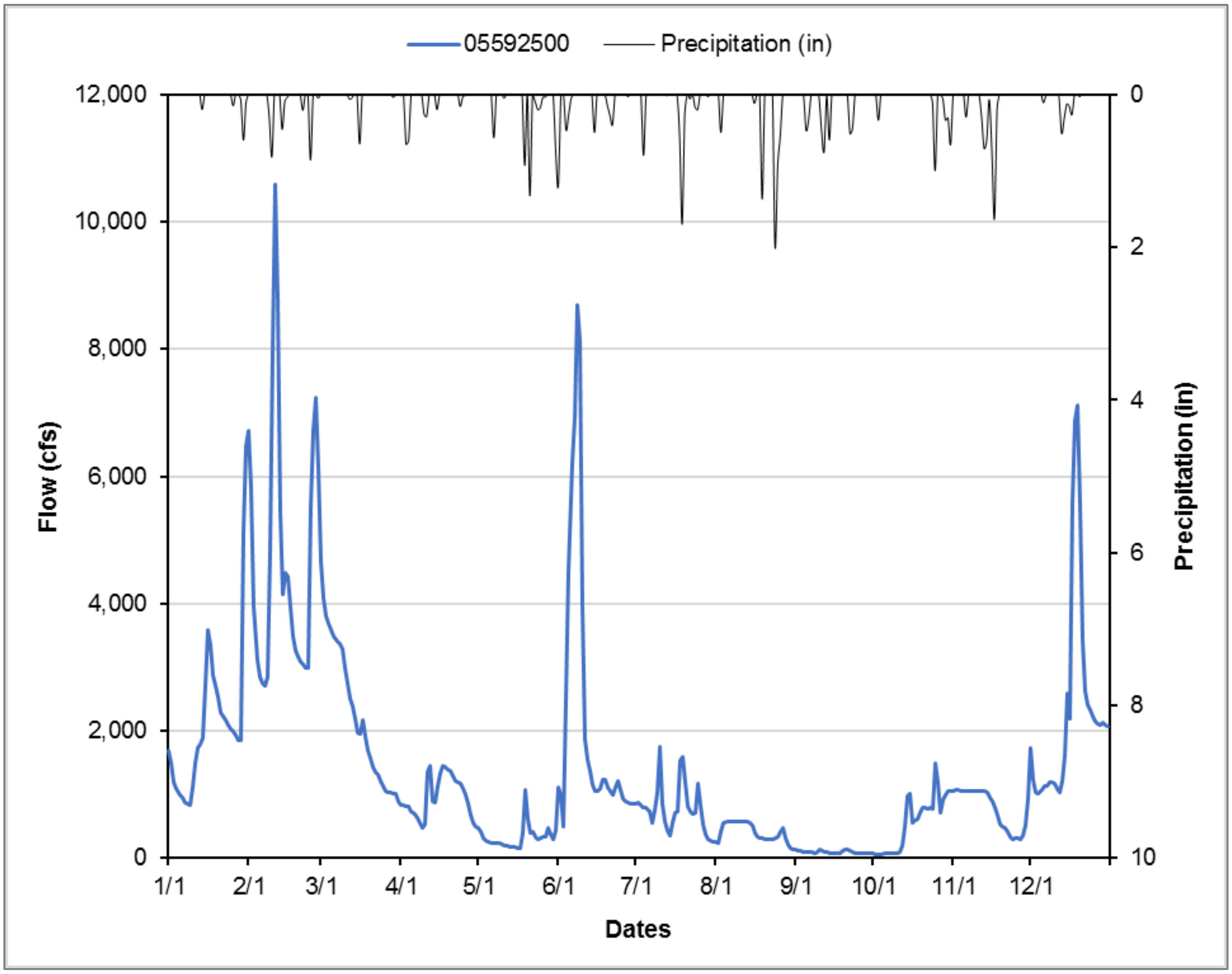

Figure 7. Daily flow in the Kaskaskia River with daily precipitation at Carlyle Lake (USC00111290), 2001.

3.7 Watershed Studies and Other Watershed Information

This section describes several of the studies that have been completed in the watershed. Many will be useful in the development of the TMDL implementation plan.

- **Carlyle Lake Watershed Plan** (Carlyle Lake Watershed Technical and Planning Committees 2000)

  The Carlyle Lake Watershed Plan provides an approach to environmental improvement based on current data and analysis for the Carlyle Lake watershed. The plan was a collaborative effort between the Carlyle Lake Watershed Committee, local soil and water conservation districts, and the public. It established goals, concerns, and recommendations for land use and recreation in the watershed. Funding was provided by an Illinois Department of Natural Resources Conservation 2000 Ecosystems Project grant.

- **Carlyle Lake Master Plan** (USACE 2017)

  The Carlyle Lake Master Plan has been developed for use as a guide for resource development impacting Carlyle Lake. The plan was first developed by the USACE in 1962 and has been updated and revised in 1974, 1979, 1986, 1997 and 2016. A description of Carlyle Lake and the land use, development pressures, and other important features of the Carlyle Lake watershed are included in the plan as well as a specific plan for resource development. Ongoing water quality, high water, fisheries, recreation and other issues are also discussed.

- **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% 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.

- **Vandalia Lake TMDL** (CDM 2004)

  This previous TMDL provides information on nutrient loading from Vandalia Lake.

- **Kaskaskia River–North Fork TMDL** (Limno Tech 2007)

  This previous TMDL provides information on pH, manganese, iron, and dissolved oxygen in the North Fork Kaskaskia River, which drains into Carlyle Lake.

- **Evaluating Watershed Health Through Integrated Water Quality Analysis and Community Capacity Assessments** (Williard 2017)

  This plan considers water quality and health risk, the impact of land use, community planning and conservation practices, and outreach techniques for the Carlyle Lake area.

- **Bank Erosion and Historical River Morphology Study of the Kaskaskia, Shelbyville to Carlyle Lake** (USACE 2003)

  This study analyzes the river evolution of the Middle and Lower sections of the Kaskaskia River and compares and recommends corrective actions for erosion problems.

- **Report on Carlyle Reservoir Wildlife Management Area Study** (USACE n.d.)

  This report examines methods of protecting the levee from flash flooding from Hurricane Creek, a tributary to Carlyle Lake.

- **Report of Sedimentation 1999 Resurvey Carlyle Reservoir** (USACE 2000)

  This report provides depth data on Carlyle Lake from its inception to 1999.

- **Carlyle Lake Watershed Plan** (CLA Technical Committee 1999)

  This report provides an overview of the Carlyle Lake watershed morphology, problems facing the watershed, and recommended actions.

- **Analysis of the Operation of Lake Shelbyville and Carlyle Lake to Maximize Agricultural and Recreational Benefits** (Illinois State Water Survey 1975)

  This survey discusses the lake and how it was functioning five years after it was created.

- **Water Quality Evaluation, Carlyle Lake 2006-2010** (USACE 2011) and **2014 Carlyle Lake Water Quality Report** (USACE 2015)

  These reports provide USACE water quality monitoring data for Carlyle Lake.

- **2016 Lake Shelbyville Masterplan Updat**e (USACE 2016)

  This report reviews current and future upgrades to the Carlyle Lake Project.

- **Historical River Morphology Study of the Kaskaskia River Headwaters to Lake Shelbyville** (USACE 2010)

  This report analyzes the river evolution upstream of the Middle Kaskaskia River watershed and compares and recommends corrective actions for erosion problems.

4. 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 listed pollutants (i.e., fecal coliform and phosphorus) in the Middle Kaskaskia River/Carlyle Lake watershed.

4.1 Pollutants of Concern

Pollutants of concern evaluated in this source assessment include fecal coliform and phosphorus. These pollutants can originate from an array of sources including point and nonpoint sources. 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.

4.2 Point Sources

Point source pollution is defined by the Federal 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 storm water including municipal separate storm sewer systems (MS4s). New information was obtained during Stage 3 and there are no MS4s in the watershed.

4.2.1 NPDES Facilities (Non-CAFO or stormwater)

NPDES facilities in the Middle Kaskaskia River/Carlyle Lake study area include municipal and industrial wastewater treatment and public water supply facilities. There are 9 individual NPDES permitted facilities in the project area (Table 14 and Figure 8). Additionally, 6 facilities are covered by one of two general NPDES permits (Table 15 and Figure 8):

- ILG580 (publicly owned domestic lagoon system, serving a population of <2,500)
- ILG640 (public water supply)

Average and maximum design flows and downstream impairments are included in the facility summaries. Three municipal wastewater facilities (IL0023574, IL0025933 and IL0061697) and one public water supply facility (ILG640114) drain directly to impaired waterbodies.

Three facilities are not expected to discharge fecal coliform or phosphorus: Marathon Petroleum-St. Elmo (IL0032271; industrial stormwater), Vandalia Water Treatment Plant (WTP; ILG640114; backwash), and Ramsey WTP (ILG640141; backwash). IEPA does not expect industrial stormwater or WTP backwash[2] to contain appreciable levels of fecal coliform or phosphorus.

Eight wastewater treatment facilities have disinfection exemptions in the watershed which allow a facility to discharge wastewater without disinfection during a specified period (Figure 8). Facilities with disinfection exemptions may be required to provide IEPA with updated information to demonstrate compliance with these requirements. No disinfection exempt facilities directly discharge into fecal-impaired segments.

[2] IEPA does not require public water supplies and water treatment plants to monitor their backwash for phosphorus. However, low phosphorus concentrations in such backwash has been observed at water treatment plants in other states. In the future, IEPA may investigate and quantify potential phosphorus concentrations in backwash from public water supplies and water treatment plants in Illinois.

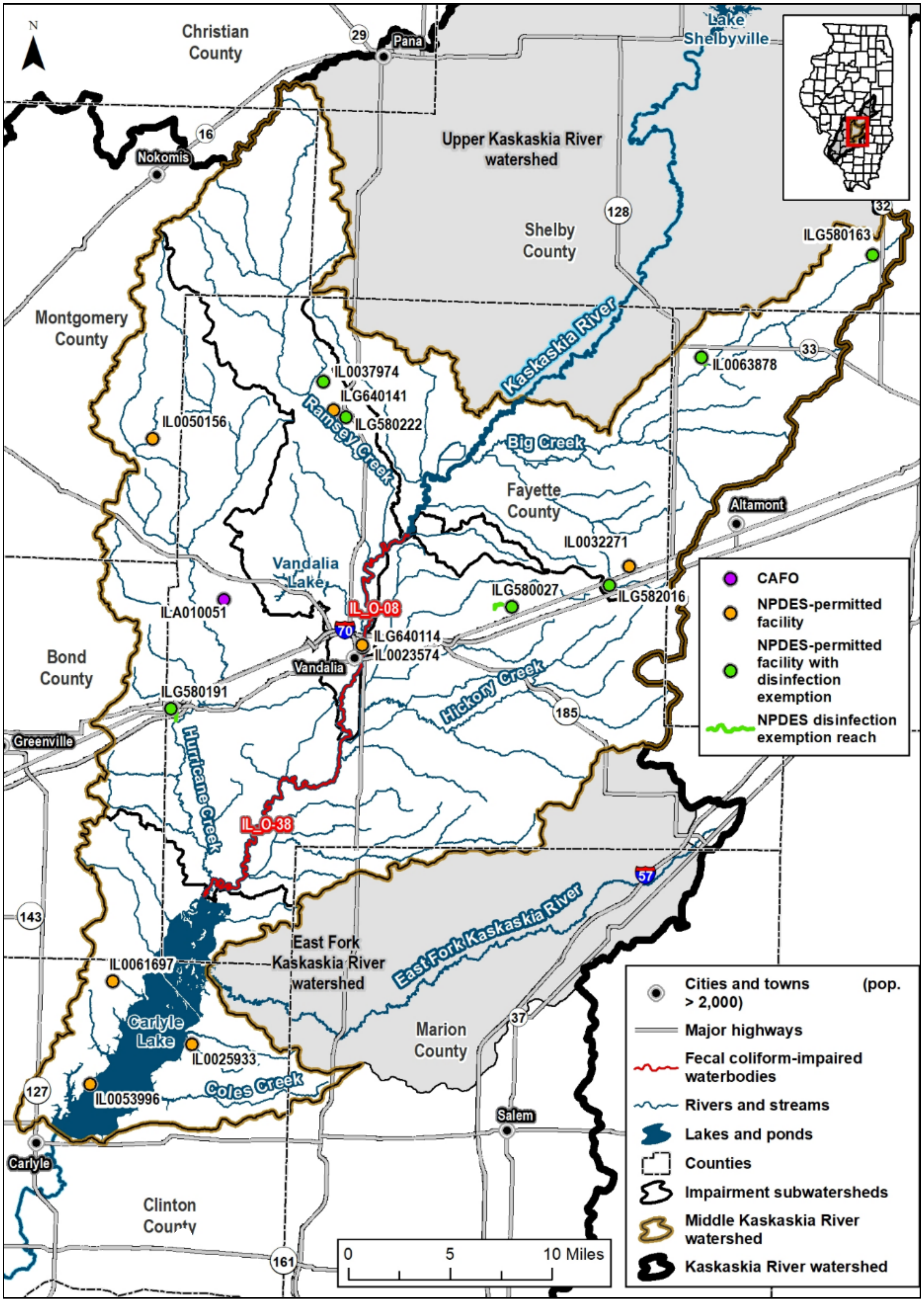

Figure 8. Point sources and facilities with disinfection exemption draining to fecal coliform impaired streams.

Table 14. Individual NPDES permitted facilities in impairment watersheds

IL Permit ID	Facility Name	Type of Discharge	Receiving Water	Downstream Impairment(s)	DAF (MGD)	DMF (MGD)	Disinfection Exemption	Existing TP Limit (mg/L) [a]
IL0023574	Vandalia STP	STP	Kaskaskia River	O-08, O-38, ROA	1.3	8.25	No DE	1.0/2.0
IL0025933	USACOE Carlyle	STP	Carlyle Lake	ROA	0.025	--	No DE	1.0 @DMF
IL0030872	St. Elmo STP	STP	St. Elmo Ditch	O-08, O-38, ROA	0.40	1.367	DE [b]	Monitoring
IL0032271	Emulsicoat of Southern Illinois LLC - St. Elmo	Multiple [d]	Unnamed ditch to East City reservoir	O-08, O-38, ROA	0.35	--	-- [c]	-- [c]
IL0037974	Ramsey Lake State Park	STP	Unnamed tributary to Ramsey Creek	O-08, O-38, ROA	0.015	0.0375	DE [b]	No TP Limit
IL0050156	Fillmore STP	STP	Lanes Branch	O-38, ROA	0.049	0.195	DE [b]	No TP Limit
IL0053996	IL DNR-Eldon Hazlet State Park	STP	Unnamed tributary of Carlyle Lake	ROA	0.0637	0.2548	No DE	No TP Limit
IL0061697	Hickory Shores Resort	STP	Carlyle Lake	ROA	0.01	0.02	No DE	Monitoring
IL0063878	Beecher City STP	STP	Wolf Creek	O-08, O-38, ROA	0.052	0.105	DE [b]	No TP Limit

DAF - design average flow
DE - disinfection exemption
DMF – design maximum flow
MGD – Million gallons per day
STP – Sewage treatment plant
TP – total phosphorus
a. The existing TP limits are displayed as monthly average and/or daily maximum.
b. Disinfection exemption with a monitoring requirement only for May through October.
c. Emulsicoat of Southern Illinois, LLC, was formerly permitted by Marathon Petroleum.
d. Water softener backwash, boiler blowdown, water feed line, hydrostatic test water, and stormwater runoff. These discharges are not expected to contribute fecal coliform or phosphorus.

Table 15. General NPDES permitted facilities in impairment watersheds

IL Permit ID	Facility Name	Type of Discharge	Receiving Water	Downstream Impairment(s)	DAF (MGD)	DMF (MGD)	Disinfection Exemption	Existing TP Limit (mg/L)
Domestic Lagoon Systems covered by a General NPDES Permit (ILG580)								
ILG580027	Brownstown STP	STP	Unnamed tributary to Camp Creek North	O-38, ROA	0.1	0.327	DE [a]	No TP Limit
ILG580163	Stewardson STP	STP	Wolf Creek	O-08, O-38, ROA	0.11	0.275	DE [a]	No TP Limit
ILG580191	Mulberry Grove SD STP	STP	Owl Creek	O-38, ROA	0.0864	0.237	DE [a]	No TP Limit
ILG580222	Ramsey STP	STP	Little Ramsey Creek	O-08, O-38, ROA	0.171	0.632	DE [a]	No TP Limit
Public Water Supplies covered by a General NPDES Permit (ILG640)								
ILG640114	Vandalia WTP	PWS	Kaskaskia River	O-08, O-38, ROA	0.12 [b]	--	No DE [c]	No TP Limit [c]
ILG640141	Ramsey WTP	PWS	Little Ramsey Creek	O-08, O-38, ROA	0.014 [b]	--	No DE [c]	No TP Limit [c]

DAF - design average flow
DE - disinfection exemption
DMF – design maximum flow
MGD – Million gallons per day
PWS – public water supply
STP – Sewage treatment plant
WTP – Water treatment plant
a. Disinfection exemption with a monitoring requirement only for May through October.
b. Average of DMR flows (2014-2016).
c. These facilities are not expected to contribute fecal coliform or phosphorus. As previously discussed, IEPA does not require PWS and WTPs to monitor their backwash for phosphorus and generally does not consider PWS or WTP as sources of phosphorus.

4.2.2 CAFOs

The area that produces manure, litter, or processed wastewater as the result of CAFOs is considered a point source that is regulated through the NPDES Program. In Illinois, the CAFO program is administered by the Illinois EPA through general permit number ILA01. The federal regulations for all CAFOs can be found in 40 CFR Parts 9, 122, and 412.U.S. EPA requires that CAFOs receive a wasteload allocation as part of the TMDL development process. The wasteload allocation is typically set at zero for all pollutants. There is one CAFO in the Middle Kaskaskia watershed: Wilder - South (ILA010051; Figure 8). The facility is located in the Hurricane Creek watershed. Hurricane Creek drains to fecal coliform-impaired segment O-38 of the Kaskaskia River.

4.2.3 NPDES Facilities (Non-CAFO or stormwater) in the Upstream Watersheds

The development of a TP TMDL to address the impaired aesthetic use of Carlyle Lake requires the assignment of WLAs to sources of TP within 25-miles upstream of Carlyle Lake (according to 35 Ill. Adm. Code 304.123[3]), which includes the East Fork Kaskaskia River and Farina Lake watershed. Permitted facilities in this upstream watershed are presented Table 16. Not all of these facilities are expected to be sources of phosphorus.

[3] Section 304.123(c) states

Pursuant to Section 28.1 of the Environmental Protection Act (Act) [415 ILCS 5/28.1], the owner or operator of any source subject to subsection (b) of this Section may apply for an adjusted standard. In addition to the proofs specified in Section 28.1(c) of the Act [415 ILCS 5/28.1(c)], such application shall, at a minimum, contain adequate proof that the effluent resulting from grant of the adjusted standard will not contribute to cultural eutrophication, unnatural plant or algal growth or dissolved oxygen deficiencies in the receiving lake or reservoir. For purposes of this subsection (c), such effluent shall be deemed to contribute to such conditions if phosphorus is the limiting nutrient for biological growth in the lake or reservoir, taking into account the lake or reservoir limnology, morphological, physical and chemical characteristics, and sediment transport. However, if the effluent discharge enters a tributary at least 40.25 kilometers (25 miles) upstream of the point at which the tributary enters the lake or reservoir at normal pool level, such effluent shall not be deemed to contribute to such conditions if the receiving lake or reservoir is eutrophic and phosphorus from internal regeneration is not a limiting nutrient.

Table 16. NPDES facilities in the East Fork Kaskaskia River and Farina Lake watershed

IL Permit ID	Facility Name	Type of Discharge	DAF (MGD)	DMF (MGD)	Source of TP
Individual NPDES Permits					
IL0075001	Kinmundy Energy Center	Miscellaneous equipment and floor drain wastewater	0.026	--	No
IL0076422	Alma STP	STP	0.05	0.199	Yes
Domestic Lagoon Systems covered by General NPDES Permits (ILG551 or ILG580)					
ILG580007	St. Peter STP	STP	0.042	0.17	Yes
ILG580022	Patoka STP	STP	0.072	0.149	Yes
ILG580047	Farina STP	STP	0.105	0.62	Yes
ILG580123	Kinmundy STP	STP	0.146	0.442	Yes
Industrial Stormwater covered by a General NPDES Permit (ILG670)					
ILG670059 [a]	Marathon Pipeline Company	Hydrostatic test water	1.44	--	No

DAF – design average flow
DMF – design maximum flow
STP – sewage treatment plant
TP - total phosphorus

a. Marathon Pipeline Company was formerly covered by individual NPDES permit IL0060585.

4.3 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, IEPA has identified several sources as contributing to the Middle Kaskaskia River/Carlyle Lake watershed impairments (Table 17).

Table 17. Potential sources in the project area based on the 2018 305(b) report

Watershed	Segment	Sources
Kaskaskia River	IL_O-08	Source unknown
	IL_O-38	Source unknown
Carlyle Lake	IL_ROA	Source unknown, littoral/shore area modifications (non-riverine), other recreational pollution sources, and crop production (crop land or dry land)

A summary of the potential nonpoint sources of pollutants is provided below, additional information on the primary pollutant sources follow. Potential nonpoint sources of fecal coliform in the Kaskaskia River include animal feeding operations (AFOs), onsite wastewater treatment systems, wildlife and stormwater and agricultural runoff. Nonpoint sources potentially contributing to Carlyle Lake's phosphorus impairment include stormwater and agricultural runoff, stream channel and shoreline erosion (and associated particulate phosphorus), and internal loading.

4.3.1 Animal Feeding Operations

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 96,587 animals are in the project area.

4.3.2 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 which 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. County health departments were contacted for information on septic systems and unsewered communities. Responses were received from Bond, Christian, Effingham, and Fayette Counties. Effingham county reported 4,862 installed septic systems since 1985 and Fayette reported permitting 605 installed septic systems since 2009. Christian and Fayette counties reported three and six unsewered communities, respectively. Bond county requires inspection of newly installed septic systems but does not have a total count of installed systems or unsewered communities. No information was provided on failure rates or results of compliance testing.

4.3.3 Wildlife

Wildlife such as deer, raccoon, and waterfowl also contribute to fecal coliform loading in the watershed; however, these sources are not typically managed. While no specific information is available on wildlife populations in the watershed or their potential to impact fecal coliform loadings, according to the University of Illinois–Extension, the highest densities of white tail deer in the state are found in wooded areas in watersheds of major rivers. White tail deer are also known to reside in areas with intensively farmed land (University of Illinois–Extension 2017).

4.3.4 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.

4.3.5 Stream Channel and Shoreline Erosion

Various forms of erosion are a common source of sediment and associated pollutants such as phosphorus. Erosion may contribute to phosphorus impairment in Carlyle Lake because phosphorus is typically bound to sediment. Bank and channel erosion refers to the wearing away of the banks and channel of a stream or river. High rates of bank and channel erosion can often be associated with water flow and sediment dynamics being out of balance. This can result from land use activities that either alter flow regimes, adversely affect the floodplain and streamside riparian areas, or a combination of both. USACE (2017) notes significant sediment entering Carlyle Lake from the Kaskaskia River. In a lake environment, shoreline erosion can be caused by changing water levels and wave action.

4.3.6 Internal Loading

Internal phosphorus loading from lake bottom sediments can be a substantial component of the phosphorus budget in lakes. Phosphorus in the sediment 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 including:

- 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 depths 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.

USACE (2017) reports that Carlyle Lake does not typically stratify during the summer months due to the presence of high winds and the overall shallow depth of the lake. If the lake does stratify, release of phosphorus in the anoxic portion of the lake could occur. USACE (2017) also notes that low dissolved oxygen concentrations often occur in the lake due to algal blooms during periods of high temperatures and low wind.

5. Water Quality

Routine water quality monitoring is a key part of the IEPA assessment program. The goals of IEPA surface water monitoring programs are to determine whether designated uses are supported, identify causes of pollution (toxics, nutrients, sedimentation) and sources (point or nonpoint) of surface water impairments, determine the overall effectiveness of pollution control programs, and identify long term resource quality trends. IEPA has operated a widespread, active long-term monitoring network in Illinois since 1977, known as the Ambient Water Quality Monitoring Network (AWQMN). The AWQMN is utilized by IEPA to provide baseline water quality information, to characterize and define trends in the physical, chemical and biological conditions of the state's waters, to identify new or existing water quality problems, and to act as a triggering mechanism for special studies or other appropriate actions.

Additional uses of the data collected by IEPA through the AWQMN program include the review of existing water quality standards and establishment of water quality based effluent limits for NPDES permits. The AWQMN is integrated with other Illinois EPA chemical and biological stream monitoring programs including Intensive River Basin Surveys, Facility –Related Stream Surveys, Fish Contaminant Monitoring, Toxicity Testing Program and Pesticide Monitoring Subnetwork which are more regionally based (specific watersheds or point source receiving stream) and cover a shorter span of time (e.g. one year) to evaluate compliance with water quality standards and determine designated use support. Information from this program is compiled by IEPA into a biennial report, known as the Illinois Integrated Water Quality Report and Section 303(d) List, required by the Federal CWA.

Along the impaired waterbodies, data were found for numerous stations that are part of AWQMN (Figure 9, Figure 10 and Table 18). Parameters sampled on the waterbodies include field measurements (e.g., water temperature) as well as those that require lab analyses (e.g., fecal coliform, nutrients, and total suspended solids). Data were obtained directly from IEPA.

Table 18. Illinois EPA water quality data for impaired waterbodies

Waterbody	Impaired Segment	AWQMN Sites	Location	Period of Record
Kaskaskia River	IL_O-08	**O-08**	RM 135.7, RT 40-51 Br. (Gallatin St.) SE edge of Vandalia	*1999–2006*, 2007-2016, 2018
		O-39	3 Mi. N Vandalia	-*
		O-51	7 Mi. upstream Vandalia	-*
	IL_O-38	O-38	Co Rd 900N Br. 4 Mi. W Shobonieer and 7 Mi. SW Vandalia	-*
Carlyle Lake [a]	IL_ROA	**ROA-1**	No site description	2011 (4 days), 2016 (1 day)
		ROA-2	Site 2 0.5 Mi. offshore from Carlyle	2011 (4 days), 2016 (1 day)
		ROA-3	Site 3 0.5 Mi. off Hazlet State Park South Shelter	2011 (4 days), 2016 (1 day)
		ROA-4	Site 4 2200 ft. NW access area	2011 (4 days), 2016 (1 day)
		ROA-5	Site 5 6000 ft. N into Hazlet State Park	2011 (4 days), 2016 (1 day)
		ROA-6	Site 6 50 ft. S large west arm	2011 (4 days), 2016 (1 day)
		ROA-99	No site description	2011 (2 days)
		Multiple other in-lake sites	-	-*

BOLD – Indicates station with data relevant to impairment
Italics – Data are greater than 10 years old
-* No data available for station in 1999–2016 water quality data received from Illinois EPA
a. Additional data are available from the USACE; see discussion below.
RM – River Mile

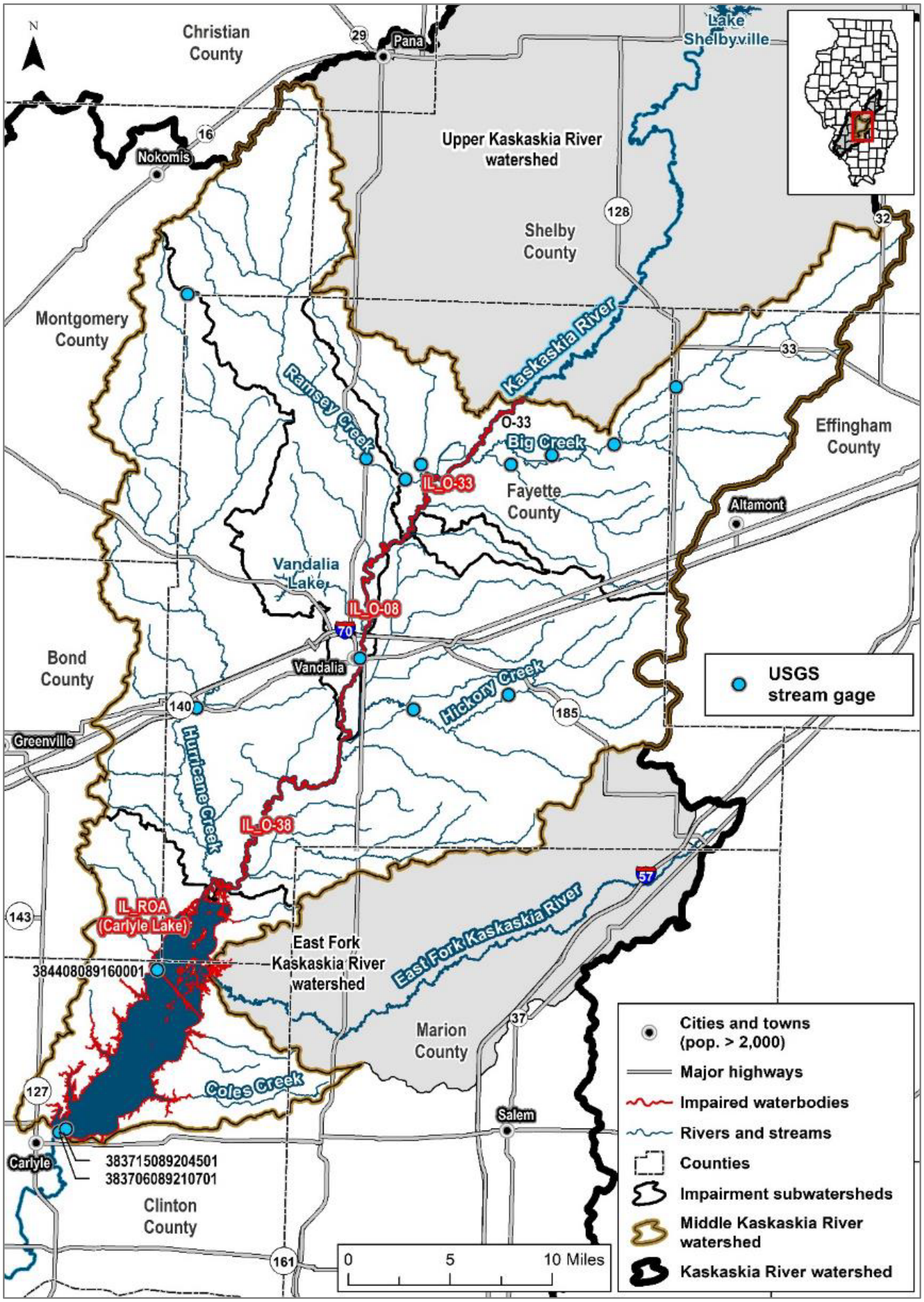

Figure 9. USGS stream gages in impairment watersheds and along impaired waterbodies.

Monitoring stations on impaired waterbodies with water quality data used in impairment assessment are labeled. Additional monitoring sites on Carlyle Lake are available from the USACE; see discussion below.
Note: IL_O-33 is not addressed in this TMDL document. See Appendix C for more information.

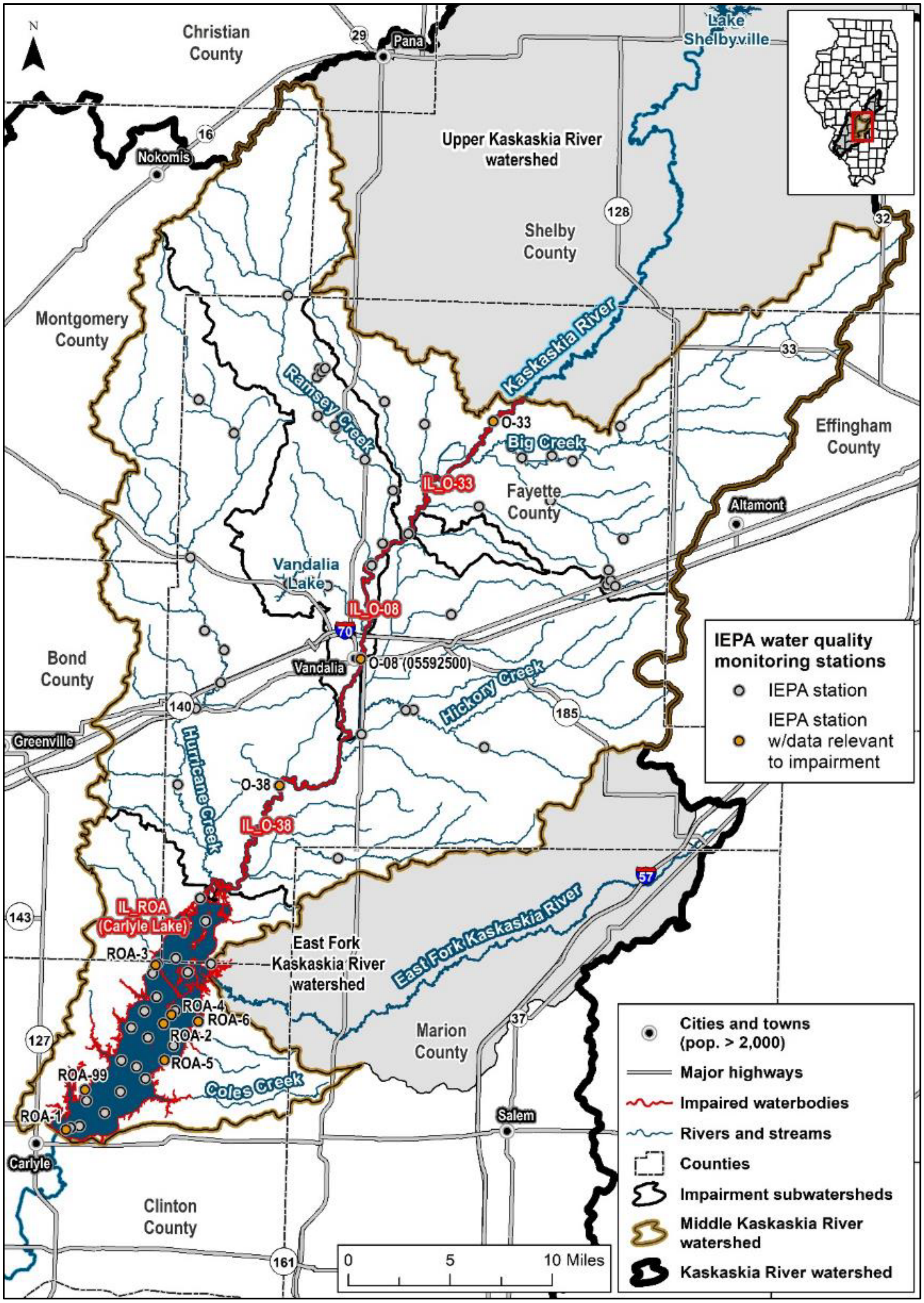

Figure 10. IEPA water quality sampling sites in impairment watersheds and along impaired waterbodies.

Monitoring stations on impaired waterbodies with water quality data used in impairment assessment are labeled. Additional monitoring sites on Carlyle Lake are available from the USACE; see discussion below.
Note: IL_O-33 is not addressed in this TMDL document. See Appendix C for more information.

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 IEPA. The most recent 10 years of data collection, 2007–2016, were used to evaluate impairment for Carlyle Lake (ROA), and the last 5 years of data collection were used to evaluate Kaskaskia River impairments. Annual data requirements for impairment assessment were also included for Carlyle Lake; see Section 2.2. Each data point was reviewed to ensure the use of quality data in the analysis below.

5.1 Kaskaskia River

The Kaskaskia River is listed as impaired along segments IL_O-08 and IL_O-38 for primary contact recreation due to fecal coliform. There is one IEPA sampling site with relevant data on IL_O-08 and no sampling sites with relevant data on IL_O-38. Fecal coliform data from site O-08 were used to assess impairment on both segment IL_O-08 and downstream segment IL_O-38. Site O-08 is located approximately five miles north (upstream) of segment IL_O-38. Recreational use impairment is verified for both segments.

Seventeen fecal coliform samples were collected at site O-08 between 2012 and 2016 (Table 19 and Figure 11). Eight exceedances of the single sample maximum standard were observed, with an average reported value above the standard at 1,387 cfu/100 mL. Additional data were collected at site O-08 in 2018, and the geometric mean of the five samples taken within a 30-day period is greater than the monthly geometric mean standard (Figure 12). Recreational use impairment is verified for the segment.

Upstream of the Middle Kaskaskia River project area covered by this TMDL report, five fecal coliform TMDLs were developed in the Upper Kaskaskia River and Lake Fork watershed to address the impaired recreation use of the Kaskaskia River (two segments), Beck Creek, Jonathon Creek, and the West Okaw River; the TMDLs were approved on September 24, 2018. Four of the five fecal coliform TMDLs were upstream of Lake Shelbyville, including the two TMDLs for the Kaskaskia River (IL_O-2 and IL_O-15). The only fecal coliform TMDL downstream of Lake Shelbyville was Becks Creek (IL_OQ-01), which discharges to the Kaskaskia River just upstream of segment IL_O-33 in the Middle Kaskaskia River project area. Segment IL_O-33 is upstream of segment IL_O-08. No bacteria data have been collected from segment IL_O-33; therefore, it is not possible to determine if segment IL_O-33 or upstream sources are contributing to impairment of segments IL_O-08 and IL_O-38.

Table 19. Data summary, Kaskaskia River O-08

Sample Site	No. of samples	Minimum (cfu/100 mL)	Average (cfu/100 mL)	Maximum (cfu/100 mL)	Number of exceedances of single sample maximum standard (400 cfu/100 mL)
Fecal Coliform					
O-08	17	78	1,387	10,000	8

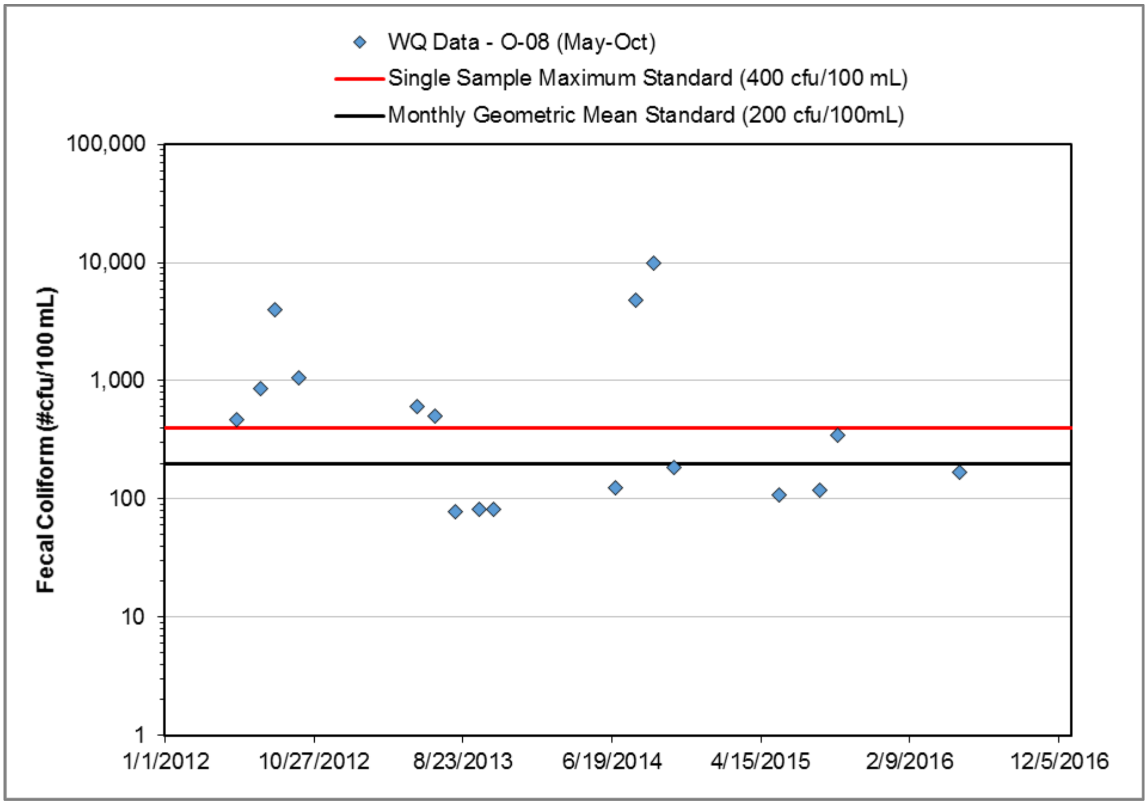

Figure 11. Fecal coliform water quality time series (2012–2015), Kaskaskia River O-08 segment.

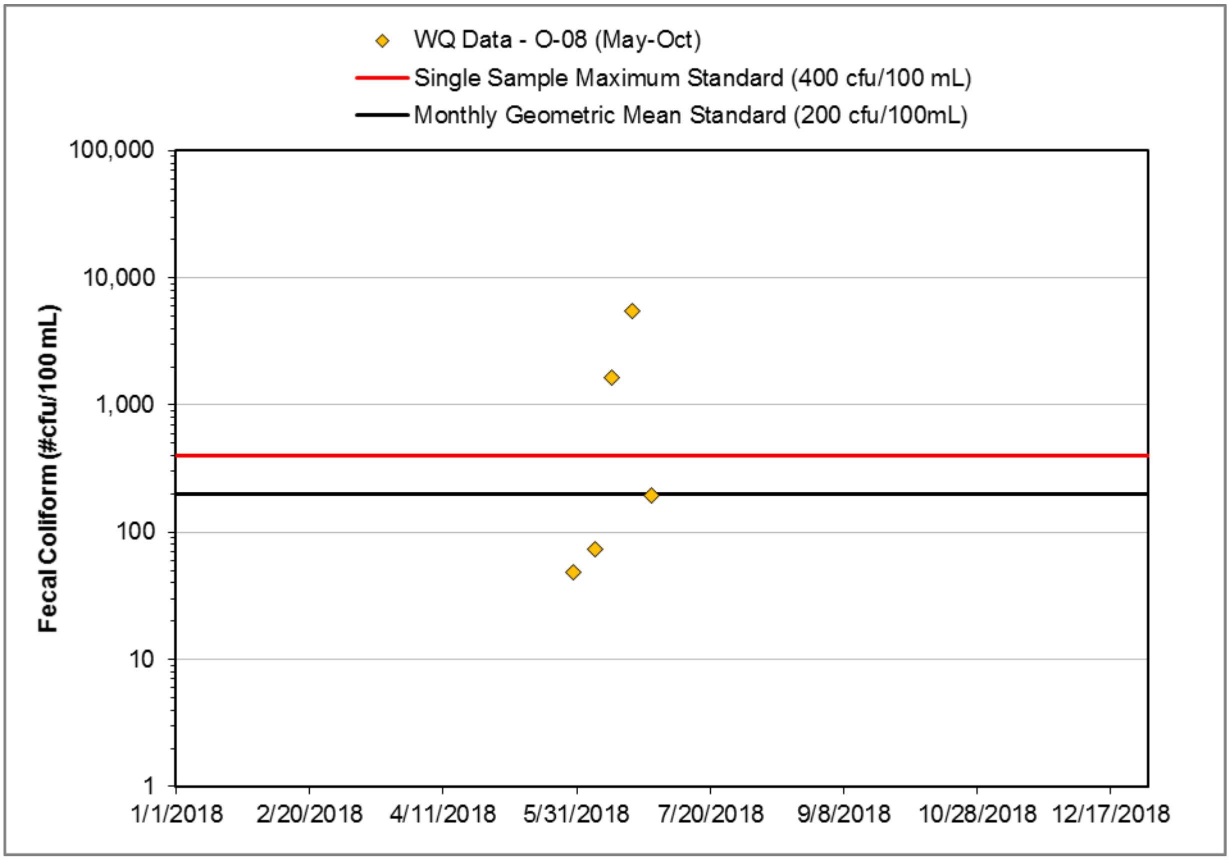

Figure 12. Fecal coliform water quality time series (2018), Kaskaskia River O-08 segment.

5.2 Carlyle Lake (ROA)

Carlyle Lake is a 9,947-hectare reservoir located 0.5-miles north of the city of Carlyle, IL, and is the largest reservoir in the state of Illinois. It was created in 1967 by impounding the Kaskaskia River and is used for recreation, with approximately 12,000 acres of public land surrounding the shoreline. The USACE maintains an average depth of 40-feet with a maximum depth of 58-feet during flood conditions at the dam outlet, however, depth of the lake varies throughout (USACE 2017).

Carlyle Lake (ROA) is listed as impaired for aesthetic quality due to elevated levels of TP. Seven IEPA sampling sites with relevant data were identified in the lake (Figure 9). Thirty-seven lake samples were collected at the sampling sites between 2011 and 2016 (Table 20). Figure 13 provides the water quality data collected during 2011. All samples exceed the general use water quality standard of 0.05 mg/L, with an average value across all sites of over three times the standard at 0.19 mg/L. Aesthetic quality impairment is confirmed for Carlyle Lake.

Additional phosphorus and chlorophyll-*a* data are available from USACE from 2005–2017 at eight monitoring sites. Up to five samples were collected per year at each site.

Table 20. Illinois EPA data summary, Carlyle Lake

Sample Site	Location	No. of samples	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Number of Exceedances
Phosphorus (Total)						
ROA-1	South end of lake	10 [a]	0.116	0.205	0.332	10
ROA-2	Center of lake	5	0.115	0.176	0.257	5
ROA-3	Western side of lake	5	0.116	0.209	0.262	5
ROA-4	Center of lake	5	0.117	0.194	0.282	5
ROA-5	Eastern side of lake	5	0.122	0.186	0.288	5
ROA-6	Eastern side of lake	5	0.108	0.181	0.288	5
ROA-99	Western side of lake	2	0.124	0.134	0.143	2

Additional data are available from the USACE.
a. Two samples were taken on each of 5 days from this sampling station.

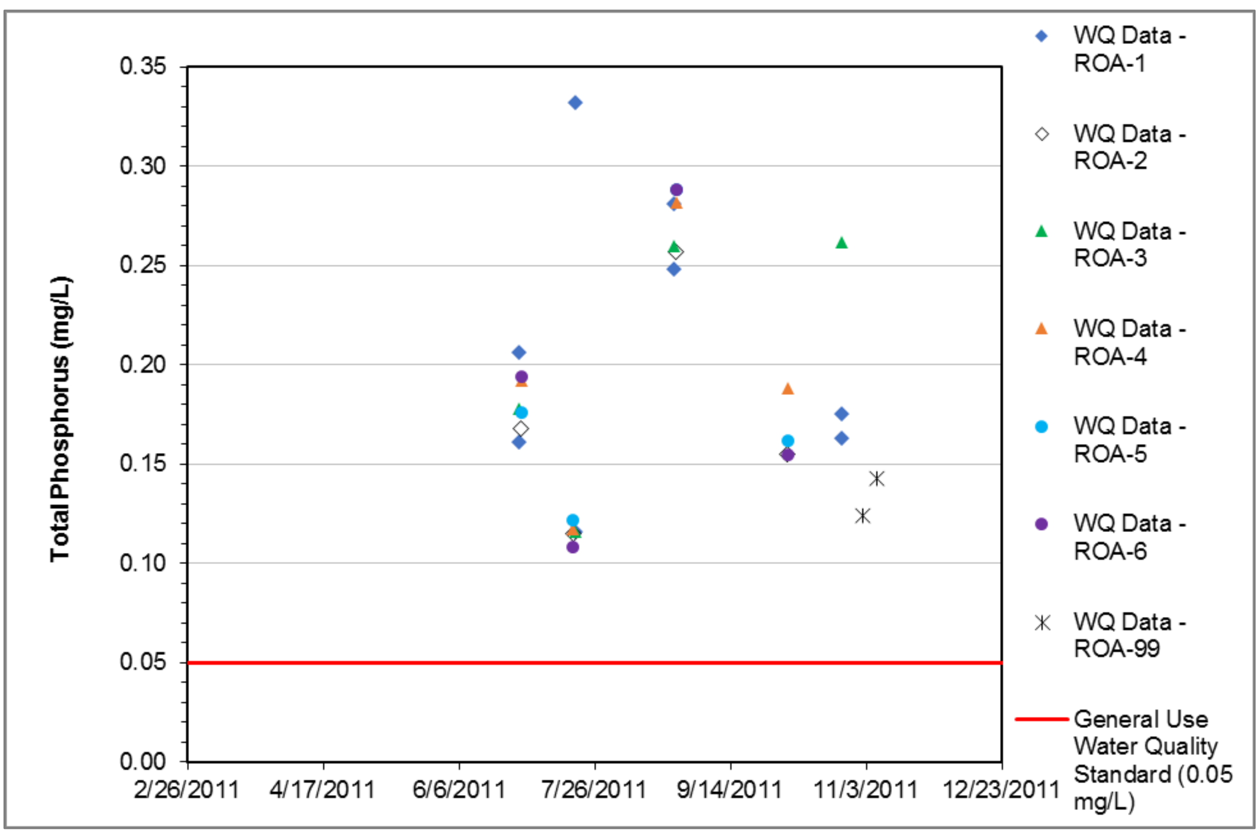

Figure 13. Total phosphorus water quality data, 2011, Carlyle Lake (ROA).

6. TMDL Derivation

The first stage of this project included 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.

A waterbody's loading capacity represents the maximum rate of pollutant loading that can be assimilated without violating water quality standards (40 CFR 130.2(f)). Establishing the relationship between in-stream water quality and source loading is an important component of TMDL development. It allows the determination of the relative contribution of sources to total pollutant loading and the evaluation of potential changes to water quality resulting from implementation of various management options. The following section describes the methodology used in this analysis; results are then presented by waterbody.

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. TMDLs are composed of the sum of individual wasteload allocations (WLAs) for regulated sources and load allocations (LAs) for unregulated sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody and may contain a reserve capacity (RC) if needed. Conceptually, this is defined by the equation:

$$\textbf{TMDL} = \sum \textbf{WLAs} + \sum \textbf{LAs} + \textbf{MOS} + \textbf{RC}$$

Allowable loads and associated allocations for each of the impaired waterbodies are provided.

The following sections describe the methods used to derive TMDLs.

6.1 Loading Capacity

6.1.1 Stream Loading Capacity

A duration curve approach is used to evaluate the relationships between hydrology and water quality and calculate the TMDLs for fecal coliform stream impairments. 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 21 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 21. 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		

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 CWA 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.

Streamflow for both Kaskaskia River impairments was estimated from USGS gauge 05592500 (Kaskaskia River at Vandalia, IL) that has a drainage area of 1,940 square miles. Streamflow data for the USGS gauge were downloaded from the National Water Information System (https://waterdata.usgs.gov/nwis) and area-weighted to each of the impairment watersheds using the gauges' watershed area relative to the impairment watershed area (Figure 14).

- **Segment IL_O-08**: The TMDL was developed at the outlet of impaired segment IL_O-08, and the TMDL included an upstream boundary condition (described below). The drainage area at the outlet of impaired segment IL_O-08 is 1,946 square miles. Daily flow at the gauge was up-weighted by the ratio drainage areas (1,946/1,940) to estimate flow at the outlet of segment IL_O-08.
- **Segment IL_O-38**: The TMDL was developed at the outlet of impaired segment IL_O-38, and the TMDL included an upstream boundary condition (described below; same boundary condition as for segment IL_O-08). The drainage area at the outlet of impaired segment IL_O-38 is 2,383 square miles. Daily flow at the gauge was up-weighted by the ratio drainage areas (2,383/1,940) to estimate flow at the outlet of segment IL_O-38.
- **Upstream boundary condition**: A boundary conditions was developed for the Middle Kaskaskia River fecal coliform TMDLs to represent the unimpaired segment IL-O-33 of the Middle Kaskaskia River and the Upper Kaskaskia River and Lake Fork watershed. The upstream boundary condition is located on the Kaskaskia River at the outlet of segment IL_O-33. The drainage area of the boundary condition is 1,773 square miles. Daily flow at the gauge was down-weighted by the ratio drainage areas (1,773/1,940) to estimate flow at the upstream boundary condition.

Similar to the calculation of daily loading capacity for impaired segments IL_O-08 and IL_O-38, the upstream boundary condition fecal coliform load was calculated by multiplying the estimated flow by the fecal coliform TMDL targets (200 cfu/100 mL and 400 cfu/100 mL). The upstream boundary condition fecal coliform load appears as a line-item in the allocation tables in Section 7.

The fecal coliform TMDL for impaired segment IL_O-08 addresses the direct drainage to segment IL_O-08; drainage to segment IL_O-33 and upstream is addressed through the upstream boundary condition. The fecal coliform TMDL for impaired segment IL_O-38 addresses the direct drainage to segments IL_O-08 and IL_O-38; drainage to segment IL_O-33 and upstream is addressed through the upstream boundary condition.

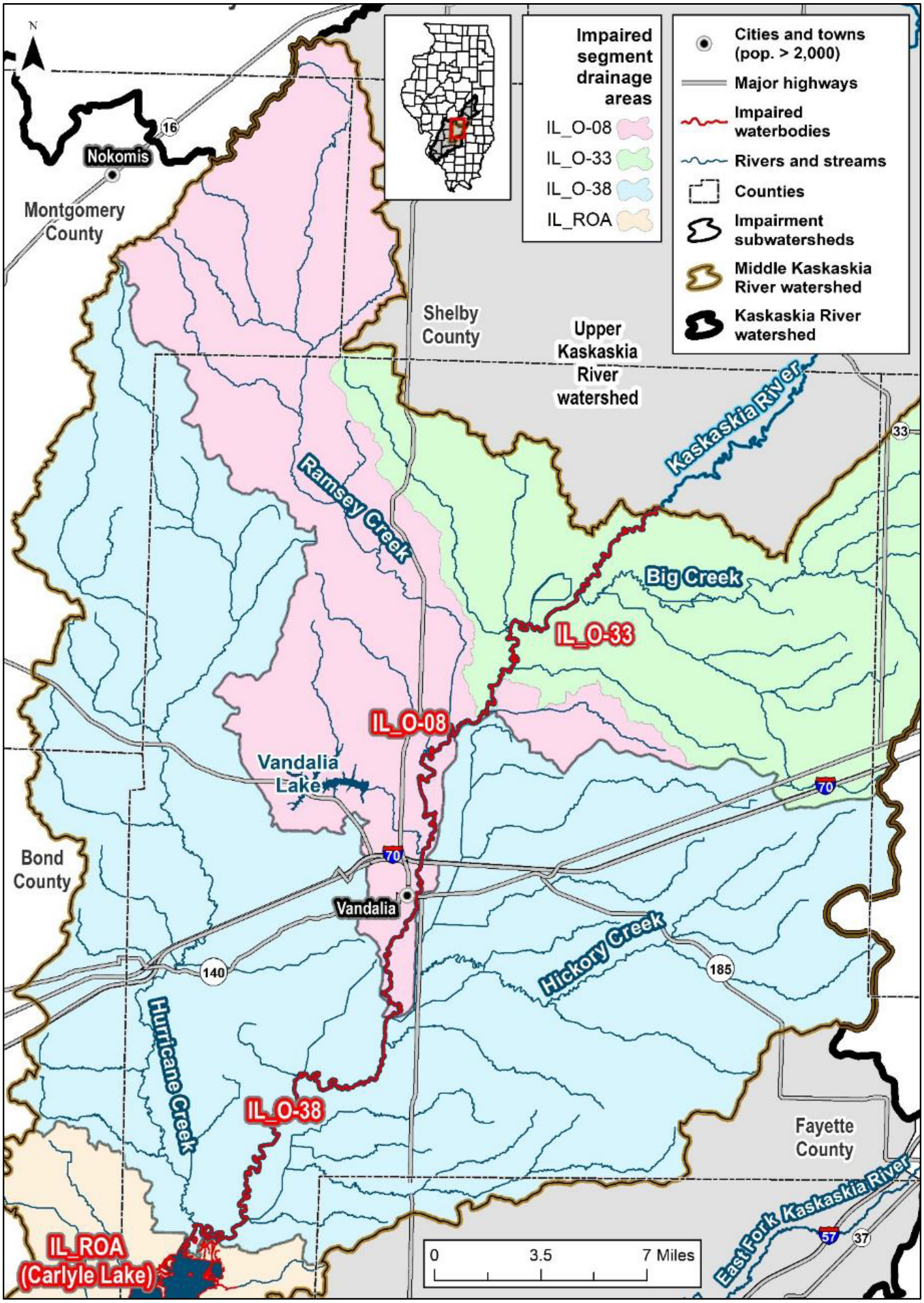

Figure 14. Fecal coliform impaired segments (IL_O-38 and IL_O-08) and their subwatersheds.

6.1.2 Lake Loading Capacity

The BATHTUB model is used to support TP TMDL development for Carlyle 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 USACE. The model requires nutrient loading inputs from the contributing watershed and atmospheric deposition, morphometric data for the lake, and estimates of mixing depth and nonalgal turbidity.

IEPA selected the Bathtub model to support lake TMDL development because BATHTUB models can be developed using readily available data for Carlyle Lake. IEPA considered data quantity and quality, time and resources necessary for model development, and the history of developing lake TMDLs using BATHTUB models. Two-dimensional (e.g., CE-QUAL-W2) and three-dimensional (e.g., Environmental Fluid Dynamics Code) lake models require much more data to develop boundary condition data (e.g., bathymetry, water level). Such complex models are dynamic, and thus, also require considerably more calibration/validation data (e.g., time-series at multiple monitoring sites) than are available for Carlyle Lake. Additionally, complex models also require much more time and resources to develop, calibrate/validate, and post-process.

BATHTUB has been used extensively in Illinois and throughout the Midwest for lake TMDL development and is typically able to simulate in-lake processes well. The data needed to develop and calibrate a BATHTUB model is readily available for Carlyle Lake. The BATHTUB model for Carlyle Lake is documented in Appendix D.

As previously discussed in Section 4.2.3, TP from permitted point sources (e.g., sewage treatment plants) within 25-miles of Carlyle lake , which includes the East Fork Kaskaskia River and Lake Farina watershed, may be transported to Carlyle Lake; therefore, such permitted point sources need to be assigned TP WLAs in the Carlyle Lake TP TMDL.

6.2 Load Allocations

Load allocations represent the portion of the allowable daily load that is reserved for nonpoint sources and natural background conditions. The load allocations are based on subtracting the WLAs and the MOS from allowable loads. The load allocations are summarized in Section 7 for each of the waterbody pollutant combinations along with the existing, baseline loads and WLAs.

For both the Kaskaskia River fecal coliform TMDLs (IL_O-08 and IL_O-38), an upstream boundary condition was set at the outlet of the segment IL_O-33 in the Middle Kaskaskia River. The boundary condition assumes compliance with the fecal coliform standard at this location. Thus, the LA for the fecal coliform TMDL to address impaired segment IL_O-08 addresses nonpoint source and background loading to the watershed directly draining to the impaired segment, while the LA for the fecal coliform TMDL to address impaired segment IL_O-38 address addresses nonpoint source and background loading to the watershed directly draining to both impaired segments. Nonpoint source and background loading to unimpaired segment IL_O-33 and the Upper Kaskaskia River and Lake Fork watershed are accounted for through the upstream boundary condition.

6.3 Wasteload Allocations

NPDES-permitted facilities within the watershed with the potential to discharge to impairments are provided in Table 14[4]. As required by the CWA, individual WLAs were developed for these permittees as part of the TMDL development process. For fecal coliform-impaired streams, each facility's design maximum flow is used to calculate the WLA for the high flow zone and the design average flow was used

[4] Three facilities are not expected to discharge fecal coliform or phosphorus: Marathon Petroleum-St. Elmo (IL0032271), Vandalia WTP (ILG640114), and Ramsey WTP (ILG640141). These facilities did not receive WLAs.

for all other flow zones. Illinois assumes that facilities will have to discharge at their maximum flow during both high flow conditions based on the following:

> *For municipal NPDES permits in Illinois, page 2 of the NPDES permit lists 2 design flows: a design average flow (DAF) and a design maximum flow (DMF). These are defined in 35 Ill. Adm. Code 370.211(a) and (b). Since rain (and to a certain extent, high ground water) causes influent flows to wastewater treatment facilities to increase and precipitation also leads to higher river levels, a correlation between precipitation and treatment flows exists. The load limits in these permits gives a tiered load limit, one based on DAF for flows of DAF and below, and another load limit in the permit for flows above DAF through DMF.*

6.3.1 Fecal Coliform WLAs

Fecal coliform WLAs are based on compliance with the geometric mean fecal coliform water quality standard of 200 cfu/100 mL and the instantaneous water quality standard requiring that no more than 10% of the samples shall exceed 400 cfu/100 mL. WLAs are provided for both the instantaneous and geomean water quality standards.

Eight of nine facilities discharging to fecal coliform impairments have disinfection exemptions (Figure 8). Disinfection exemptions are either seasonal (November-April) or year-round and allow a facility to discharge without disinfection. Facilities with disinfection exemptions are required to meet the in-stream water quality standard at the end of the exempted reach (i.e., geometric mean of 200 cfu/100 mL). WLAs for facilities with disinfection exemptions were based on the design flows for each facility multiplied by the water quality target. The resulting WLAs apply at the end of their respective disinfection exemption reaches (Figure 8). Facilities with year-round disinfection exemptions may be required to provide IEPA with updated information to demonstrate compliance with these requirements, and facilities directly discharging into a fecal impaired segment may have their year-round disinfection exemption reviewed through future NPDES permitting actions.

6.3.2 TP WLAs

For Carlyle Lake, using the BATHTUB model that simulates a steady-state annual time period, the design average flow is used to calculate the TP WLAs since the Carlyle Lake TMDL is based on average annual conditions.

Permitted facilities (Figure 15) expected to discharge TP in the following three areas receive TP WLAs.

- Facilities that discharge directly to Carlyle Lake
- Facilities in the Middle Kaskaskia River watershed within 25-miles of Carlyle Lake
- Facilities in the East Fork Kaskaskia and Farina Lake watershed within 25-miles of Carlyle Lake

The WLAs are based on (1) the permit limit(s) or (2) the DAF and an assumed untreated discharge of 4 or 5 mg/L TP when there is no permit limit. Refer to Section 7.3 for the permit limit(s) and DAFs for facilities that receive TP WLAs.

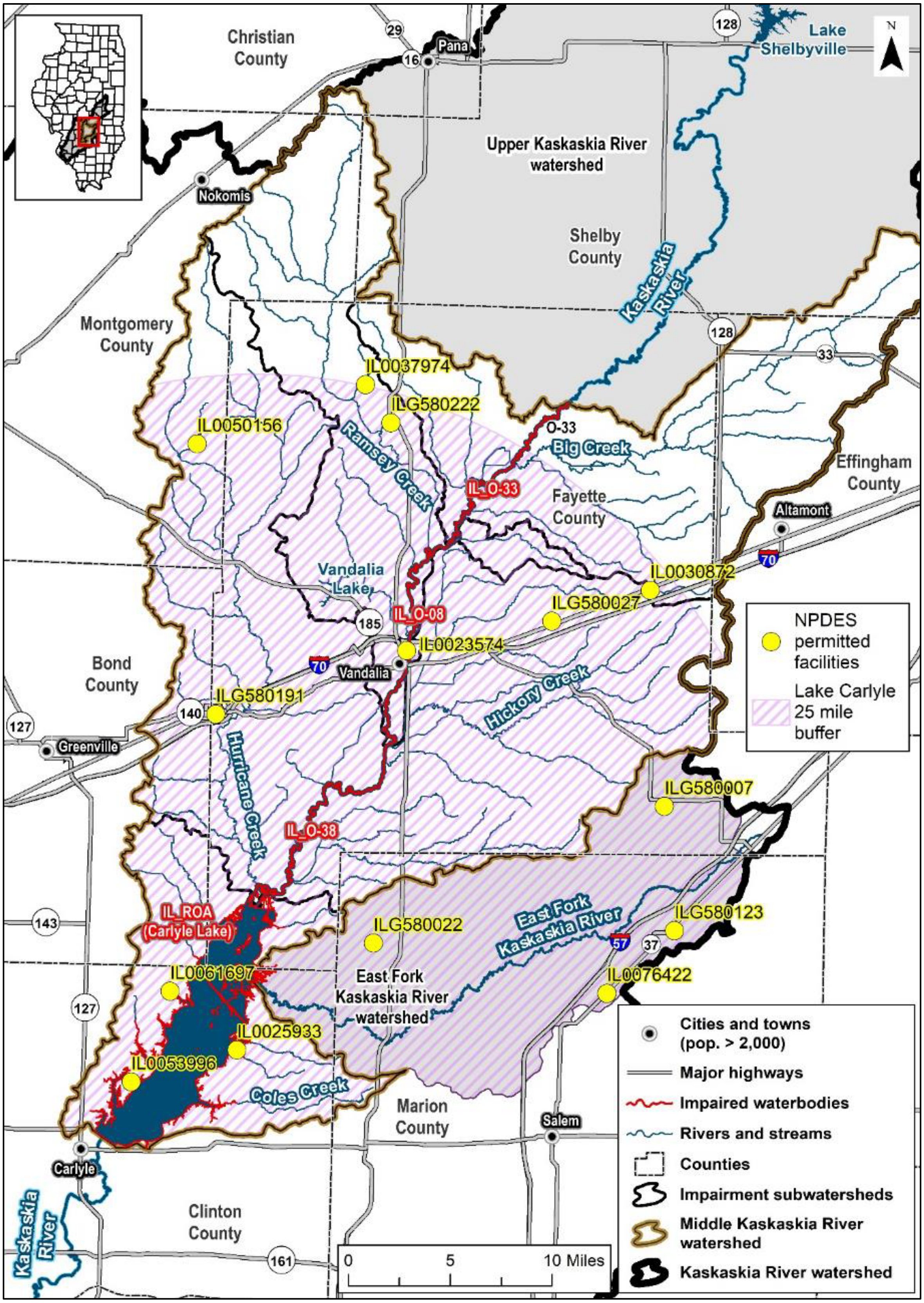

Figure 15. NPDES permitted facilities that receive TP WLAs.

6.4 Margin of Safety

The CWA requires that a TMDL include a MOS to account for uncertainties in the relationship between pollutants loads and receiving water quality. U.S. EPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS).

A 10% explicit MOS has been applied to both TMDLs for fecal coliform. A moderate MOS was specified because the use of load duration curves is expected to provide accurate information on the loading capacity of the stream, but this estimate of the loading capacity may be subject to potential error associated with the method used to estimate flows. The MOS for fecal coliform is also implicit because the load duration analysis does not address die-off of pathogens. The load duration analysis assumes that conservative pollutants persist in-stream. However, unlike a conservative pollutant, pathogens die-off based upon environmental conditions (e.g., temperature, light, microbial predation) and pathogen density decreases over time. For both the fecal coliform TMDLs (IL_O-08 and IL_O-38), the MOS was allocated after the upstream boundary condition allocation (i.e., 10% of the quantity of the loading capacity less the upstream boundary condition).

In Carlyle Lake, the MOS addresses environmental variability in pollutant loading and monitoring data and uncertainty in modeling outputs. An extensive dataset of many years of monitoring data from multiple monitoring sites in Carlyle Lake were used to develop the BATHTUB model. Watershed loading was determined based on monitoring data (water chemistry results from IEPA and long-term daily flow timeseries from USGS gages), therefore confidence is higher in these estimates. As discussed in Appendix D, steady-state model corroboration yielded simulated TP and chlorophyll-*a* concentrations within 1 microgram per liter of monitoring results. Given the ample datasets for model development and corroboration and good model corroboration results, a MOS of 5% was provided for the Carlyle Lake phosphorus TMDL.

6.5 Reserve Capacity

RC is provided to those watersheds that are expected to further develop. For fecal coliform and nitrate, any new or expanded discharges will be required to comply with permit limits. As long as the facility is meeting the standard, any new flow and associated load will be in compliance with the TMDL.

A 10% reserve capacity is set aside to accommodate future growth. Future growth could result in a needed expansion of an NPDES facility (i.e., increased flow) which could require a recalculation of the WLA. The reserve capacity provides flexibility to IEPA in these cases.

6.6 Critical Conditions and Seasonality

The CWA requires that TMDLs take into account critical conditions for streamflow, loading, and water quality parameters as part of the analysis of loading capacity. Through the load duration curve approach (for fecal coliform-impaired streams) it was determined that load reductions are needed for specific flow conditions; however, the critical conditions (the periods when the greatest reductions are required) vary by location and are inherently addressed by specifying different levels of reduction according to flow. Additionally, the summer recreation season (May-October) is a critical condition. During the summer recreation season, primary contact recreation is highest, while streamflow is typically lower (i.e., less flow available to assimilate bacteria loading). Due to these conditions, Illinois has incorporated the summer recreation season into its fecal coliform water quality standards to protect primary contact recreation.

Critical conditions in lakes occurs during the growing season when frequency and severity of nuisance algal growth is typically highest.

The CWA also requires that TMDLs be established with consideration of seasonal variations. Seasonal variations are addressed in TMDLs by assessing conditions only during the season when the water quality standard applies (May through October) for fecal coliform. The load duration approach also accounts for seasonality by evaluating allowable loads on a daily basis over the entire range of observed flows and by presenting daily allowable loads that vary by flow. In the case of lake eutrophication, TMDLs are based on data collected during the critical condition (summer). By setting the TMDLs to meet targets based on the most critical period (summer), the TMDLs will inherently be protective of water quality during all other seasons.

7. Allocations

7.1 Kaskaskia River (IL_O-08) Fecal Coliform TMDL

A fecal coliform bacteria TMDL has been developed for the Kaskaskia River segment O-08. IEPA assessed segments IL_O-08 and IL_O-38 for aquatic recreation impairment using data collected at sampling station O-08. Figure 16 presents the fecal coliform load duration curve and Table 22 and Table 23 summarize the TMDL and required reductions for both the single sample maximum standard and the geomean standard, respectively. Pollutant reductions are needed for all flow conditions to meet the single sample maximum standard. A 44% reduction is needed to meet the geomean standard. Table 24 summarizes the individual NPDES WLAs.

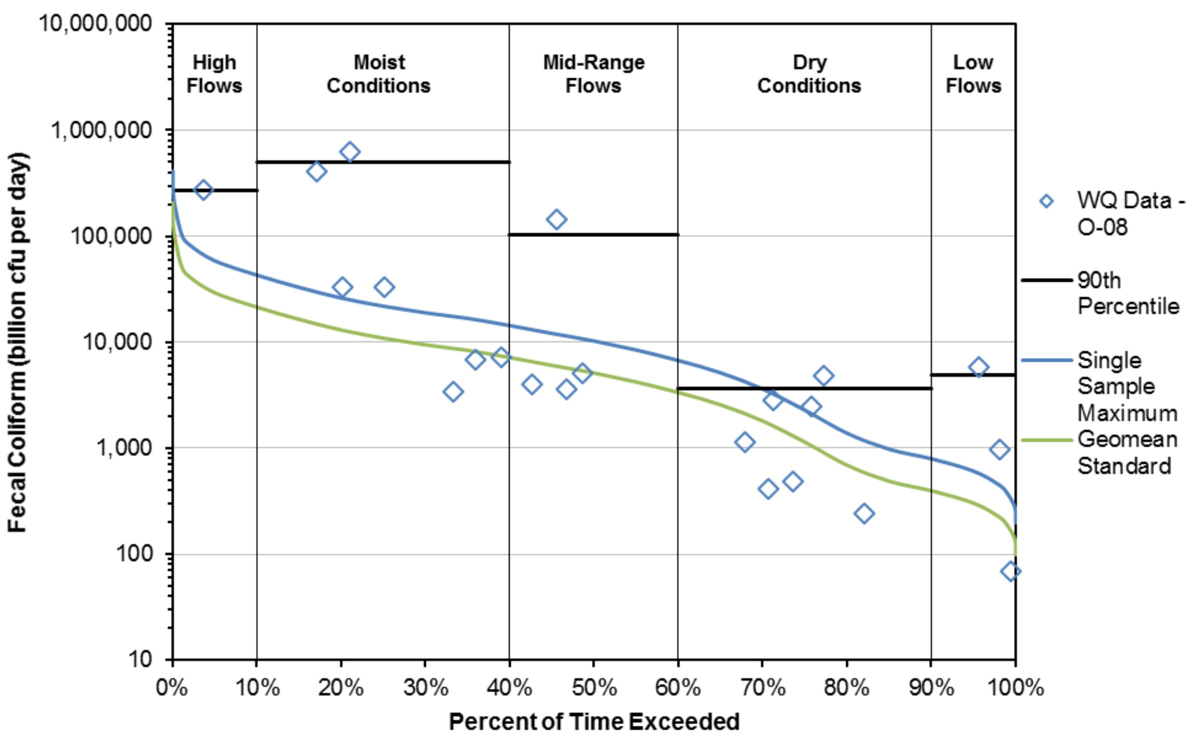

Figure 16. Fecal coliform load duration curve, Kaskaskia River at O-08.

Water quality data presented in the load duration curve were collected from 2012 to 2018.

Table 22. Fecal coliform TMDL summary (single sample maximum standard; Kaskaskia River IL_O-08)

TMDL Parameter		Flow Zones				
		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
		Fecal Coliform Load (billion cfu/day)				
Upstream Boundary Condition		53,870	20,045	9,396	2,085	553
Wasteload Allocation	NPDES-permitted facilities	157	31	31	31	31
Load Allocation		4,023	1,525	698	131	12
RC		523	194	91	20	5.4
MOS		523	194	91	20	5.4
Loading Capacity		**59,096**	**21,989**	**10,307**	**2,287**	**607**
Existing Load		273,217	495,626	102,936	3,634	4,842
Load Reduction [a]		78%	96%	90%	37%	87%

a. TMDL reduction is based on the observed 90th percentile load in each flow regime.

Table 23. Fecal coliform TMDL summary (geomean standard; Kaskaskia River IL_O-08)

TMDL Parameter		Flow Zones				
		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
		Fecal Coliform Load (billion cfu/day)				
Upstream Boundary Condition		26,935	10,022	4,698	1,043	277
Wasteload Allocation	NPDES-permitted facilities	80	15	15	15	15
Load Allocation		2,011	764	349	66	5.8
RC		261	97	46	10	2.6
MOS		261	97	46	10	2.6
Loading Capacity		**29,548**	**10,995**	**5,154**	**1,144**	**303**
Geomean Concentration (# cfu/100 mL) [a]		360				
Geomean Reduction [b]		44%				

a. Geomean concentration of five samples collected by IEPA in June and July 2018.
b. TMDL reduction is based on the 2018 observed geometric mean concentration and the geomean standard (200 cfu/100 mL).

Table 24. Individual NPDES fecal coliform WLAs, Kaskaskia River IL_O-08

Permit ID	Facility Name	Fecal Coliform WLA (billion cfu per day)					
		High Flow Conditions			Moist to Low Flow Conditions		
		Design Maximum Flow (MGD)	Single Sample Maximum Standard	Geomean Standard	Design Average Flow (MGD)	Single Sample Maximum Standard	Geomean Standard
IL0023574	Vandalia STP	8.25	120	62	1.3	20	10
IL0037974	Ramsey Lake State Park	0.0375	0.57	0.28	0.015	0.23	0.11
IL0063878	Beecher City STP	0.105	1.6	0.79	0.052	0.79	0.39
ILG580163	Stewardson STP	0.275	4.0	2.0	0.11	1.7	0.83
ILG580222	Ramsey STP	0.632	9.6	4.8	0.171	2.6	1.3
ILG582016	St. Elmo STP	1.367	21	10	0.40	6.1	3.0
	Total	**10.6**	**157**	**80**	**2.0**	**31**	**15**

Totals rounded to nearest 0.1 MGD or 1 billion cfu per day.

7.2 Kaskaskia River (IL_O-38) Fecal Coliform TMDL

A fecal coliform bacteria TMDL has been developed for the Kaskaskia River segment IL_O-38. IEPA assessed segments IL_O-08 and IL_O-38 for aquatic recreation impairment using data collected at sampling station O-08. Thus, sampling data from station O-08 are presented here for the evaluation of segment IL_O-38. Figure 17 presents the fecal coliform load duration curve and Table 25 and Table 26 summarize the TMDL and required reductions for both the single sample maximum standard and the geomean standard, respectively. Based upon data collected at station O-08, pollutant reductions are needed for all flow conditions to meet the single sample maximum standard. A 44% reduction is needed to meet the geomean standard. Table 27 summarizes the individual NPDES WLAs.

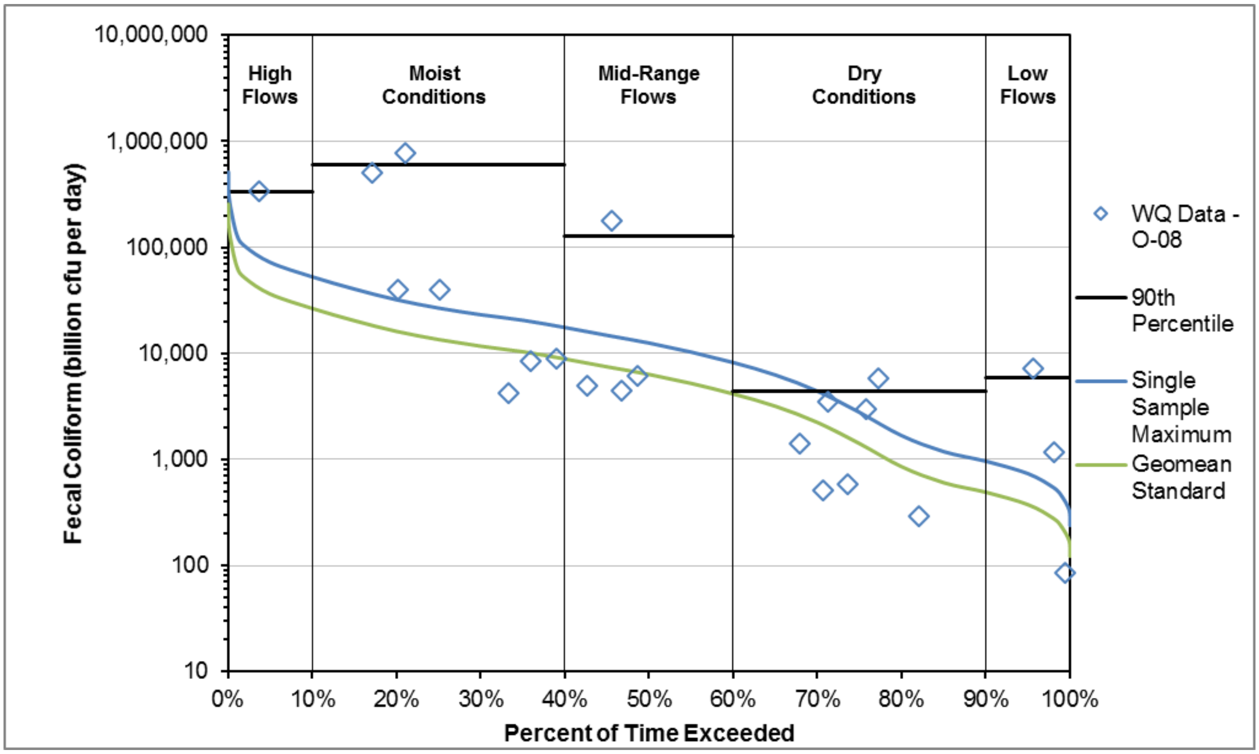

Figure 17. Fecal coliform load duration curve, Kaskaskia River Figure IL_O-38.

Water quality data presented in the load duration curve were collected from 2012 to 2018.

Table 25. Fecal coliform TMDL summary (single sample maximum standard; Kaskaskia River IL_O-38)

TMDL Parameter		Flow Zones				
		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
		Fecal Coliform Load (billion cfu/day)				
Upstream Boundary Condition		53,870	20,045	9,396	2,085	553
Wasteload Allocation	NPDES-permitted facilities	169	35	35	35	35
Load Allocation		14,627	5,471	2,545	537	117
RC		1,850	688	323	72	19
MOS		1,850	688	323	72	19
Loading Capacity		**72,366**	**26,927**	**12,622**	**2,801**	**743**
Existing Load		334,571	606,925	126,052	4,450	5,930
Load Reduction [a]		78%	96%	90%	37%	87%

a. TMDL reduction is based on the observed 90th percentile load in each flow regime.

Table 26. Fecal coliform TMDL summary (geomean standard; Kaskaskia River IL_O-38)

TMDL Parameter		Flow Zones				
		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
		Fecal Coliform Load (billion cfu/day)				
Upstream Boundary Condition		26,935	10,022	4,698	1,043	277
Wasteload Allocation	NPDES-permitted facilities	86	17	17	17	17
Load Allocation		7,312	2,737	1,274	268	58
		925	344	161	36	9.4
MOS		925	344	161	36	9.4
Loading Capacity		**36,183**	**13,464**	**6,311**	**1,400**	**371**
Geomean Concentration (# cfu/100 mL) [a]		360				
Geomean Reduction [b]		44%				

a. Geomean concentration of five samples collected by IEPA in June and July 2018.
b. TMDL reduction is based on the 2018 observed geometric mean concentration and the geomean standard (200 cfu/100 mL).

Table 27. Individual NPDES fecal coliform WLAs, Kaskaskia River IL_O-38

Permit ID	Facility Name	Fecal Coliform WLA (billion cfu per day)					
		High Flow Conditions			Moist to Low Flow Conditions		
		Design Maximum Flow (MGD)	Single Sample Maximum Standard	Geomean Standard	Design Average Flow (MGD)	Single Sample Maximum Standard	Geomean Standard
IL0023574	Vandalia STP	8.25	120	62	1.3	20	10
IL0037974	Ramsey Lake State Park	0.0375	0.57	0.28	0.015	0.23	0.11
IL0050156	Fillmore STP	0.195	3.0	1.5	0.049	0.74	0.37
IL0063878	Beecher City STP	0.105	1.6	0.79	0.052	0.79	0.39
ILG580027	Brownstown STP	0.327	5.0	2.5	0.1	1.5	0.76
ILG580163	Stewardson STP	0.275	4.0	2.0	0.11	1.7	0.83
ILG580191	Mulberry Grove SD STP	0.237	4.0	2.0	0.0864	1.3	0.65
ILG580222	Ramsey STP	0.632	9.6	4.8	0.171	2.6	1.3
ILG582016	St. Elmo STP	1.367	21	10	0.40	6.1	3.0
	Total	**11.4**	**169**	**86**	**2.2**	**35**	**17**

Totals rounded to nearest 0.1 MGD or 1 billion cfu per day.

7.3 Carlyle Lake (IL_ROA) Total Phosphorus TMDL

The BATHTUB model was used to develop a TP TMDL for Carlyle Lake (see Appendix D for model summary). The Carlyle Lake BATHTUB model was segmented based on the earthen barrier which bisects the lake for the Burlington and Northern Railroad (RR) Crossing. North of the RR crossing is model "segment 1", which flows south into the deeper pool of lake, or model "segment 2". The two segments of Carlyle Lake are connected by 4 flow-through areas, the largest connection of which is the most northwestern location near Keyesport (Figure 18).

Watershed flow and phosphorus loading to Carlyle Lake were determined based on drainage area weighting of USGS gages on the Kaskaskia River at Vandalia, IL (gage 05592500) and East Fork Kaskaskia River near Sandoval, IL (gage 05592900). The concentration in watershed runoff leading to the lake is 0.330 mg/L phosphorus into the northern segment (segment 1) and 0.430 mg/L in the southern segment (segment 2) as compared to the 0.05 mg/L in-lake water quality standard. Existing loading (in pounds per day [lbs./day]) from point sources, septic systems, and atmospheric deposition were also quantified.

Lake response to phosphorus loading is predicted by the BATHTUB model. An existing condition model was developed and calibrated to in-lake water quality data. A TMDL scenario was then developed that required an overall load reduction of 85% to meet the in-lake phosphorus target of 0.05 mg/L (Table 28). It is recommended for NPDES Permittees without TP limit to develop a monitoring plan in the interim, and individual WLAs are provided for those facilities that discharge directly to Carlyle Lake, within 25-miles of Carlyle Lake in the Middle Kaskaskia River watershed and the East Fork Kaskaskia River and Farina Lake watershed.

For facilities without TP permit limits, the WLA was calculated with the DAF and a TP concentration limit as follows (Table 29):

(1) For major facilities with a design average flow of 1.0 mgd, or above, the WLA was developed with a TP concentration limit of 1.0 mg/L as phosphorus

(2) For minor facilities (including those covered by general NPDES permits) with treatment processes such as *Lagoon Systems*, *Imoff Tanks*, *Rotating Biological Contactors (RBCs)*, and *Recirculating Sand Filters*, the WLA was developed with a TP concentration limit of 5.0 mg/L,

(3) For minor facilities with treatment processes composed of septic systems the WLA was developed with a TP concentration limit of 7.0 mg/L.

These TP concentration limits are based on the current treatment technology at each facility, literature values, and previously developed TMDLs in other watersheds for similar facilities.

The WLAs were calculated based on the DAF in the respective NPDES Permits.

During BATHTUB modeling, only those point sources directly discharging to Carlyle Lake were explicitly identified with individual WLAs. Thus, in Appendix D, loading from upstream permitted point sources (i.e., those that do not directly discharge to Carlyle Lake) is contained within the 'Watershed' load that is part of the Load Allocation. In Table 28, the upstream permitted point sources loads are presented as 'Upstream' within the Wasteload Allocation, and the Load Allocation and 'Watershed' are reduced accordingly

Table 28. Total phosphorus TMDL, Carlyle Lake (IL_ROA)

TMDL Parameter	TMDL TP Load (lbs/yr)*	TMDL TP Load (lbs/day)
Wasteload Allocation	21,535	59
Direct	*1825*	*5*
Upstream	*19,710*	*54*
Load Allocation	190,530	522
Watershed	*188,705*	*517*
Atmospheric Deposition	*3,285*	*9*
Septic Systems	*1,095*	*3*
RC	24,930	68
MOS	12,410	34
Load Capacity	**249,405**	**683**
Existing Load	1,664,836	4,561
Load Reduction	85%	

*lbs/yr = pounds per year.

Table 29. Individual NPDES phosphorus WLAs, Carlyle Lake (IL_ROA)

Permit ID	Facility Name	Type [a]	Watershed	Direct to Carlyle Lake or Upstream	Permit load limit at DAF or DMF (lbs/day)	DAF (MGD)	TP Concentration @DAF or DMF (mg/L)	TP WLA (lds/day)
Individual NPDES Permits with TP Limits								
IL0023574	Vandalia STP	--	MK	Upstream	11 @DAF	1.3	1.0 @DAF [b]	11
IL0025933	USACOE Carlyle	--	MK	Direct	0.21 @DMF	0.025	1.0 @DMF [b]	0.21
Individual NPDES Permits currently without TP Limits								
IL0030872	St . Elmo STP	TS	MK	Upstream	--	0.343	5.0 @DAF	14.30
IL0037974	Ramsey Lake State Park	TS	MK	Upstream	--	0.015	5.0 @DAF	0.63
IL0050156	Fillmore STP	TS	MK	Upstream	--	0.049	5.0 @DAF	2.04
IL0053996	IL DNR-Eldon Hazlet State Park	TS	MK	Direct	--	0.045	5.0 @DAF	1.88
IL0061697	Hickory Shores Resort	SS	MK	Direct	--	0.01	7.0 @DAF	0.58
IL0076422	Alma STP	SS	EF&FL	Upstream	--	0.05	7.0 @DAF	2.92
Lagoon Systems covered by General Permits (ILG551 and ILG580)								
ILG580007	St. Peter STP	TS	EF&FL	Upstream	--	0.042	5.0 @DAF	1.75
ILG580022	Patoka STP	TS	EF&FL	Upstream	--	0.072	5.0 @DAF	3.0
ILG580027	Brownstown STP	TS	MK	Upstream	--	0.1	5.0 @DAF	4.17
ILG580123	Kinmundy STP	TS	EF&FL	Upstream	--	0.146	5.0 @DAF	6.09
ILG580191	Mulberry Grove SD STP	TS	MK	Upstream	--	0.0864	5.0 @DAF	3.6
ILG580222	Ramsey STP	TS	MK	Upstream	--	0.171	5.0 @DAF	7.13

EF&FL = East Fork Kaskaskia River and Lake Fork
DAF = design average flow
lb/day = pounds per day
MGD = million gallons per day
mg/L = milligrams per liter
MK = Middle Kaskaskia River
STP = sewage treatment plant
a. Type of wastewater treatment:
TT - Treatment System (Lagoon System/Imhoff Tank/ Rotating Biological Contactor (RBC)/ Recirculating Sand Filters)
SS - Septic System
b. The concentration limits are based on the current NPDES permit effluent limits.

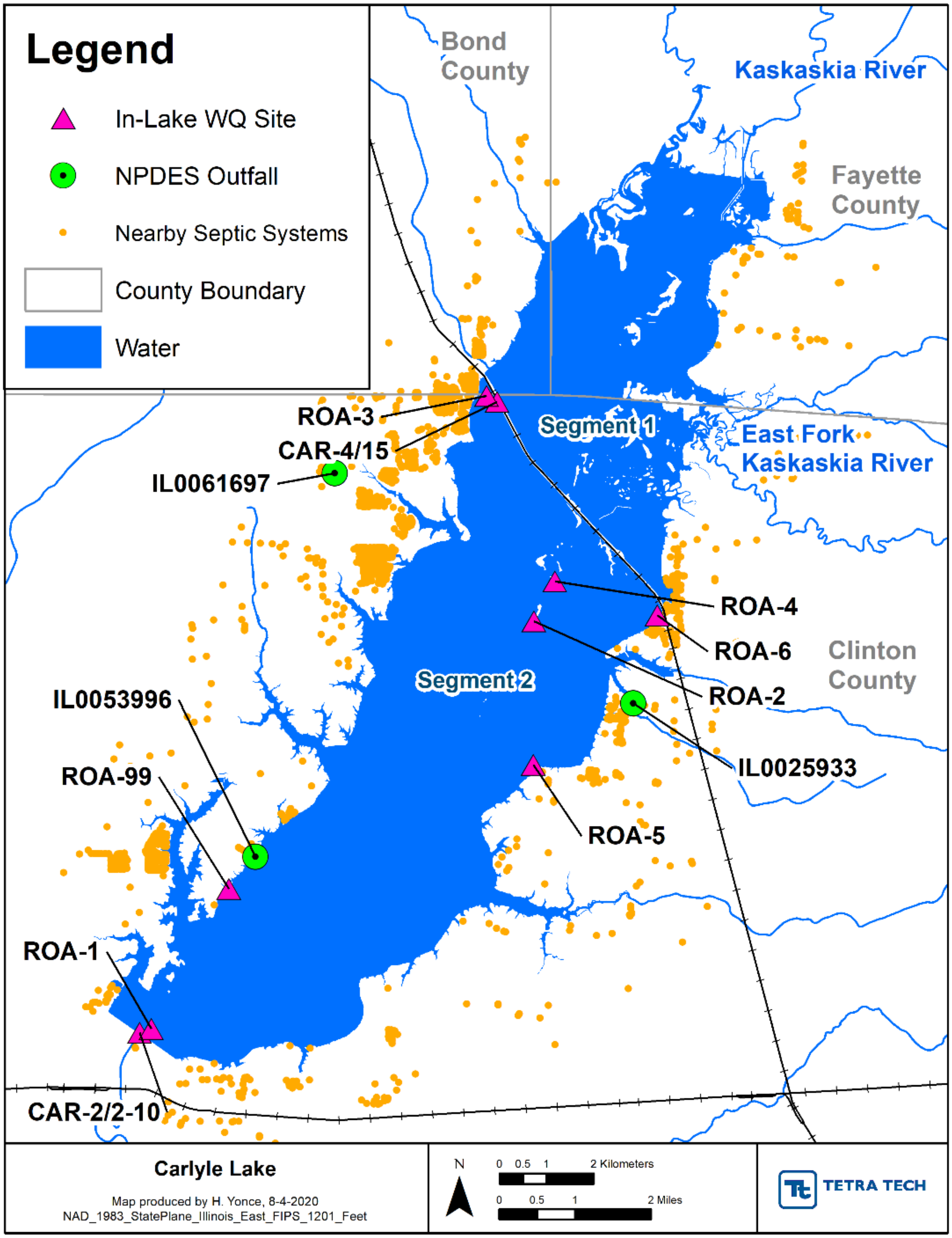

Figure 18. Carlyle Lake and key features (in-lake water quality sampling sites, NPDES facility locations, nearby septic systems).

8. Implementation Plan and Reasonable Assurance

The objective of this implementation plan is to recommend activities that when implemented will reduce pollutant loads and improve conditions in the Middle Kaskaskia River/Carlyle Lake watershed in a cost effective and timely manner. These activities will help to achieve reductions and attain water quality standards and will result in a cleaner, healthier watershed for the people who depend on the resources of the watershed for their livelihood now and in the future.

This implementation plan is a framework that watershed stakeholders may use to guide implementation of best management practices (BMPs) to address fecal coliform and phosphorus TMDLs in the Middle Kaskaskia River/Carlyle Lake watershed. This framework is flexible and incorporates adaptive management to allow watershed stakeholders to align the implementation plan with existing priorities and limitations. This flexibility is necessary because the implementation of nonpoint source controls is voluntary. Adaptive management is also necessary because factors unique to specific localities may yield better or worse results for a certain BMP (or suite of BMPs) and the implementation plan will need to be modified to account for such results.

8.1 Clean Water Act Section 319 Eligibility

An important factor for implementation of the recommended BMPs is access to technical and financial resources. One potential source of funding is the CWA Section 319 Nonpoint Source Management grants. Section 319 grant funding supports implementation activities including technical and financial assistance, education, training, demonstration projects, and monitoring to assess the success of nonpoint source implementation projects. To be eligible for these funds, watershed management plans must address nine elements identified by U.S. EPA (2008, revised 2014) as critical for achieving improvements in water quality. These nine elements include:

- Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve load reductions estimated within the plan
- Estimate of the load reductions expected from management measures
- Description of the nonpoint source management measures that will need to be implemented to achieve load reductions estimated in element 2; and identification of critical areas
- Estimate of the amounts of technical and financial assistance needed, associated costs, and the sources and authorities (e.g., ordinances) that will be relied upon to implement the plan
- An information and public education component; early and continued encouragement of public involvement in the design and implementation of the plan
- Implementation schedule
- A description of interim, measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented
- Criteria to measure success and reevaluate the plan
- Monitoring component to evaluate the effectiveness of the implementation efforts over time

While pollutants impacting bacteria and phosphorus levels may originate from a combination of point and nonpoint sources, only nonpoint sources will be evaluated further in this plan. The Middle Kaskaskia River/Carlyle Lake watershed TMDL, including this implementation plan, is considered a watershed plan that meets U.S. EPA’s nine elements. Table 30 illustrates which sections of the document contain information that fulfills U.S. EPA’s nine elements.

Table 30. Comparison of TMDL study and implementation plan to U.S. EPA's nine elements

Section 319 Nine Elements	Applicable Section of the TMDL/Implementation Plan
1. Identification of **causes of impairment and pollutant sources** or groups of similar sources that need to be controlled to achieve **load reductions** estimated within the plan.	Section 8.2
2. Estimate of the **load reductions expected from management measures**	Section 8.3.5
3. Description of the **nonpoint source management measures** that will need to be implemented to **achieve load reductions** estimated in element 2; and identification of **critical areas**	Section 8.3 and 8.2.4
4. Estimate of the amounts of **technical and financial assistance needed**, associated **costs**, and the **sources and authorities** (e.g., ordinances) that will be relied upon to implement the plan.	Section 8.4
5. An **information and public education component**; early and continued encouragement of public involvement in the design and implementation of the plan.	Section 8.5
6. **Implementation schedule**	Section 8.6
7. A description of **interim, measurable milestones** for determining whether nonpoint source management measures or other control actions are being implemented.	Section 8.6
8. Criteria to **measure success** and **reevaluate** the plan	Section 8.7
9. **Monitoring component** to evaluate the effectiveness of the implementation efforts over time	Section 8.8

8.2 Critical Areas for Implementation

*This section contains the requirement for U.S. EPA's **element one**: identification of causes of impairment and pollutant sources.*

Successful implementation begins with identifying and focusing resources in critical areas for implementation. Critical areas are the focus of outcome-based plans because they represent those locations where project funding will provide the greatest environmental benefit. Upon identification of critical areas, BMPs can be evaluated and selected to address the needs of each area. Critical areas for implementation were determined for each impaired subwatershed and then analyzed for any overlapping area or multi-pollutant reduction to further prioritize actions.

Critical areas were determined using the suggested process provided in U.S. EPA's *Critical Source Area Identification and BMP Selection: Supplement to Watershed Planning Handbook* (2018) (Figure 19). In accordance with this guidance, critical source areas (CSAs) were determined for the first ten years of implementation. Upon completion of the first ten years of implementation, adaptive management principles (outlined in Section 8.7) can be used to determine CSAs for the next ten years, and so on. The U.S. EPA's (2018) suggested process for CSA selection is summarized by step in this section.

8.2.1 Step 1: Establish Priorities

The Illinois 303(d) list and the Middle Kaskaskia River/Carlyle Lake watershed TMDL establish the priorities of this plan. The impaired waters addressed in this implementation plan are Kaskaskia River (IL_O-08), Kaskaskia River (IL_O-38), and Carlyle Lake (IL_ROA). Both Kaskaskia River segments are listed as impaired for primary contact recreation due to high existing loads of fecal coliform bacteria. Carlyle Lake (IL_ROA) is listed as impaired for aesthetic quality due to total phosphorus. As such, TMDL reductions for fecal coliform bacteria and total phosphorus have been developed in Section 7 and are summarized below.

The goal of this implementation plan is to achieve the following water quality standards and required reductions:

- For Kaskaskia River segments IL_O-08 and IL_O-38,
  - 200 cfu/100 mL or a 44% reduction in fecal coliform concentrations
- For Carlyle Lake (IL_ROA),
  - 0.05 mg/L or an 85% reduction in total phosphorus loading

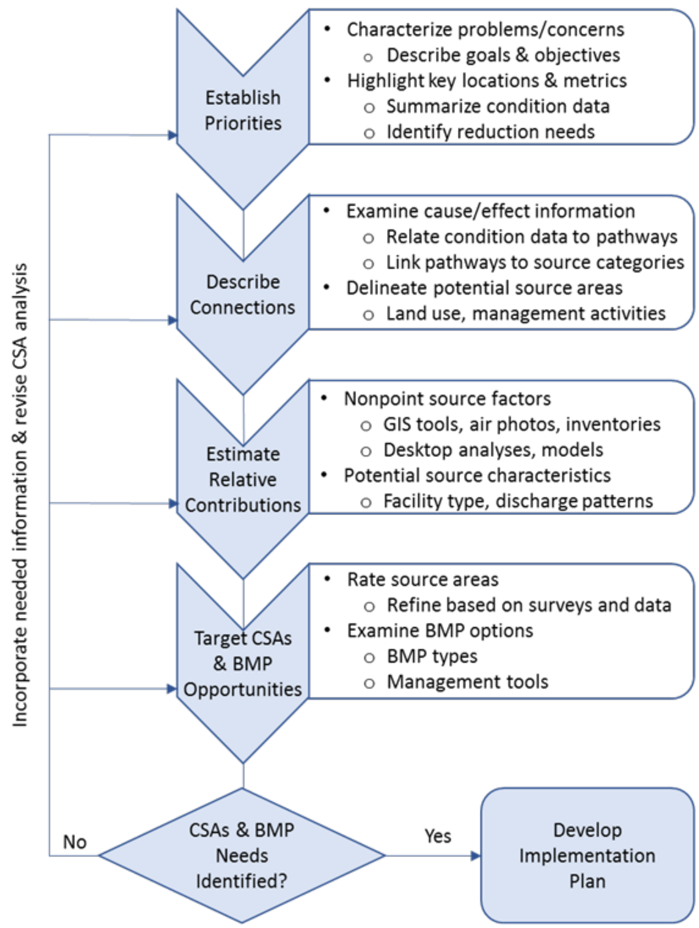

Figure 19. Critical area selection process (U.S. EPA 2018).

In addition, stakeholders have expressed concerns for sediment loading to Carlyle Lake. Because phosphorus is often sediment-bound, selection of BMPs for Carlyle Lake will focus on those BMPs that achieve both phosphorus and sediment load reductions. The U.S. Army Corps of Engineers (USACE) has completed numerous studies within Carlyle Lake and the Kaskaskia River. They are actively addressing sediment-related issues as documented in the Carlyle Lake Master Plan (USACE 2017).

8.2.2 Step 2: Describe Connections

Understanding the nature of nonpoint source pollutants and the potential pathways to deliver those pollutants to impaired waters can help to determine CSAs to target for implementation.

Fecal coliform exceedances occur across all flow zones in the two impaired segments (Table 22 and Table 25) which suggests that multiple sources of pathogens are contributing to impairment. Nonpoint sources of fecal coliform in the Middle Kaskaskia River watershed include livestock, stormwater runoff, wildlife, and wastewater. These nonpoint sources are connected to bacteria-impaired stream segments via the following pathways:

- **Animal feeding operations.** Livestock in both confined and pasture-based feeding operations are a potential source of bacteria to streams, particularly when direct access to streams and waters is not restricted and where feeding structures are located near riparian areas. Additionally, manure from animal feeding operations applied to cropland can potentially contribute additional bacterial loading.

- **Stormwater runoff.** In urban areas, sources of fecal coliform bacteria may include pet and wildlife waste, trash, and other suspended solids. These sources are often incorporated into stormwater runoff and can be delivered to downstream waterbodies.

- **Wildlife.** Wildlife are commonly found throughout Illinois. Fecal coliform contributions from animals such as deer, squirrels, racoons, and migratory and resident waterfowl can be a source of bacteria to waters throughout the larger Kaskaskia River watershed.

- **Onsite wastewater treatment systems.** Conventional onsite wastewater treatment systems are composed of a septic tank and drainfield. Fully functioning onsite wastewater systems (i.e., septic systems) remove bacteria from wastewater during the percolation of effluent through the drainfield. Fecal coliform loading rates for appropriately sited and properly functioning systems are typically insignificant. However, if systems are placed on unsuitable soils, not maintained properly, or are connected to subsurface drainage systems or surface waters, loading rates may be relatively high.

Nonpoint sources of phosphorus loading to impaired waters include watershed loading, atmospheric deposition, and onsite wastewater treatment systems. Watershed loading includes sources such as cropland (specifically fertilizer application), animal feeding operations, stormwater, and streambank and shoreland erosion. Within the Middle Kaskaskia River/Carlyle Lake watershed, these nonpoint sources are connected to impaired stream segments via the following pathways:

- **Watershed loading** contributions from cropland, animal feeding operations, stormwater, and erosion include:
    - **Cropland** fertilizer application accounts for the majority of phosphorus on cropland. During wet-weather events (snowmelt and rainfall), phosphorus can be incorporated into runoff and delivered to downstream waterbodies. Cropland erosion can result in the direct transport of sediment-bound phosphorus into nearby waterbodies. Fertilizer can also leach into tile lines, typically in dissolved form, and be transferred to downstream receiving waters
    - **Animal feeding operations.** Confined and pasture-based animal feeding operations may contribute nutrients via the mobilization and transportation of pollutant laden waters from feeding, holding and manure storage sites. Feedlots also generate manure which may be spread onto fields and can contain high concentrations of phosphorus.
    - **Stormwater runoff** may also be a source of phosphorus loading if proper BMPs are not in place, especially in areas with development activities where soils have been disturbed or where commercial products (such as phosphorus-based lawn fertilizers) are applied. The contribution of phosphorus loading from watershed runoff is also exacerbated by the presence of impervious surfaces which can channelize stormwater flows and reduce the time available for infiltration or evaporation.
    - **Streambank and shoreland erosion** refers to the wearing away of the banks and channel of a stream or river and the shore of lakes. High rates of erosion can often be associated with water flow and sediment dynamics being out of balance that can result from land use activities that either alter flow regimes, adversely affect the floodplain and riparian areas, or a combination of both. Hydrology is a major driver for stream channel erosion; high water levels, wind, and wave action are major drivers for shoreland erosion in Carlyle Lake. Phosphorus can be tied to sediment, and therefore sediment loading from these sources is also a source of phosphorus to the lake.

- **Atmospheric deposition**. Nutrients are present in the atmosphere which are then picked up by rain and snow and deposited on the land surface. Regional monitoring provides data on the concentration of nutrients in the atmosphere and in precipitation.

- **Onsite wastewater treatment systems** (e.g., septic systems) contribute phosphorus to downstream receiving waters, however those that are properly designed and maintained should not serve as a major source of phosphorus to surface waters. If systems are maintained improperly, sited improperly, or are connected to surface waters or subsurface drainage systems, septic discharge can have adverse effects on surface waters. We assumed 10% of conforming system effluent reaches the lake, while 30% of non-conforming system effluent reaches the lake[5].

8.2.3 Step 3: Estimate Relative Contributions

Once the sources and pathways of pollutants are known, estimating the relative contributions from these areas can help to further prioritize areas to target for implementation. U.S. EPA (2018) states that estimates of relative contributions "…can range from narrative descriptors (e.g., high, medium, low) derived from aerial photo analysis or field inventories to quantitative values developed from desktop screening tools or models." The approaches used to estimate the relative contribution of pollutants to the Middle Kaskaskia River/Carlyle Lake watershed vary depending on the size of the contributing area, type of pollutant, and amount of available information. Estimates of relative contributions for each pollutant are described in the following subsections.

Fecal Coliform Relative Contributions to Kaskaskia River (IL_O-08 and IL_O-38)

As the exact nature of fecal coliform loading in the Middle Kaskaskia River/Carlyle Lake watershed is unknown, a qualitative approach was used to identify significant nonpoint sources of fecal coliform bacteria in the two fecal coliform-impaired subwatersheds of Kaskaskia River (IL_O-08 and IL_O-38). Bacterial loading in the Middle Kaskaskia River watershed is significant during all flow zones, which indicates that a mixture of wet weather sources (such as runoff) and dry weather sources (such as wildlife with access to riparian areas and wastewater discharge) are contributing to bacterial loading. Table 31 summarizes the relative contribution of fecal coliform from potential sources.

Table 31. Relative contribution of fecal coliform to Kaskaskia River segments IL_O-08 and IL_O-38.

Potential Source	Relative Contribution
Animal feeding operations	High
Stormwater runoff	Low
Wildlife	Low
Onsite wastewater treatment systems	Moderate

Animal feeding operations are likely the largest contributor of bacteria to impaired streams. Using aerial imagery, 227 pastures and feedlots were identified within the subwatersheds of Kaskaskia River segments IL_O-08 and IL_O-38, excluding additional upstream drainage areas. Feedlots and pasture locations were distinguished by the presence of animal housing structures, drainage lagoons, cattle pens, stock ponds, troughs, and other identifiable features that indicated the existence of livestock. The significant presence of feedlots and pasture in the Middle Kaskaskia River watershed indicate that animal feeding operations potentially contribute substantially to fecal coliform loading in the watershed.

Stormwater runoff in developed areas may also contribute fecal coliform loading to the impaired subwatersheds. Approximately 8% of the Middle Kaskaskia River/Carlyle Lake watershed is covered by

[5] Barr Engineering Company, 2004. Detailed Assessment of Phosphorus Sources to Minnesota Watersheds. Prepared for Minnesota Pollution Control Agency.

urban development, including areas near the City of Vandalia and several small towns (Figure 2). Depending on the intensity of human activity in residential, commercial, and industrial areas, stormwater runoff may contribute bacteria to local water bodies. Common fecal coliform sources in stormwater include pet waste, trash, and other residential suspended solids.

Wildlife may also contribute to fecal coliform contributions in the watershed. especially in areas of the watersheds with low densities of human population or areas where animals have access to riparian areas, such as wooded, wetland, and agricultural habitats. According to the University of Illinois–Extension, the highest densities of white tail deer in the state are found in wooded areas around major rivers such as the Kaskaskia. Approximately 50% of land cover in the Middle Kaskaskia River/Carlyle Lake watershed is cultivated cropland, throughout which deer and other wildlife are also known to reside (University of Illinois Extension 2017). Additionally, Kaskaskia River segment IL_O-38 runs through a large area of forested wetlands. These sheltered, wet areas are typically attractive for many species of waterfowl and can be large sources of fecal coliform to impaired waters. While wildlife is a potential source of bacteria, the presence of wildlife in rural areas is typically natural.

Onsite wastewater treatment systems also likely contribute bacteria significantly. County health departments were contacted for information on septic systems and unsewered communities to estimate the relative contributions of septic system failures to pollutant loading in the watershed. Effingham County reported 4,862 installed septic systems since 1985 and Fayette reported permitting 605 installed septic systems since 2009 (see Section 4.3.2). Christian and Fayette counties reported three and six unsewered communities, respectively. Bond County requires inspection of newly installed septic systems but does not have a total count of installed systems or unsewered communities. Additionally, no information was provided on failure rates or results of compliance testing. According to area weighted assessment of unsewered communities in the fecal coliform-impaired watersheds, an estimated 6,300 septic systems are located in the drainage areas of IL_O-08 and IL_O-38, excluding additional upstream areas. Given the number of septic systems and unsewered communities identified in the watershed, septic systems are assumed to be a source of fecal coliform to streams.

Phosphorus Relative Contributions to Carlyle Lake (IL_ROA)

The primary source of phosphorus to Carlyle Lake is watershed loading. Watershed loading includes nutrients derived from cropland, animal feeding operations, onsite wastewater treatment systems, and stormwater. Contributions of each of these sources were quantified during the development of the Bathtub model for Carlyle Lake (See Section 7.3) and are summarized below.

Table 32. Phosphorus contribution to Carlyle Lake (IL_ROA).

Phosphorus Source	Average Annual Existing Load (lbs/year)	Percent of Total Load
Watershed load	1,659,418	99.7%
Atmospheric deposition	3,968	0.3%
Onsite wastewater treatment systems [a]	1,179	
Point sources [b]	271	
Total load	**1,664,836**	**100%**

a. Loading from septic systems within one mile of the lake.
b. Point sources are not addressed in this non-point source implementation plan.

Watershed phosphorus loads to Carlyle Lake were estimated using USGS flow gages and water quality data collected by IEPA. A drainage area weighting approach was used to estimate the contribution from the Kaskaskia River, East Fork Kaskaskia River, and the direct drainage area to Carlyle Lake (see Appendix D for additional information). The concentrations of phosphorus entering the lake are clearly contributing to the lake's phosphorus impairment. The Kaskaskia River is discharging on average 0.33

mg/L and the East Fork Kaskaskia River is discharging on average 0.43 mg/L compared with an in-lake water quality standard of 0.05 mg/L which also requires contributing streams to discharge at 0.05 mg/L.

Watershed loading takes into account streambank and shoreland erosion and sediment loading to Lake Carlyle which is occurring along tributaries and the shore of the lake itself. Shoreland erosion was identified as a significant threat to water quality in the Carlyle Lake Master Plan (USACE 2017). According to the USACE's 2003 report on the Kaskaskia River (USACE 2003), Carlyle Lake has been widening 0.9 feet per year on average since 1966 and erosion is expected to continue at this rate. In addition, bank failure, overbank scour, levee failures and maintenance needs along the Vandalia Levee System, and bridge scour were identified as sources of sediment along the mainstem Kaskaskia River upstream of Carlyle Lake. These processes are contributing significantly to sediment and phosphorus loading to the lake. The Illinois Nutrient Reduction Loss Strategy notes that severely eroding stream banks can contribute as much as 30-50% of the sediment entering waterways from all sources (IEPA and the Illinois Department of Agriculture (IDOA) 2015).

Table 33 summarizes the attribution of the different existing watershed sources.

Table 33. Existing watershed loading attribution

Watershed Load Source Attribution	Estimated Existing Load (lbs/year)	Percent of Total Watershed Load
Streambank and shoreland erosion	663,767	40%
Kaskaskia River at Vandalia + Direct Drainage to Carlyle Lake above the railroad tracks [a]	950,943	57%
East Fork Kaskaskia River + Direct Drainage to Carlyle Lake below the railroad tracks [a]	44,708	3%
Total	**1,659,418**	**100%**

a. A 40% reduction from the watershed is allocated to streambank and shoreland erosion per the NLRS (IEPA and IDOA 2015)

Atmospheric deposition to Carlyle Lake was quantified based on National Atmospheric Deposition Program data for the central Illinois site Bondville. Phosphorus deposition data from 1992-2017 were used to approximate an average loading of 3,968 lbs./year onto the Carlyle Lake water surface.

Onsite wastewater treatment system phosphorus loads to Carlyle Lake were calculated using a series of assumptions and observations. A total of 1,402 houses were identified within the 1-mile of the lake which are not within known sewered areas and assumed to be treated by onsite systems. The TP load that arrives to Carlyle Lake was approximated as a function of phosphorus load produced per capita, the shoreline population, and assumptions related to system failure rate and the percentage of phosphorus loading which arrives to the lake based on system status. Based on these parameters, the total phosphorus load that arrives at Carlyle Lake from septic systems is 1,179 lbs./year. Approximately 57% of phosphorus loading from septic systems is from conforming systems, and 43% is due to nonconforming, or failing systems.

8.2.4 Step 4: Target Critical Areas and BMP Opportunities

This section contains part of the requirement for U.S. EPA's ***element three:*** *identification of critical areas*

Critical areas are considered by the U.S. EPA (2018) as areas that are 1) large sources of pollutants, 2) have the greatest pollutant transport potential, and 3) provide opportunity for improvements (i.e., areas disproportionately impacting impaired streams, areas with local support and participation, etc.). Sources and pathways of pollutants and their relative contribution (Steps 1-3) were used to determine critical areas for the first ten years of implementation. Critical area selection is an iterative process (U.S. EPA 2018). When all information is not known or more information is needed, monitoring and use of an adaptive management approach will help to determine what areas to target for implementation.

Critical areas for the Kaskaskia River (IL_O-08 and IL_O-38)

Animal feeding operations have been identified as the largest relative contributor of bacteria loading to fecal coliform impairments in the Kaskaskia River watershed. Locations of feedlots and pastures were identified in an aerial imagery assessment and the density of feedlots and pastures by HUC12 watershed are provided in Figure 20. Three to 37 feedlots or pastures were identified in each HUC12 watershed. Areas with high density, or areas with darker shading, are considered critical areas for Kaskaskia River IL_O-08 and IL_O-38 fecal coliform impairments.

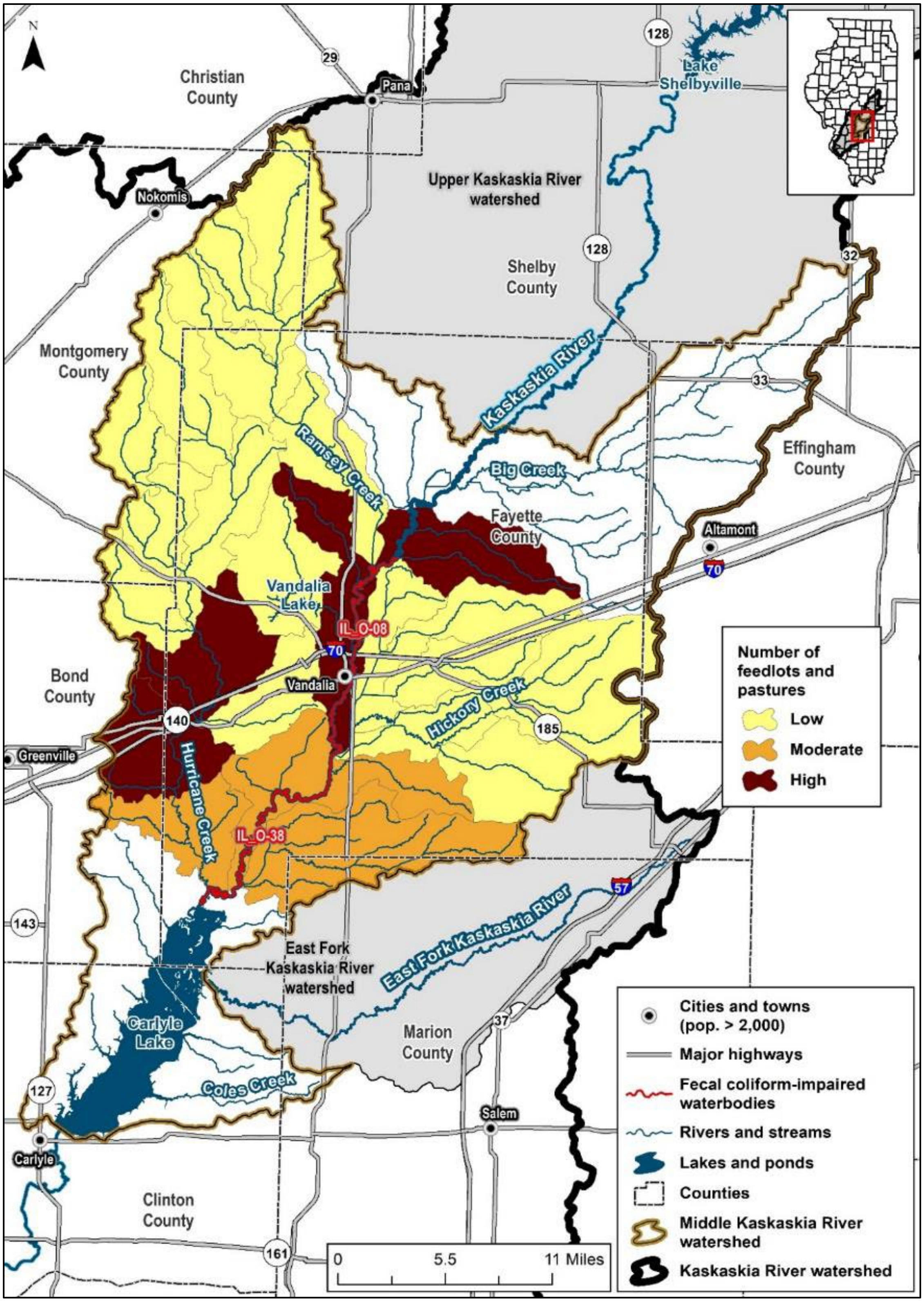

Figure 20. Density of feedlots and pastures in fecal coliform-impaired subwatersheds (HUC12 watersheds) of the Kaskaskia River (IL_O-08 and IL_O-38). Range of values in each HUC12 varied from 3-37 feedlots or pastures.

Critical Areas for Carlyle Lake (IL_ROA)

There are three types of critical areas for Carlyle Lake:

1) **Near shore critical area** – A 1.0-mile buffer is provided around Carlyle Lake (Figure 21); sources of phosphorus are targeted within this critical area including septic systems, animal agriculture activities (e.g., livestock), sediment sources, etc. Locations of these sources were identified using aerial imagery.
2) **Watershed cropland** – Due to the very high phosphorus concentration entering Carlyle Lake from the contributing drainage area, cropland, which makes up almost 50% of the land cover and has a high phosphorus yield, is expected to be a significant source of phosphorus. Cropland is identified as a critical area throughout the watershed (Figure 22, Table 34).
3) **Streambank and shoreland erosion** – Phosphorus-bound sediment entering Carlyle Lake is also a significant source. Key locations for sediment loading include Kaskaskia River outlet to the lake, smaller streams laden with sediment, and lakeshore sediment sources as identified from aerial imagery (Figure 21).

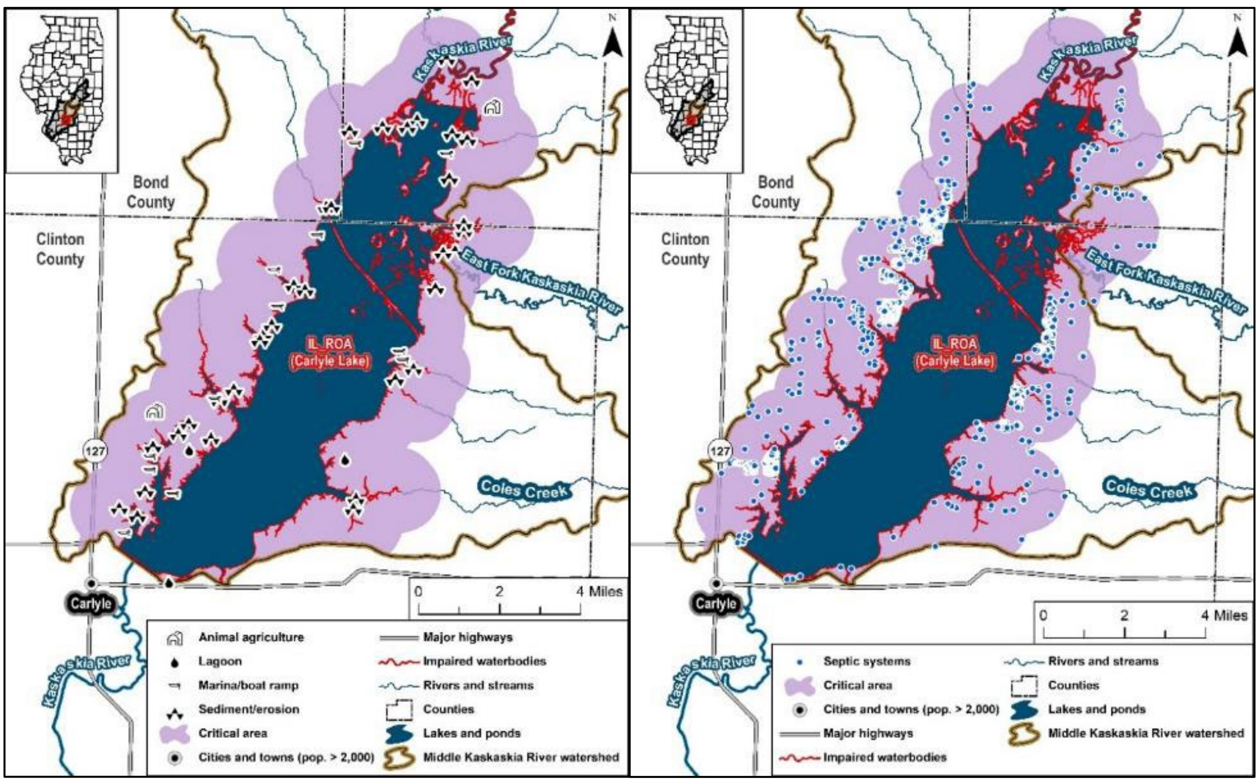

Figure 21. Near shore critical area and potential locations of phosphorus sources.

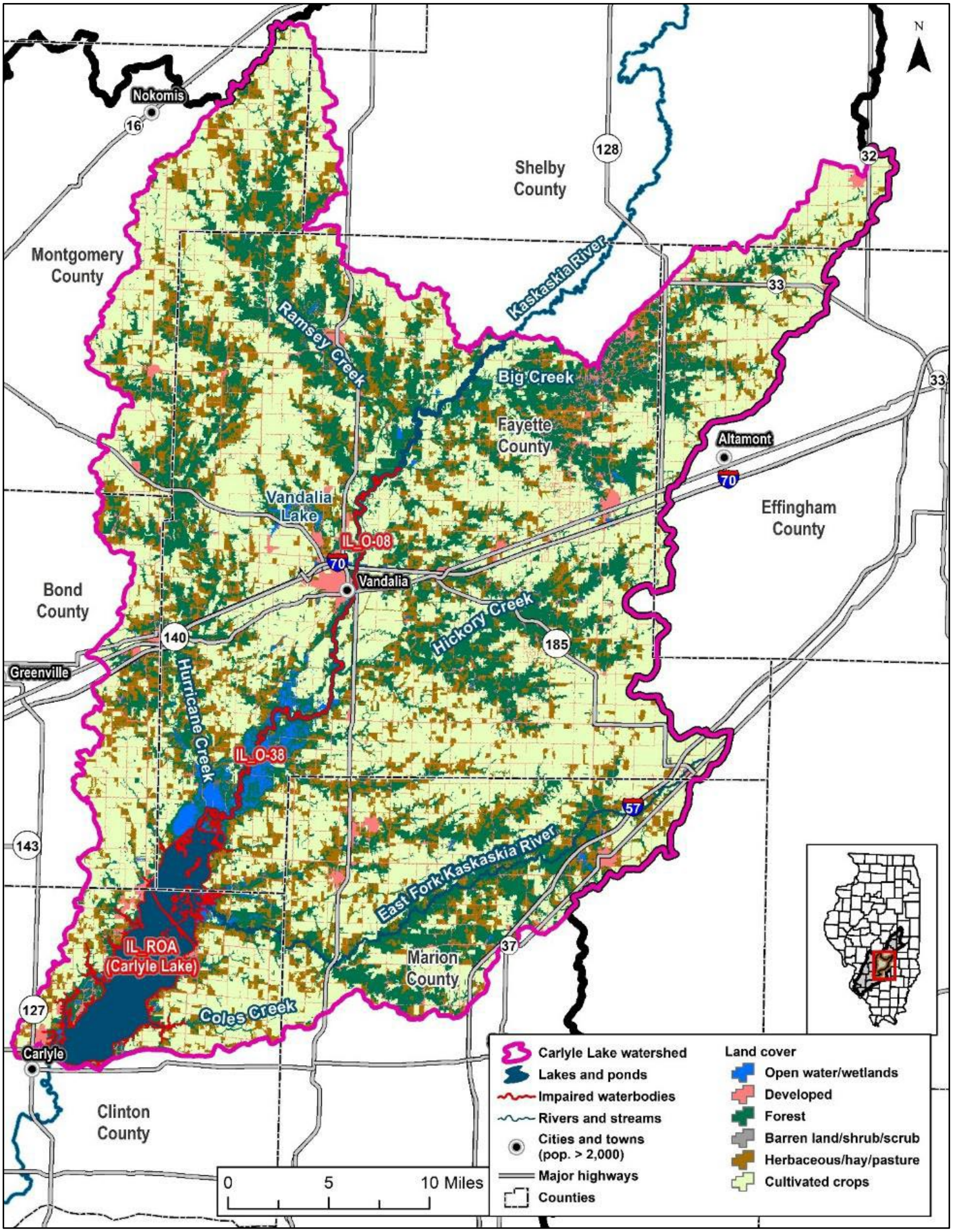

Figure 22. Watershed cropland (cultivated crops) critical areas.

Table 34. Land cover distribution in the Carlyle Lake watershed.

Land Cover Classification	Area (square miles)	Percent of Watershed
Cultivated crops	559.1	48.5%
Forest	276.1	24.0%
Herbaceous/hay/pasture	174.7	15.1%
Developed	87.8	7.6%
Open water/wetlands	54.9	4.8%
Barren land/shrub/scrub	0.1	0.01%
TOTAL	**1,152.7**	**100%**

8.3 Best Management Practices

This section contains the second requirement for U.S. EPA's ***element three:*** *description of nonpoint management measures needed to achieve load reductions.*

Within the watershed planning framework, candidate BMPs are identified and then evaluated to determine which BMPs will best address the causes and sources of pollutant loads. For watersheds with multiple causes and sources such as the Middle Kaskaskia River/Carlyle Lake watershed, suites of BMPs must be identified and evaluated. There are many different BMPs and BMP scenarios that could be used to achieve pollutant load reductions. Recommended BMPs and associated pollutant removal efficiencies are provided below in Table 35 for significant sources of pollutants in the Middle Kaskaskia River/Carlyle Lake watershed.

Table 35. BMP removal efficiencies for example practices

BMP	Fecal Coliform Removal Efficiency	Total Phosphorus Removal Efficiency
Cropland practices		
Conservation tillage	--	50% [d]
Cover crops	--	30% [d]
Nutrient and fertilizer management	--	Varies depending on existing practices
Vegetated buffers and filter strips	34-74% [a]	25-50% [d]
Animal feeding operations practices		
Feedlot and pasture BMPs (composting manure structures and manure management, runoff management, clean water diversions, rotational grazing, and forage biomass planting)	90-97% [b, c]	35-80% [e]
Livestock exclusion BMPs	24-46% [b]	15-49% [b]
Streambank and shoreland restoration	--	75% [e]
Onsite wastewater treatment practices		
Upgrading, replacing, and maintaining failing septic systems	100% for failing systems	Varies depending on existing system conditions
Education and inspection programs	Varies depending on level of effort required and number of systems in area	

a. Source: Wenger 1999
b. Source: U.S. EPA 2003
c. Source: Meals and Braun 2006
d. Source: IEPA and IDOA 2015
e. Source: U.S. EPA STEPL

8.3.1 Cropland Practices

Agricultural runoff is an important source of total phosphorus loading to impaired segments in the Middle Kaskaskia River watershed. Example cropland BMPs to address total phosphorus loading are presented in the following subsections and estimated reductions are summarized in Table 35. A subset of the management practices provided in the Illinois Nutrient Loss Reduction Strategy (NLRS) are included for use in the Middle Kaskaskia River watershed. Other management practices can also be used to achieve the goals of the TMDL and this plan such as wetland restoration. The Illinois Council on Best Management Practices provides additional information on these and other BMPs (http://illinoiscbmp.com/). Many of these practices have the added benefit of improving soil health.

Conservation Tillage

The Illinois NLRS identifies reduced or conservation tillage as a primary BMP to control phosphorus loading to waters. The Illinois Agronomy Handbook defines conservation tillage as any tillage practice that results in at least 30% coverage of the soil surface by crop residuals after planting (University of Illinois Extension 2009). Several practices are commonly used to maintain the suggested 30% cover:

- **No-till** systems disturb only a small row of soil during planting, and typically use a drill or knife to plant seeds below the soil surface.
- **Strip till** operations leave the areas between rows undisturbed but remove residual cover above the seed to allow for proper moisture and temperature conditions for seed germination.
- **Ridge till** systems leave the soil undisturbed between harvest and planting: cultivation during the growing season is used to form ridges around growing plants. During or prior to the next planting, the top half to two inches of soil, residuals, and weed seeds are removed, leaving a relatively moist seed bed.
- **Mulch till** systems are any practice that results in at least 30% residual surface cover, excluding no-till and ridge till systems.

Corn residues are more durable and capable of sustaining the required 30% cover required for conservation tillage. Soybeans generate less residue, the residue degrades more quickly, and supplemental measures or special care may be necessary to meet the 30% cover requirement. Based on 2018 satellite imagery, less than half of the cropland acres in the Middle Kaskaskia River major watershed had residue greater than 30% (Applied Geosolutions LLC et al. 2019).

Cover Crops

Winter cover crops are also identified in the NRLS as an important management practice (IDOA and IEPA 2015). According to NRCS, cover crops "have the potential to provide multiple benefits in a cropping system. They can prevent soil and wind erosion, improve soil's physical and biological properties, supply nutrients, suppress weeds, improve the availability of soil water, and break pest cycles along with various other benefits. The species of cover crop selected along with its management determine the benefits and returns" (NRCS 2020). There are many different types of crops being used for cover crops including various grasses and legumes. Based on 2018 satellite imagery, approximately 10% of the cropland acres in the Middle Kaskaskia River major watershed were using winter cover crops (Applied Geosolutions LLC et al. 2019).

Nutrient and Fertilizer Management

Proper application of fertilizer (both commercial and manure) to cropland can greatly reduce nutrient levels in agricultural runoff. In general, nutrient and fertilizer management aims to optimize application rates and improve storage and disposal of fertilizer to reduce pollution in runoff.

The Illinois Agronomy Handbook lists guidelines for fertilizer application rates based on the inherent properties of the soil (typical regional soil phosphorus concentrations, root penetration, pH, etc.), the starting soil test phosphorus concentration for the field, and the crop type and expected yield (University of Illinois Extension 2009). Limiting commercial application of fertilizers to only fields with soil test phosphorus levels below the recommended maintenance and applying nitrogen according to the

University of Illinois "Maximum Return to Nitrogen" recommendations can reduce nutrient loading from excess fertilization. Application of fertilizer should address application rates, methods, and timing as described in the NRLS and according to the 4Rs – **R**ight Source, **R**ight Rate, at the **R**ight Time, and in the **R**ight Place. Application to frozen ground or snow cover should be strongly discouraged. Researchers studying loads from agricultural fields in east-central Illinois found that fertilizer application to frozen ground or snow followed by a rain event could transport 40% of the total annual phosphorus load (Gentry et al. 2007).

Fertilizer transport, storage, and disposal practices should also be monitored to reduce potential pollution in runoff. Commercial fertilizers should be stored at least 100 feet from nearby surface waters and should not be stored underground or in pits. Application equipment should be cleaned, inspected, and calibrated regularly, and excess fertilizer from wash water should be recovered for reuse. Disposal of commercialized fertilizers should follow manufacturer guidelines. Improvements to storage and disposal practices may require improvements to existing equipment or storage infrastructure to reduce potential leakages.

Vegetated Buffers and Filter Strips

Vegetated buffers and filter strips provide many benefits and can effectively address water quality degradation. Riparian buffers that include perennial vegetation and trees can filter runoff from adjacent cropland and the root structure of the vegetation in a buffer enhances subsequent trapping of pollutants. However, buffers are only effective in this manner when the runoff enters the buffer as a slow moving, shallow "sheet"; concentrated flow in a ditch or gully and quickly passes through the buffer offering minimal opportunity for retention and uptake of pollutants. The Illinois NRCS electronic Field Office Technical Guide recommends the minimum width of a riparian buffer should be 2.5 times the width of the stream (at bank-full elevation) or 35 feet for water bodies to achieve additional water quality improvements (NRCS 2017a).

Filter strips are a strip of permanent vegetation located between disturbed land (cropland or pasture) and environmentally sensitive areas that can effectively address water quality degradation from nutrient loading while also enhancing habitat (NRCS 2017b). Filter strips provide many of the same benefits as vegetated buffers but are also subject to the same design considerations. Determining adequate filter strip widths depends on the slope of the land. Table 36 summarizes the minimum and maximum flow lengths for filter strips according to Illinois NRCS standards.

Table 36. Minimum and maximum filter strip length for land slope (NRCS 2017b)

Slope (%)	0.5	1.0	2.0	3.0	4.0	5.0 or greater
Minimum (feet)	36	54	72	90	108	117
Maximum (feet)	72	108	144	180	216	234

Depending on the nature of pollutant loading in individual watersheds, vegetated buffers and filter strips may reduce pollutant loading from cropland, pasture, stormwater, and feedlots.

8.3.2 Animal Feeding Operation Practices

Proper management of runoff and waste is important to improving water quality and reducing nutrient loading to the watershed. Animal operations are typically either pasture-based or confined, or sometimes a combination of the two. The operation type dictates the practices needed to manage manure and soil erosion from the facility. A pasture or open lot system with a relatively low density of animals (1 to 2 head of cattle per acre [U.S. EPA 2003]) may not produce manure in quantities that require management for the protection of water quality. If excess manure is produced, then the manure will typically be stored which can then be land applied. Application of manure should be at agronomic rates, taking into account commercial fertilizer application, when the ground is not frozen and precipitation forecasts are low. Rainfall runoff should be diverted around storage facilities with berms or grassed waterways.

Confined facilities (typically dairy cattle, swine, and poultry operations) often collect manure in storage pits. Wash water used to clean the floors and remove manure buildup combines with the solid manure to form a liquid or slurry in the pit. Final disposal of waste usually involves land application on the farm or transportation to another site.

Livestock operation BMPs generally seek to contain manure and manure wastewater; contain and treat runoff contaminated with manure or manure wastewater; divert clean water; and prevent runoff following manure land application. The following feedlot and pasture BMPs are recommended:

- **Composting manure structures and manure management**. Composting manure structures contain manure and other organic materials as they are broken down through aerobic microbial processes. Once decomposed, the organic materials are suitable for storage, on farm use, and application to land as a soil amendment. Composting facilities typically consist of a concrete floor separated by stalls, cover such as a roof or loose tarp is recommended to maintain an environment conducive to aerobic digestion (NRCS 2017c). Other manure management practices include:
    - Grading, earthen berms, and such to collect, direct, and contain manure
    - Installation of concrete pads
- **Runoff management** (runoff from production areas)
    - Grading, earthen berms, and such to collect and direct manure-laden runoff
    - Filter strips
    - Storage ponds
- **Clean water diversion**
    - Roof runoff management
    - Grading, earthen berms, and such to collect and direct uncontaminated runoff
- **Manure land application**
    - Nutrient management strategy (e.g., the 4Rs: **R**ight Source, **R**ight Rate, **R**ight Time, **R**ight Place), see Nutrient and Fertilizer Management
    - Application at agronomic rates, taking into account commercial fertilizer application, when the ground is not frozen and precipitation forecasts are low

In addition, BMPs for alternative water systems and exclusion fencing can be used to reduce nutrients and fecal coliform from livestock with access to streams. These BMPs limit or eliminate livestock access to a stream or waterbody. Fencing can be used with controlled stream crossings to allow livestock to cross a stream while minimizing disturbance to the stream channel and streambanks. Providing alternative water supplies for livestock allows animals to access drinking water away from the stream, thereby minimizing the impacts to the stream and riparian corridor. U.S. EPA (2003) studied the impacts of providing alternative watering sites without structural exclusions and found that cattle spend 90% less time in the stream when alternative drinking water is furnished and estimates that total phosphorus reductions from 15-49% can be expected.

8.3.3 Onsite Wastewater Treatment System BMPs

BMPs to reduce pollutant loading from wastewater sources include the maintenance and inspection of private onsite wastewater treatment systems. The most effective BMP for managing loads from septic systems is regular maintenance. U.S. EPA recommends that septic tanks be pumped every 3 to 5 years depending on the tank size and number of residents in the household (U.S. EPA 2002). When not maintained properly, septic systems can cause the release of pathogens, as well as excess nutrients, into surface water. Annual inspections, in addition to regular maintenance, ensure that systems are functioning properly. An inspection program can identify those systems that are currently connected to tile drain systems or storm sewers. Inspections also help to determine if systems discharge directly to a waterbody ("straight pipe") and can recommend alternative solutions. Additional point of sale inspections, or inspections when a property is sold and purchased, can improve the baseline understanding of septic conditions and decrease occurrences of leaks potentially contributing to phosphorus loading in the watershed. These may include a soil boring to determine if the soil has adequate separation, and an examination of the inside of the tank after it has been pumped.

The development of regulatory or ordinance language may also support septic system improvements in the watershed. The City of Vandalia, IL passed an ordinance in 2002 to inspect all septic systems around Vandalia Lake every three years (Vandalia Lake Planning and Technical Committees 2002). Additionally, septic systems installed after Jan 1, 2014, are required to have a documented evaluation by the Illinois Department of Public Health Sewage Code. The owner is required to keep the documentation for the life of the system or pass the documentation to a new owner.

Education and outreach are a crucial component of reducing pollution from septic systems and can occur through public meetings, mass mailings, and radio and television advertisements. An inspection program can also help with public education because inspectors can educate owners about proper operation and maintenance during inspections. Education and outreach programming should also be utilized to collect data on wastewater characteristics in the watershed, including numbers of failing systems, locations of unsewered communities, and additional private wastewater management practices that might implicate water quality. This data collection should support a centralized system of information that can be used for future implementation and watershed planning efforts.

8.3.4 Streambank and Shoreland Restoration

Streambanks and beds along the Kaskaskia River and tributary streams are impacted by channelization, erosion, and streambank destabilization. Eroded lakeshores, banks and beds have been identified as a source of sediment in the watershed. The following BMPs are appropriate to restore these areas:

- **Stream channel natural design methods** that establish meanders and natural flow complexity and connects the stream channel with the floodplain.
- **Engineering controls** include armoring with materials, deflection of the water course with rock or log structures, and removal of debris to restore flows. Example practices include stone toes, stream barbs and removal of any problematic log jams that contribute to erosion. Levee maintenance and improvements may be needed; and scour along infrastructure such as bridges may need engineering controls.
- **Vegetative stabilization and restoration of riparian areas** can reduce peak flows from runoff areas and channel velocities directing runoff. Using vegetative controls also enhances infiltration, which reduces high flows that cause erosion. Selection of BMPs and costs will depend on location-specific factors.
- **Shoreland improvements**, as indicated in the Carlyle Lake Master Plan (USACE 2017), include engineering solutions such as revetments and other armoring, riparian vegetation management, water level controls, and land acquisition.

The Carlyle Lake Master Plan (USACE 2017) notes that multiple projects have been underway to address Lake Carlyle shoreland erosion including use of revetments and land acquisition:

"In 1989, an Engineering Letter Report was approved which proposed a combination of land acquisition and revetment to solve the ongoing shoreline erosion issues at nine (9) locations around the lake. Due to funding constraints and unwilling sellers, the land acquisition proceeded very slowly. However, to date only one area remains unresolved from this Letter Report. In 2012, the Carlyle Lake staff initiated another study to address ongoing erosion problems, resulting from frequent and long-lasting flood events. Surveys were completed for approximately 30 identified sites. In 2014, work began on ten of the sites determined to be the most critical. Each of the sites were evaluated to establish the most cost-effective solution for each location. The two solutions considered were revetment or acquisition of additional land. In 2015 work was completed by developing a revetment design for each erosion location. This allowed for the development of an accurate cost estimate to determine the most cost-effective solution for each of the ten erosion sites. Upon approval of the Engineering Letter Report in 2016, it was agreed to incorporate the next tier of erosion sites into the report. Once these sites are included in the report, an Environmental Assessment will be initiated."

Watershed stakeholders should work with partnering organizations to identify segments impacted by stream and lakeshore erosion, select appropriate activities, and then finance and implement the selected activities. A site assessment and/or feasibility study are recommended prior to BMP selection.

8.3.5 Level of BMP Implementation

This section contains the requirement for U.S. EPA's ***element two:*** *estimate of the load reductions expected from management measures.*

While critical areas identify locations in which to target implementation activities for the first ten years of the plan, it is unlikely that the needed TMDL reductions will be met with only work in these areas. Therefore, a general level of implementation was calculated for each impaired subwatershed to provide an estimate of the effort required to achieve load reductions. These calculations may increase or decrease as management activities are evaluated and monitored through the adaptive management process.

Level of Implementation for Fecal Coliform Impairments

A 44% reduction in fecal coliform is needed to meet water quality standards in IL_O-08 and IL-O-38. Based on the estimated relative contributions of nonpoint sources in the Middle Kaskaskia River/Carlyle Lake watershed and the BMPs identified in previous sections, the following level of implementation is recommended to achieve necessary bacteria load reductions:

- Implement vegetated buffers and filter strips and livestock exclusion fencing on all animal feeding operations. Other BMPs such as compost manure structures, feedlot runoff management, and clean water diversions can also be used to meet fecal coliform reductions from animal feeding operations.
- 100% of failing septic systems in the watershed upgraded as needed, assuming 20% of all septic systems are failing or non-conforming.

Level of Implementation for Phosphorus Impairments

An 86% reduction in watershed loads is needed to meet the phosphorus water quality standard in Carlyle Lake. This equates to a reduction in 1,415,450 lbs. of phosphorus per year, on average. A scenario is provided below that illustrates the level of effort needed to achieve this high level of phosphorus reduction, assuming that phosphorus loading is only coming from streambank and shoreline erosion and cropland. This assumption does not take into account opportunities in the developed portion of the watershed, or on land covers such as pasture.

- Reduce streambank and shoreland erosion by 75% throughout the watershed.
- Implement agricultural practices on cropland within the contributing drainage area to achieve an approximately 90% reduction in phosphorus loads.

- Implement conservation tillage on 55% of cropland, when combined with farmers already implementation conservation tillage results in a 90% adoption rate.
- Implement cover crops on an additional 60% of cropland.
- Implement nutrient and fertilizer management on 60% of cropland, resulting in a net decrease of 20% phosphorus.
- Implement buffers and filter strips to treat 80% of all cropland acres.

- Bring all onsite wastewater treatment systems within 1 mile of Carlyle Lake into conformance.

Table 37 summarizes the load reductions associated with the above scenario.

Table 37. Carlyle Lake (IL_ROA) BMP implementation scenario for total phosphorus reduction

BMP [a]	Amount (Unit)	TP Load Reduction (lbs/year)
Cropland practices		
Conservation tillage	196,803 acres treated	273,804
Cover crops	214,694 acres treated	179,217
Nutrient and fertilizer management	214,694 acres treated	119,478
Vegetated buffers and filter strips	286,259 acres treated	318,608
Streambank and shoreland restoration	100% of eroding streambanks and shoreland	497,825
Onsite wastewater treatment systems upgrades or replacements	100% of failing septic systems	339
Other practices and reductions [b]	--	26,178
Total [c]	--	1,415,450

a. Animal feeding operation practices that are needed to meet the fecal coliform TMDLs (see section above) will also provide nutrient reduction benefits for Carlyle Lake. No additional implementation is included for animal feeding operations to meet phosphorus reductions.
b. Additional reductions are expected from other practices such as feedlot improvements, stormwater management, wetland restoration, etc. which are not explicitly quantified in this plan (approximately 2% of total needed reductions).
c. Due to rounding, the total is slightly larger than the summation of the annual reduction line items.

Monitoring and public outreach should be incorporated throughout implementation of these recommended practices to further refine and direct the level of BMP implementation needed to achieve necessary load reductions in the watershed. More information on existing and recommended monitoring and outreach activities is available in Section 8.5 and Section 8.8.

8.4 Technical and Financial Assistance

*This section contains the requirements for U.S. EPA's **element four:** technical and financial assistance needed, associated costs, and the sources and authorities that will be relied upon for implementation.*

This implementation plan focuses on voluntary efforts and a result, technical and financial assistance are essential to successful implementation over time. This section identifies sources of funding and technical assistance to implement the recommended implementation practices. This section also identifies the watershed partners who could play a role in implementation.

8.4.1 Implementation Costs

Table 38 summarizes the estimated cost per recommended BMP. These costs are derived from a variety of sources including the Illinois NLRS, the 2020 Environmental Quality Incentive Program schedule, and other regional cost data. Total costs were calculated from these data sources and the estimated level of implementation needed to achieve required pollutant load reductions. The total cost to implement the Middle Kaskaskia River watershed TMDL is very high, therefore a plan estimate is provided (see Table 39) for the first 15 years only, corresponding to short- and mid-term implementation activities, as described in section 8.6.

Table 38. Implementation costs per BMP

BMP	Cost/Unit
Cropland practices	
Conservation tillage	(-$16.60) per pound of phosphorus removed [a]
Cover crops	$24.50 per pound of phosphorus removed [a]
Nutrient and fertilizer management	(-$48.75) per pound of phosphorus removed [a]
Vegetated buffers and filter strips	$11.97 per pound of phosphorus removed [a]
Animal feeding operation BMPs	
Vegetated buffer and filter strips	Accounted for under Cropland practices
Livestock exclusion BMPs	$1.78 per foot [b]
Streambank and shoreland restoration	$250 - $400 per linear foot [c]
Onsite wastewater treatment system BMPs	
Upgrading or replacing failing septic systems	$6,000 – 15,000 per system [c]
Septic maintenance	$100-300 per system [c]
Education and inspection programs	Varies depending on level of effort required to communicate the importance of proper maintenance and the number of systems in the area

a. IEPA and IDOA 2015
b. Source: Environmental Quality Incentive Program
c. Estimated based on similar project costs

Table 39. Plan cost estimate (Years 1-15)

BMP/activity	Cost estimate	Assumptions
Cropland practices		
Conservation tillage	$(2,892,365.57)	See Table 42
Cover crops	$2,927,213.35	See Table 42
Nutrient and fertilizer management	$(3,883,038.12)	See Table 42
Vegetated buffers and filter strips	$1,906,870.41	See Table 42
Animal feeding operation BMPs	$469,920	50 miles of exclusion fencing
Streambank and shoreland restoration	$39,600,000 - $63,360,000	30 miles of streambank or shoreland restored
Onsite wastewater treatment system upgrades or replacements	$5,462,400 - $13,656,000	See Table 42
Other practices with phosphorus reductions	--	Not planned for first 15 years of plan implementation
Local capacity to implement the plan	$4,500,000	$300,000/year over the plan duration of 15 years
Total Estimate	**$48,091,000 - $80,044,600**	

8.4.2 Financial Assistance Programs

There are many existing financial assistance programs which may assist with funding implementation activities. Many involve cost sharing, and some may allow the local contribution of materials, land, and in-kind services (such as construction and staff assistance) to cover a portion or the entire local share of the project. Several of these programs are presented in Table 40. In addition to these programs, partnerships between local governments can help to leverage funds. State and federal grant programs may also be available, depending on the nature of the implementation activity.

Table 40. Potential funding sources

Funding Program	Type of Funding	Entity	Eligible Projects	Eligible Applicants	Available Funding	Website
Federal Programs						
Five Star Wetland and Urban Water Restoration Grant	Grant	U.S. EPA	On-the-ground wetland, riparian, in-stream and/or coastal habitat restoration, education and training activities through community outreach, participation and/or integration with K-12 environmental curriculum. Projects that provide benefits to the community through ecological and environmental efforts, and partnerships.	Non-profits, state government agencies, local and municipal governments, Indian tribes, and educational institutions	$10,000-$40,000 per project	http://www.nfwf.org/fivestar/Pages/home.aspx
Wetland Program Development Grants	Grant	U.S. EPA	Projects that promote the understanding of water pollution through review and refinements of wetland programs. Cause and effects, reduction and prevention, and elimination of water pollution.	States, tribes, local governments, interstate associations, and intertribal consortia (Regional grants) Nonprofits, interstate associations and intertribal consortia (National grants)	$20,000 to $600,000/fiscal year	https://www.epa.gov/wetlands/wetland-program-development-grants
North American Wetlands Conservation Act (standard grant)	Grant through the North American Wetlands Conservation Act	USFWS	Wetlands conservation projects in the United States, Canada, and Mexico. Projects must provide long-term protection, restoration, and/or enhancement of wetlands and associated uplands habitats.	Non-profits, state government agencies, local and municipal governments, Indian tribes, and educational institutions	Since 1995 1,025 projects have been funded with a combined total of over $850 million grant dollars. Requires a 1-1 partner contribution	https://www.fws.gov/service/north-american-wetlands-conservation-act-nawca-grants-us-standard
North American Wetlands Conservation Act (small grant)	Grant through the North American Wetlands Conservation Act	USFWS	Wetlands conservation projects in the United States, Canada, and Mexico. Grant requests must not exceed $100,000.	Non-profits, state government agencies, local and municipal governments, Indian tribes, and educational institutions	Since 1996, 750 projects have been funded with a combined total of $43.2 million grant dollars Requires a 1-1 partner contribution	https://www.fws.gov/service/north-american-wetlands-conservation-act-nawca-grants-us-standard
Environmental Quality Incentive Program (EQIP)	Cost-share through contract (usually 3 years)	NRCS	Approved conservation practices that are constructed according to NRCS.	Farmers in livestock, agricultural, or forest production who utilize approved conservation practices	Up to 75% of project cost	https://www.fws.gov/service/north-american-wetlands-conservation-act-nawca-grants-us-small
National and State Conservation Innovation Grants	EQIP funded grants	NRCS	Innovative problem-solving projects that boost production on farms, ranches, and private forests that improve water quality, soil health, and wildlife habitat.	Non-federal governmental or nongovernmental organizations, American Indian Tribes, or individuals. Producers involved in CIG funded projects must be EQIP eligible.	More than $22.6 million was awarded to 33 projects in 2017 Grantees much match funds	https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/cig/
Environmental Education Grants Program	Grant	U.S. EPA	Environmental education programs that promote environmental awareness and stewardship and help provide people with the skills to take responsible actions to protect the environment.	• Local education agencies • State education or environmental agencies • Colleges or universities • Non-profit organizations 501(c)(3) • Noncommercial educational broadcasting entities • Tribal education agencies (including schools and community colleges controlled by an Indian tribe, band, or nation)	In 2015, 35 projects in the county were funded for a total of $3,306,594	https://www.epa.gov/education/environmental-education-ee-grants
State/Federal Partnerships						
Nonpoint Source Management Program (319)	Grant	U.S.EPA/ IEPA	Priority given to projects that implement cost-effective corrective and preventative BMPs on a watershed scale. Also available for BMPs on a non-watershed scale and the development of information/education nonpoint source pollution control programs.	Units of government and other organizations	Approximately $3,000,000 is available per year, awarded amongst approximately 15 projects. Provides up to 60% project cost share	https://www2.illinois.gov/epa/topics/water-quality/watershed-management/nonpoint-sources/Pages/grants.aspx Supplemental guidance on 319 funding for urban BMPS:

Funding Program	Type of Funding	Entity	Eligible Projects	Eligible Applicants	Available Funding	Website
			Projects that meet requirements of a NPDES permit are not eligible for 319 funding.			http://www.epa.state.il.us/water/watershed/publications/nps-pollution/urban-bmps-supplemental-guidance.pdf
Clean Water State Revolving Fund	Low interest loans, purchase of debt or refinance, subsidization	IEPA	Nonpoint source pollution control. Green infrastructure projects, construction of municipal wastewater facilities and decentralized wastewater treatment systems, watershed pilot projects, stormwater management, technical assistance (qualified nonprofit organizations only).	Corporations, partnerships, governmental entities, tribal governments, state infrastructure financing authorities	Varies	https://www.epa.gov/cwsrf
Healthy Forest Reserve Program	Easements, 30-year contracts, 10-year contracts	USDA	Projects that restore, enhance and protect forestland reserves on private land to measurably increase the recovery of threatened or endangered species, improve biological diversity, or increase carbon storage.	Private landowners	1. 10-year restoration cost-share agreement: up to 50% of average cost of approved conservation practices 2. 30-year easement: up to 75% of the easement value of the enrolled land plus 75% of the average cost of the approved conservation practices 3. 30-year contract on acreage owned by Indian Tribes 4. Permanent easements: up to 100% of the easement value of the enrolled land plus 100% of the average cost of the approved conservation practices	https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/forests/
Healthy Watersheds Consortium Grant	Grant	EPA, NRCS and U.S. Endowment for Forestry and Communities	• "Healthy watershed" program development projects that aim to preserve and protect natural areas, or local demonstration/trainings • Conservation easements are *not* eligible • Grants awarded are generally within three categories: 1. Short term funding to leverage larger financing for targeted watershed protection 2. Funds to help build the capacity of local organizations for sustainable, long term watershed protection 3. New replicable techniques or approaches that advance the state of practice for watershed protection.	Consortiums or "one entity who is linked with or in a collaborative partnership with other groups or organizations having similar healthy watersheds protection goals"	$50,000-150,000 per project	https://www.epa.gov/hwp/healthy-watersheds-consortium-grants-hwcg
Partners for Fish and Wildlife Program	Technical and financial support	USFWS	Collaborations and partnerships with private landowners to improve fish and wildlife habitat on their lands. Voluntary, community-based stewardship for fish and wildlife conservation.	Private landowners	Varies per project/partners	https://www.fws.gov/program/partners-fish-and-wildlife
State Programs						
Streambank Stabilization and Restoration Program	Grant	Illinois Department of Agriculture	Labor, equipment, and materials for effective streambank stabilization demonstration sites that use inexpensive vegetative and bio-engineering techniques.	This program is currently not funded but may be reinstated in the future.	This program is currently not funded but may be reinstated in the future.	Contact Illinois Department of Agriculture for more information: https://www.agr.state.il.us/conservation/.
Open Space Lands Acquisition and Development (OSLAD) Grant/Land and Water Conservation Fund Grant	Grant	IDNR	Acquisition and/or development of land for public parks and open space by Illinois governments. *Note: OSLAD program will not be available for Fiscal Year 2021 according to DNR website.*	Local governments	Up to $750,000 for acquisition projects and $400,000 for development/renovation projects. Funding up to 50% of project cost	https://www.dnr.illinois.gov/aeg/pages/openspacelandsaquisitiondevelopment-grant.aspx

Funding Program	Type of Funding	Entity	Eligible Projects	Eligible Applicants	Available Funding	Website
Illinois Buffer Partnership	Cost share, on site assistance from Trees Forever (Iowa) staff, project signs and field days	Illinois Buffer Partnership	Eligible projects include: Installation of streamside buffer plantings on projects including riparian buffers, livestock buffers, streambank stabilization projects, wetland development, pollinator habitat, rain gardens, and agroforestry projects.	Landowners willing to implement projects on their lands which can serve as a demonstration site to showcase benefits of conservation buffers.	Reimbursed up to $2,000 for 50 percent of the expenses remaining after other grant programs are applied	http://www.treesforever.org/Illinois_Buffer_Partnership.

Note: BMP = best management practice; EQIP = Environmental Quality Incentive Program; IDNR = Illinois Department of Natural Resources; IEPA = Illinois Environmental Protection Agency; NRCS = Natural Resources Conservation Service; USDA = U.S. Department of Agriculture; U.S. EPA = U.S. Environmental Protection Agency; USFWS = U.S. Fish and Wildlife Service.

8.4.3 Partners

There are several partners that may provide technical or financial assistance to promote successful TMDL implementation and watershed management:

- Carlyle Lake Association
- Carlyle Lake Ecosystem Partnership
- Carlyle Lake Waterfowlers Association
- County Forest Preserve Districts
- Farm Service Agency
- Heartlands Conservatory
- IDOA
- IEPA
- Illinois Department of Natural Resources
- Illinois Certified Crop Adviser Program
- Illinois Farm Bureau
- Illinois Rural Water Association
- Illinois State Water Survey
- Kaskaskia Watershed Association
- Kaskaskia Regional Port District
- Kaskia-Kaw Rivers Conservancy
- Local and regional governments
- Local school districts
- Mid-Kaskaskia River Basin Coalition
- NRCS
- OKAW River Basin Coalition
- Original Kaskaskia Area Wilderness
- Soil and Water Conservation District offices
- Southern Till Prairie Reserve
- Southwestern Illinois RC&D
- Upper Kaskaskia Watershed Ecosystem Partnership
- University of Illinois Extension
- USACE
- U.S. EPA Region 5

8.5 Public Education and Outreach

*This section contains the requirements for U.S. EPA's **element five** of a watershed plan: information and education component.*

Raising stakeholders' awareness about issues in the watershed and developing strategies to change stakeholders' behavior is essential to promoting voluntary participation. Successful implementation in the Middle Kaskaskia River/Carlyle Lake watershed will rely heavily on effective public education and outreach activities that will encourage participation and produce changes in behavior. This section presents recommendations related to developing and implementing coordinated watershed-wide education and outreach.

The first step to a successful information and education strategy is to identify target audiences and to determine how to best reach these audiences. Potential stakeholders in the Middle Kaskaskia River/Carlyle Lake watershed may include homeowners, row crop and livestock producers, certified crop advisors, and audiences interested in outdoor recreational activities (Table 41). Consideration should be given to the complexity of the water resource concerns of each of these groups. Whenever possible, stakeholder attitudes and preferences should be considered in the implementation of protection activities and should influence message development, selection of outreach platforms, and other aspects of information and education.

Table 41. Potential audience concerns and communication channels

Key Target Audiences	Potential Audience Concerns	Potential Communication Channels
Residents with septic systems	• Septic system operation, maintenance and cost • Water quality issues (safety, aesthetics, quality) • Property values	• Newspapers • Social media • Local media • Local governments • SWDCs • Watershed groups • Informational meetings • Brochures and other handouts • County and state health departments • Existing community, waterfront, and neighborhood associations
Riparian landowners	• Streambank and shoreland erosion • Surface water issues (safety, aesthetics) • Property values • Flooding • Drinking water quality	
Recreational enthusiasts **Tourists** **Hunting and fishing groups** **Boaters** **Small craft operator**	• Lake water quality • Aesthetics and odor • Safety and public health • Public safety • Adequate public access points • Recreational opportunities • Aesthetics • Healthy ecosystems to support hunting, fishing, and birdwatching activities	• Websites • Local media • Public information providers • Public signage • Social media • Local Trout & Ducks Unlimited chapters • Land trusts • School fishing teams • Canoe/kayak rental companies • Outdoor gear retailers
Livestock producers	• Potential future regulation • Cost and programmatic requirements of funding programs • Water quality issues (safety, aesthetics)	• Commodity groups • Agricultural associations • 4-H groups • Soil and water conservation districts • Watershed groups • Demonstration farms • Field days • Radio and newspapers • Word of mouth • On-site visits • Informational meetings
Row crop producers	• On-field practices to implement • Costs and programmatic requirements of funding programs • Water quality issues (safety, aesthetics, quality) • Loss of cropland acreages • Flooding	

Key Target Audiences	Potential Audience Concerns	Potential Communication Channels
Certified Crop Advisors	• Areas and practices to target for implementation • Costs and programmatic requirements for funding programs • Updated information to pass along to agricultural producers	• Training sessions • Outreach and distributed information from research institutions • Informational meetings

After stakeholder audiences have been identified, engagement and outreach strategies should be developed. Developed engagement strategies should be flexible to accommodate future changes in stakeholder awareness and behaviors. A pre- and post-implementation survey can be used to measure these changes, and the results of these surveys should be shared between local partners. These surveys can be used to measure changes in the level of stakeholder knowledge and involvement and will help watershed outreach campaign organizers to further develop tailored outreach messages. Other measures of change can include the number of producers who are signing up for cost-share programs or participating in field days or demonstration projects. Keeping in line with the adaptive nature of a nine-element plan, results from stakeholder input should also inform changes or adaptations to the implementation plan.

A variety of activities can be undertaken in order to reach the various stakeholders and should address each audience appropriately. The costs associated with these activities will depend on the lead organization and the ability to collaborate with other existing agencies and entities. Resources for information and education in the watershed are available to assist with promoting implementation activities and increasing awareness of water quality issues in the area. Examples of these resources are described below.

Illinois Manure Share

Created by the University of Illinois Extension, Illinois Manure Share is a free manure exchange program between livestock owners who have excess manure and those looking for organic material to use for gardening or landscaping. Its goal is to remove the manure from farms that do not have the acreage to adequately utilize its nutrients on their fields or pastures, benefiting water quality by both reducing nutrient runoff and lowering the amount of commercial fertilizer used by gardeners. For more information visit: https://extension.illinois.edu/lfmm/manure.

Animal Agricultural Discussion Group

The group is an informal and iterative group of individuals from the U.S. Department of Agriculture, all sectors of the animal feeding industry and their association, academia, and states, formed by the U.S. EPA. The goal of the group is to develop a shared understanding of how to implement the CWA through open communication and improved two-way understanding of viewpoints. The group convenes via conference calls and face-to-face meetings twice per year. For more information, visit https://www.epa.gov/npdes/factsheet-animal-agriculture-discussion-group

University of Illinois Extension Units

The University of Illinois Extension has several units within the Middle Kaskaskia/Carlyle Lake watershed. Each unit has extensive education and outreach programs in place that range in topic from commercial agriculture, horticulture, energy, and health that can provide meaningful resources to the information and education effort in the watershed.

- Coles-Cumberland-Douglas-Moultrie-Shelby Extension Unit
    - http://web.extension.illinois.edu/ccdms/

- Clay-Effingham-Fayette-Jasper Extension Unit
    - http://web.extension.illinois.edu/cefj/
- Bond-Clinton-Jefferson-Marion-Washington Extension Unit
    - https://web.extension.illinois.edu/bcjmw/
- Christian-Jersey-Macoupin-Montgomery Extension Unit
    - https://web.extension.illinois.edu/cjmm/

8.6 Schedule and Milestones

This section contains the requirements for U.S. EPA's element ***six and seven*** *of a watershed plan: implementation schedule and a description of interim measurable milestones.*

A key part of U.S. EPA's nine-elements is interim milestones that provide meaningful evaluation points and a focus for program activities. Interim milestones are steps that demonstrate that implementation measures are being executed in a manner that will ensure progress over time; milestones are not changes in water quality. Measurable milestones are an important tool for directing limited resources towards the array and number of sources and nonpoint source pollution problems across the watershed. Interim measurable milestones are presented in Table 42.

A 30-year implementation schedule is assumed and divided into three phases: 2020-2025, 2026-2035, and 2036-2050. Each phase will rely on an adaptive management approach and will build upon previous phases. Short-term efforts (Year 1-5) include implementing practices in critical areas. Mid-term efforts (Year 6-15) are intended to build on the results of short-term implementation activities. This includes evaluating the success of Phase 1 projects installed (success rate, BMP performance, pollutant reductions realized, actual costs, etc.). Long-term efforts (Year 16-30) are those implementation activities that result in the watershed reaching full pollutant load reductions for fecal coliform and make additional progress towards phosphorus reductions in Carlyle Lake.

Table 42. Schedule and milestones for TMDL implementation

Watershed (AUID)	BMP	Milestones		
		Year 1-5	**Year 6-15**	**Year 16-30**
All impaired watersheds	Onsite wastewater treatment practices	Develop maintenance and inspection program for septic systems and implement in critical areas. Inspections of 20% of septic systems in fecal coliform impaired subwatersheds and all systems in phosphorus near shore critical area, upgrades as needed (assuming 280 systems need upgrade). Develop centralized information system on septic system locations and conditions.	Inspections of 50% of septic systems in fecal coliform impaired subwatersheds. Maintenance of septic system information system.	Expand maintenance, inspection, and outreach program watershed wide. Inspections on all septic systems watershed wide, upgrades as needed. Maintenance of septic system information system.

Watershed (AUID)	BMP	Milestones		
		Year 1-5	Year 6-15	Year 16-30
Kaskaskia River (IL_O-08 and IL_O-38)	Animal feeding operation BMPs	Map locations of feedlots and associated animal units; develop feedlot and animal feeding operation inspection program.		Implement animal feeding operation BMPs across impaired watersheds as needed.
	Livestock exclusion BMPs (fencing)	Identify and map livestock access areas in impaired watersheds. Implement 10 miles of livestock exclusion BMPs (fencing) in fecal coliform critical areas.	Implement 50 miles of livestock exclusion BMPs (fencing) in fecal coliform critical areas.	Implement livestock exclusion BMPs (fencing) on all remaining areas with livestock access to streams and rivers in fecal coliform impaired watersheds.
	Vegetated buffers and filter strips	Conduct farmer/landowner survey and GIS analysis to determine potential locations for implementation of buffers and filter strips. Implement buffers and filter strips on 10% of cropland adjacent to riparian areas in fecal coliform critical areas.	See Carlyle Lake: Vegetated buffers and filter strips.	See Carlyle Lake: Vegetated buffers and filter strips.
Carlyle Lake (IL_ROA)	Conservation tillage	50% of cropland adopting conservation tillage in phosphorus critical areas (including cropland already using conservation tillage).	70% of cropland adopting conservation tillage in phosphorus critical areas (including cropland already using conservation tillage).	90% of cropland adopting conservation tillage in watershed (representing an increase in 55%).
	Cover crops	20% of cropland in cover crops in phosphorus critical areas (including cropland already using cover crops).	40% of cropland in cover crops in phosphorus critical areas (including cropland already using cover crops).	60% of cropland in cover crops in watershed (representing an increase in 50%).
	Nutrient and fertilizer management	Farmer/landowner survey to determine existing nutrient management and fertilizer practices. 20% of cropland converted to management under 4Rs in phosphorus critical areas.	40% of cropland converted to management under 4Rs in watershed.	60% of cropland converted to management under 4Rs in watershed.

Watershed (AUID)	BMP	Milestones		
		Year 1-5	Year 6-15	Year 16-30
	Vegetated buffers and filter strips	Conduct farmer/landowner survey and GIS analysis to determine potential locations for implementation of buffers and filter strips. Implement buffers and filter strips on 20% of cropland adjacent to riparian areas in phosphorus critical areas.	Implement buffers and filter strips on 40% of cropland adjacent to riparian areas.	Implement buffers and filter strips on 80% of riparian areas.
	Streambank and shoreline restoration	Studies and assessments to identify priority opportunities for restoration. Create partnerships and apply for grant funds.	Conduct 30 miles of streambank or shoreline restoration.	Conduct 60+ miles of streambank or shoreline restoration (total of 90+ miles).
	Other practices and phosphorus reductions	No milestone.	No milestone.	As needed to reach water quality standards.

8.7 Progress Benchmarks and Adaptive Management

*This section contains the requirements for U.S. EPA's **element eight** of a watershed plan: a set of criteria that can be used to determine whether loading reductions are being achieved over time.*

Implementation activities for the Middle Kaskaskia River/Carlyle Lake watershed occur in three phases using outcome-based strategic planning and an adaptive management approach. Phase 2 (mid-term) and Phase 3 (long-term) are designed to build on results from the preceding phase. To guide plan implementation through each phase using adaptive management, water quality benchmarks are identified to track progress towards attaining water quality standards. Progress benchmarks (Table 43) are intended to reflect the time it takes to implement management practices, as well as the time needed for water quality indicators to respond.

Table 43. Progress benchmarks

Indicator	In-Stream Target	Segments	Timeframe	Progress Benchmark
Fecal coliform	200 cfu/100 mL	Kaskaskia River (IL_O-08) Kaskaskia River (IL_O-38)	Year 1-5	10% of load reductions
			Year 6-15	30% of load reductions
			Year 16-30	Full attainment of load reductions summarized in Section 8.2.1 and full attainment of water quality standards
Phosphorus	0.05 mg/L	Carlyle Lake (IL_ROA)	Year 1-5	20% of load reductions
			Year 6-15	60% of load reductions
			Year 16-30	Additional progress made towards meeting water quality standards. It is anticipated that new technologies and unknown opportunities will be needed to bring Carlyle Lake into full attainment.

To ensure management decisions are based on the most recent knowledge, the implementation plan follows the form of an adaptive and integrated management strategy and establishes milestones and benchmarks for evaluation of the implementation program. U.S. EPA (2008) recognizes that the processes involved in watershed assessment, planning, and management are iterative and that actions might not result in complete success during the first or second cycle. For this reason, it is important to remember that implementation will be an iterative process, relying upon adaptive management.

Adaptive management is a commonly used strategy to address natural resource management that involves a temporal sequence of decisions (or implementation actions), in which the best action at each decision point depends on the state of the managed system. As a structured iterative implementation process, adaptive management offers the flexibility for responsible parties to monitor implementation actions, determine the success of such actions and ultimately, base management decisions upon the measured results of completed implementation actions and the current state of the system. This process, depicted in Figure 23, enhances the understanding and estimation of predicted outcomes and ensures refinement of necessary activities to better guarantee desirable results. In this way, understanding of the resource can be enhanced over time, and management can be improved.

In addition to focusing future management decisions, with established assessment milestones and benchmarks, adaptive management can include a re-assessment of the TMDL. Re-assessment of the TMDL is particularly relevant when completion of key studies, projects or programs result in data showing load reductions or the identification/quantification of alternative sources. Reopening/ reconsidering the TMDL may include refinement or recalculation of load reductions and allocations.

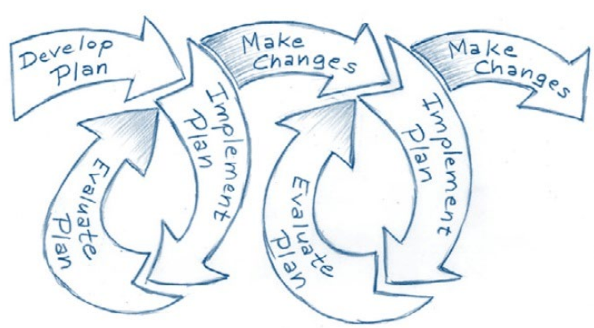

Figure 23. Adaptive management iterative process (U.S. EPA 2008).

The implementation phases, milestones, and benchmarks will guide the adaptive management process, helping to determine the type of monitoring and implementation tracking that will be necessary to gauge progress over time. Evaluation for adaptive management can include a variety of evaluation components to gain a comprehensive understanding of implementation progress. An implementation evaluation determines if non-structural and structural activities are put in place and maintained by implementation partners according to schedule; this is often referred to as an output evaluation. An outcome evaluation focuses on changes to behaviors and water quality as a result of implementation actions. This type of evaluation looks at changes in stakeholder behavior and awareness, BMP performance, and changes to ambient water quality.

8.8 Follow Up Monitoring

This section contains the requirements for U.S. EPA's ***element nine*** *of a watershed plan: a monitoring component to evaluate the effectiveness of the implementation efforts.*

The ultimate measure of success will be documented changes in water quality, showing improvement over time (see Table 43 for progress benchmarks). In addition, long-term monitoring of the overall health and quality of the watershed is important. Monitoring will help determine whether the implementation actions have improved water quality and support future resource management decisions. In addition, monitoring will help determine the effectiveness of various BMPs and indicate when adaptive management should be initiated. The primary goal of the monitoring plan is to assess the effectiveness of source reduction strategies for attaining water quality standards and designated uses.

8.8.1 Water Quality Monitoring

Progress towards achieving water quality standards will be determined through ambient monitoring by IEPA. The state conducts studies of ambient conditions across the state by evaluating watersheds on a rotating basis, collecting measurements of physical, chemical, and biological parameters. This ambient monitoring program will continue as the Middle Kaskaskia River/Carlyle Lake TMDL is implemented with a particular focus on impaired sites and increasing the understanding of pollutant sources. Water quality monitoring efforts may also be supported through volunteer citizen monitoring efforts that typically allow for more frequent monitoring at a lower cost. Formation of a monitoring committee may help streamline efforts.

Sampling during different flow regimes is also critical to understanding sources. Monitoring flow is also recommended for each stream site when water quality samples are taken. Very low flow conditions can be found throughout the watershed, documenting when streams have zero or close to zero flow is also relevant to understanding sources and impairment status. The Illinois NLRS (IEPA and IDOA 2019) Biennial Report also recommends increasing the frequency of sampling practices, especially during high flow conditions.

To better understand the internal dynamics of Carlyle Lake, monthly grab samples of total phosphorus, chlorophyll-a, suspended solids (total and volatile) and pH, Secchi disk readings, and dissolved oxygen and temperature profiles should be collected to determine when the lake is stratified or mixed, and determine any seasonal variation in lake conditions. Additional sampling in the middle of the lake would also be useful in understanding nutrient dynamics. In addition, nitrogen and phosphorus species data can be used to further understand the lake.

Continued and supporting monitoring should be conducted throughout the watershed and in impaired waters to support the assessment of other designated uses. These parameters may include but are not limited to:

- Fecal coliform
- Phosphorus species
- Suspended solids, total and volatile
- Fish and macroinvertebrates

Monitoring of tributaries to Carlyle Lake would also provide additional information on critical areas and loading and allow for focused implementation in the future.

Monitoring of streambank and lakeshore erosion is also important. Specifically, field surveys which can be used to identify opportunities for streambank and shoreland restoration are needed in the smaller tributaries to the Kaskaskia River and Carlyle Lake. Coordination with USACE may provide additional insight and opportunities.

8.8.2 Microbial Source Tracking

Sources of bacteria are widespread and often intermittent. Some sources pose a greater risk to human health than others. Understanding the different source contributions and their potential risk to human health is important to overall TMDL implementation and prioritizing implementation activities that address the recreational use impairments due to fecal coliform. Microbial source tracking (MST) is a useful tool to help differentiate sources of fecal indicator bacteria. Human markers along with a variety of other bird and animal markers can be identified. While human sources of fecal pollution are critical to eliminate, it is also important to minimize other sources that can cause illness in humans, although the actual risk associated with these other sources may fall within "acceptable" levels of risk. MST can help inform selection of BMPs for fecal coliform to best align with the pollution source. Fecal Bacteroidetes, or fecal indicator bacteria, are used in MST. Two common types of testing are available for bacterial source tracking, quantification tests and presence/absence tests. While presence/absence tests are typically less expensive than a quantification test, they do not measure the relative amount of DNA from various fecal sources, which might be used to estimate the relative abundance of those sources. Neither test, however, can determine exact source location (i.e., this farm is contributing the most fecal coliform loads). Best professional judgement from site surveys and local knowledge can help determine source locations. MST monitoring and sample collection methods are similar to fecal coliform sampling procedures. They should include both dry and wet (samples taken within at least 24 hours of a rainfall of ½ inches or more) samples, and target areas with high levels of fecal coliform. Topography, watershed delineations, and other factors may also influence sample design.

8.8.3 BMP Effectiveness Monitoring

Multiple BMPs will be needed to address the water quality impairments in the Middle Kaskaskia River/Carlyle Lake watershed. There are limited local data on the effectiveness of many BMPs; therefore, monitoring the results of programs and representative practices are critical. BMP monitoring can include quantitative monitoring of physical components (e.g., water quality and flow) qualitative (i.e., visual) monitoring of physical components (e.g., vegetation), and monitoring of behaviors. A monitoring program should be put in place as BMPs are implemented to 1) measure success and 2) identify changes that could be made to increase effectiveness.

8.9 Reasonable Assurance

U.S. EPA requires that a TMDL provide reasonable assurance that the required bacteria and phosphorus load reductions will be achieved, and water quality will be restored. A number of watershed groups are already active in the TMDL watershed and have projects and on-going programming that will support successful attainment of the water quality standards outlined in this implementation plan. Several relevant groups and projects are summarized below:

- **Kaskaskia Watershed Association (KWA):** The KWA partners across the watershed to protect the watershed and balance navigation, recreation, water supply, and conservation. Recent projects include the establishment of an Illinois conservation 2000 Ecosystem Partnership with the Illinois Department of Natural Resources for financial support on 88 projects within the larger Kaskaskia River basin, as well as development of a comprehensive watershed management strategy. The KWA also hosts an Annual Summit where regional leaders and stakeholders share knowledge and information about ongoing and future water quality concerns.

- **Heartlands Conservancy:** Dedicated to protecting open spaces, farmland, and cultural assets in Southwestern Illinois, the Heartlands Conservancy provide consultation, support, funding, and outreach activities to local communities and partners. Their work involves a wide range of ongoing projects, including the purchase and preservation of conservation easements, targeted BMP implementation, regional watershed and ecological planning support, and a wide range of education and outreach activities for local communities. Heartlands also supports and partners with many local organizations and supports the KWA's annual conference.
- **The Kaskaskia Project:** An ongoing University of Illinois Urbana-Champaign project study is currently researching the impact of existing and projected environmental and socio-cultural stressors on agro-ecosystem services in the Kaskaskia River watershed. More information on this project is available on their website (https://publish.illinois.edu/kaskaskia/).

The efforts of these organizations will be essential to the success of this implementation plan. Local organizations with a legacy of positive community and watershed impact are more likely to encounter support and acceptance from local communities. While resistance to change and upfront cost can deter participation, educational efforts and cost-share programs can increase participation to levels needed to protect water quality.

Technical and financial assistance, as summarized in Section 8.4, provides the resources needed to improve water quality and meet watershed goals. Additional assurance can be achieved in implementation of the TMDLs through contracts, memorandums of understanding, and other similar agreements, especially for BMPs that are eligible to receive the support of outside funds and cost shares. With the support of outside funds and cost share programs, additional outside funding sources, water quality goals and recommended implementation in this plan can reasonably be achieved with the continued efforts of local and regional groups and the engagement of stakeholders and local communities.

8.9.1 Point Sources

During the next NPDES permit renewal process, all minor domestic wastewater dischargers in the watershed that currently do not monitor for TP will be required to monitor for TP in the interim and develop an action plan to reduce TP discharge in their effluent. However, future plant expansions and new facilities may be subject to applicable WQS or technologically achievable Water Quality Based Effluent Limits (WQBELs). IEPA also recommends for permittees and stakeholders in the watershed to collaborate and determine the most cost-effective best management practices to address total phosphorus removal/reduction measures in the watershed to the extent feasible.

IEPA encourages NPDES Permittees in the watershed to take advantage of the Water Pollution Control Loan Program (WPCLP) that offer a reduction to the amount of principal that an applicant would otherwise need to repay for their project. This reduction is called "principal forgiveness," per federal statute. Although the name is different, in practical application, principal forgiveness functions much like a grant, i.e., the eligible capital costs of the project are reduced by the principal forgiveness amount, thereby eliminating a portion of the principal (and interest) that the borrower must repay.

For Wastewater Treatment Facility Consolidation Principal Forgiveness – IEPA will make $2,000,000 in principal forgiveness available for public loan applicants who own and operate a wastewater treatment facility whose project would result in the consolidation of two or more wastewater treatment facilities that are compliant with their NPDES Permit conditions. The funded project must result in the elimination of one or more NPDES permit(s) for a wastewater treatment facility meeting the following requirements:

1) The wastewater treatment facility being eliminated has an NPDES permit Design Average Flow of less than one-million gallons per day (i.e., <1 mgd).

IEPA will make $2,000,000 in principal forgiveness available for these projects in fiscal year 2023, and this program may also be available in future years. Applicants will be scored and ranked for priority in accordance with 35 Ill. Adm. Code 662.345. No applicant can receive more than $1,000,000 in wastewater treatment facility non-compliance principal forgiveness in fiscal year 2023.

9. 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, and others. The public comment period closed on January 12, 2019. One set of comments were provided; these and a response to comments are provided in Appendix A. The draft Stage 1 report was updated based on comments received.

A virtual public meeting was held on xxxxx at the xxxxx to present the Stage 3 report and findings. A public notice was placed on the IEPA website. The public comment period closed on xxxxx. Comments and response to comments are provided in Appendix E.

10. References

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Appendix A—Stage 1 Report

Middle Kaskaskia River Watershed Total Maximum Daily Load

Final Stage 1 Report

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Report Prepared by:

TETRA TECH

March 2019

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Acronyms and Abbreviations

AFOs	animal feeding operations
AQI	Aesthetic Quality Index
AWQMN	Ambient Water Quality Monitoring Network
CAFO	confined animal feeding operation
CWA	Clean Water Act
HSG	hydrologic soil group
Illinois EPA	Illinois Environmental Protection Agency
IPCB	Illinois Pollution Control Board
MGD	millions of gallons per day
MS4	municipal separate storm sewer system
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NVSS	non-volatile suspended solids
RM	river mile
STP	sewage treatment plant
SWCD	soil and water conservation district
TMDL	total maximum daily load
TSI	Trophic State Index
TSS	total suspended solids
USACE	United States Army Corps of Engineers
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WQS	water quality standards
WTP	water treatment plant
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 them. This TMDL study addresses the approximately 946 square mile Middle Kaskaskia River watershed located in central Illinois (Figure 1). The Upper Kaskaskia River watershed and East Fork Kaskaskia River watershed drain to the Middle Kaskaskia River watershed, but are being addressed in separate TMDL studies. Several waters in the Middle Kaskaskia River watershed have been placed on the State of Illinois 303(d) list, and require the development of a TMDL. This project addresses three impaired segments along the mainstem of the Kaskaskia River and Carlyle Lake.

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.

1.1 Water Quality Impairments

Three segments along the mainstem of the Kaskaskia River and Carlyle Lake have been placed on the State of Illinois §303(d) list (Table 1 and Figure 1). There are other impaired waters in the Middle Kaskaskia River watershed that are not being addressed by the TMDL study, including fecal coliform impairments in Kaskaskia River (O-10), Hurricane Creek (OL-02), and Hickory Creek (ON-01) and two aesthetic quality lake impairments in Vandalia Lake and Ramsey Lake. Of the waters being addressed by this TMDL study, one waterbody–pollutant combination was found to be unimpaired (see Table 1 and Appendix A – Unimpaired Stream Data Analysis). In addition, two pollutants (temperature and total suspended solids) are not being addressed as part of this project.

Table 1. Middle Kaskaskia River watershed impairments and pollutants (2016 Illinois 303(d) Draft List)

Name	Segment ID	Segment Length (Miles)	Watershed Area (Sq. Miles)	Designated Uses [b]	Cause of Impairment
Kaskaskia River	IL_O-08	17.74	1,946	Primary Contact Recreation	**Fecal Coliform**
				Public and Food Processing Water Supply	Atrazine [d]
	IL_O-33	15.21	1,774	Aquatic Life	**Dissolved Oxygen**, Temperature [e]
	IL_O-38	21.3	2,383	Primary Contact Recreation	**Fecal Coliform**
Carlyle Lake	IL_ROA	24,580 ac (surface area)	2,945 [a]	Aesthetic Quality	**Phosphorus (Total)**, Total Suspended Solids (TSS) [e]

a. Watershed area includes East Fork Kaskaskia River watershed (562 sq. miles).
b. Only the designated uses and their associated causes of impairment from the 2016 303(d) list are included. Waters may have additional designated uses.
c. Based on evaluation of the last three years of available data (2014–2016), it was determined that this segment is not impaired (see Appendix A – Unimpaired Stream Data Analysis.)
d. Impairment was removed from the 2018 draft 303(d) list and is not addressed further in this report.
e. These causes of impairment are not being addressed as part of this project.
BOLD – TMDLs are addressed in this Stage 1 report

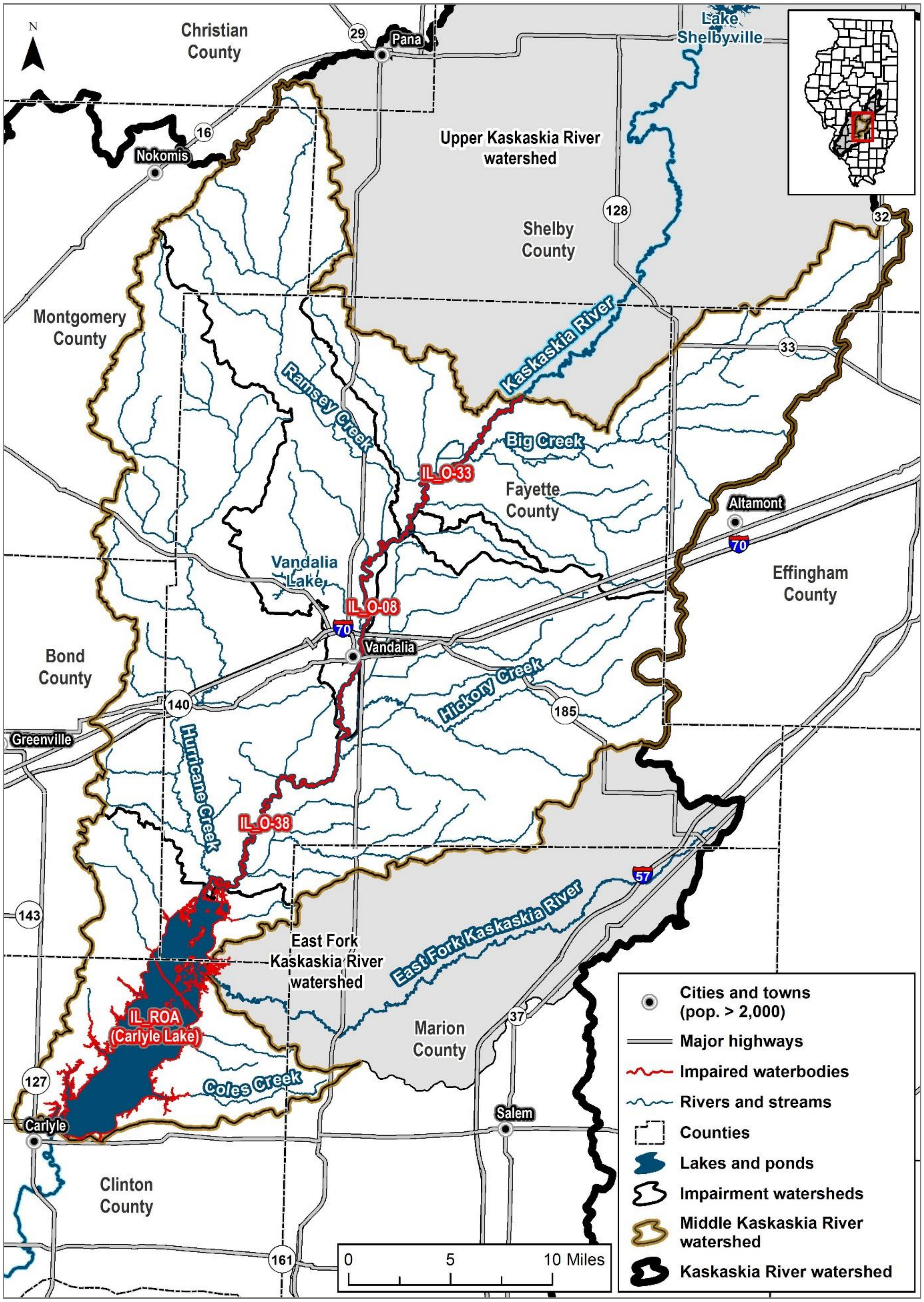

Figure 1. Middle Kaskaskia River watershed, TMDL project area.

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 Middle Kaskaskia River 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.

Carlyle Lake is also designated as a public and food processing water supply. This designation, however, is not applicable to the impairments addressed in this TMDL:

Public and Food Processing Water Supply Standards (35 Ill. Adm. Code Part 302, Subpart C) - These standards protect surface waters of the state for human consumption or for processing of food products intended for human consumption. These standards apply at any point at which water is withdrawn for treatment and distribution as a potable water supply or for food processing.

In addition to these Illinois EPA designated uses, the Army Corps of Engineers also identifies the following primary purposes of Carlyle Lake (USACE 2016): flood risk management, navigation, water supply, water quality, fish and wildlife conservation, and recreation. These purposes are not directly applicable to TMDL development; however, they are noted as important to management of the lake.

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 study area. Water quality standards and TMDL endpoints to be used for TMDL development in the Middle Kaskaskia River watershed are listed in Table 2. Impairments of aquatic life, primary contact recreation, and aesthetic quality are present in the watershed.

Table 2. Summary of water quality standards for the Middle 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
Fecal Coliform [b]	#/100 ml	400 in <10% of samples [c]
		Geometric mean < 200 [d]
Phosphorus (Total)	mg/L	0.05 for lakes

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.
b. Fecal coliform standards are applicable for the recreation season only (May through October).
c. Standard shall not be exceeded by more than 10% of the samples collected during a 30-day period.
d. Geometric mean based on minimum of 5 samples taken over not more than a 30-day period.

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). 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).

According to Illinois water quality standards, primary contact means ...*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* (35 Ill. Adm. Code 301.355). Additional recreational activities that may be impacted include small craft sailing and jet ski operations. The assessment of primary *contact* use is based on fecal coliform bacteria data. The General Use Water Quality Standard for fecal coliform bacteria specifies that during the months of May through October, based on a minimum of five samples taken over not more than a 30-day period, fecal coliform bacteria counts shall not exceed a geometric mean of 200/100 ml, nor shall more than 10 percent of the samples during any 30-day period exceed 400/100 ml (35 Ill. Adm. Code 302.209). This standard protects primary contact use of Illinois waters by humans.

Due to limited state resources, fecal coliform bacteria is not normally sampled at a frequency necessary to apply the General Use standard, i.e., at least five times per month during May through October, and very little data available from others are collected at the required frequency. Therefore, assessment guidelines are based on application of the standard when sufficient data is available to determine standard exceedances; but, in most cases, attainment of primary contact use is based on a broader methodology intended to assess the likelihood that the General Use standard is being attained.

To assess primary contact use, Illinois EPA uses all fecal coliform bacteria from water samples collected in May through October, over the most recent five-year period (i.e., 2012 through 2016 for this report). Based on these water samples, geometric means and individual measurements of fecal coliform bacteria are compared to the concentration thresholds in Table 3 and Table 4. To apply the guidelines, the geometric mean of fecal coliform bacteria concentration is calculated from the entire set of May through October water samples, across the five years. No more than 10 percent of all the samples may exceed 400/100 ml for a waterbody to be considered Fully Supporting.

Table 3. Guidelines for Assessing Primary Contact Use in Illinois Streams and Inland Lakes

Degree of Use Support	Guidelines
Fully Supporting (Good)	No exceedances of the fecal coliform bacteria standard in the last five years and the geometric mean of all fecal coliform bacteria observations ≤200/100 ml, and ≤10% of all observations exceed 400/100 ml.
Not Supporting (Fair)	One exceedance of the fecal coliform bacteria standard in the last five years (when sufficient data is available to assess the standard) or The geometric mean of all fecal coliform bacteria observations in the last five years ≤200/100 ml, and >10% of all observations in the last five years exceed 400/100 ml or The geometric mean of all fecal coliform bacteria observations in the last five years >200/100 ml, and ≤25% of all observations in the last five years exceed 400/100 ml.
Not Supporting (Poor)	More than one exceedance of the fecal coliform bacteria standard in the last five years (when sufficient data is available to assess the standard) or The geometric mean of all fecal coliform bacteria observations in the last five years >200/100 ml, and >25% of all observations in the last five years exceed 400/100 ml

Table 4. Guidelines for Identifying Potential Causes of Impairment of Primary Contact Use in Illinois Streams and Freshwater Lakes

Potential Cause	Basis for Identifying Cause - Numeric Standard[1]
Fecal Coliform	Geometric mean of at least five fecal coliform bacteria observations collected over not more than 30 days during May through October >200/100 ml or > 10% of all such fecal coliform bacteria observations exceed 400/100 ml or Geometric mean of all fecal coliform bacteria observations (minimum of five samples) collected during May through October >200/100 ml or > 10% of all fecal coliform bacteria observation exceed 400/100 ml.

1. The applicable fecal coliform standard (35 Ill. Adm. Code, 302, Subpart B, Section 302.209) requires a minimum of five samples in not more than a 30-day period. However, because this number of samples is seldom available in this time frame, the criteria are also based on a minimum of five samples over the most recent five-year period.

The Aesthetic Quality Index (AQI; Table 5) 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 are used to calculate the AQI score. Higher AQI scores indicate increased impairment (Table 6).

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 NVSS) and 3) Usable data are available from at least half of all lakes 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 5. 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 6. 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 Middle Kaskaskia River watershed is located in central Illinois (Figure 1). The headwaters for the watershed begin north of Vandalia City, IL. The Kaskaskia River then flows through Carlyle Lake at the downstream end of the watershed. Carlyle Lake is a very popular recreational area, has five swimming beaches, and is frequented by jet skiers, swimmers, kayakers and other small water crafts. The watershed covers 946 square miles; major tributaries of the river include Big Creek, Ramsey Creek, Hickory Creek, and Hurricane Creek.

2.1 Jurisdictions and Population

Counties with land located in the watershed area include Bond, Christian, Clinton, Effingham, Fayette, Marion, Montgomery, and Shelby. The city of Vandalia is the only major government unit with jurisdiction in the Middle Kaskaskia River watershed area. The cities of Altamont, Nokomis, Greenville, and Carlyle border the watershed, with the city of Carlyle located along the downstream end of Carlyle Lake. Populations are area weighted to the watershed in Table 7. All county population estimates, with the exception of Fayette County, were adjusted to account for major cities outside the watershed area.

Table 7. Area weighted county populations in watershed

County	2000	2010	Percent Change
Bond	1,649	1,662	1%
Christian	57	55	-4%
Clinton	3,722	4,005	8%
Effingham	3,104	3,109	0%
Fayette	17,959	18,237	2%
Marion	573	549	-4%
Montgomery	2,289	1,970	-14%
Shelby	638	629	-1%
TOTAL	***29,991***	***30,216***	***1%***

Source: U.S. Census Bureau

2.2 Climate

Climate data are available from the National Oceanic and Atmospheric Administration (NOAA) Global Historical Climatology Network Database; Station USC00111290 is located at the southern end of Carlyle Lake near Carlyle, IL along the southern boundary of the watershed. Daily data from 1962-2016 for temperature, precipitation and snowfall are summarized in Table 8. In general, the climate of the region is continental with hot, humid summers and cold winters. The average high winter temperature is 40 °F and the average high summer temperature is 86 °F. The annual average precipitation is approximately 41 inches, including approximately 11 inches of snowfall. In general, larger volumes of precipitation tend to occur between the months of April and September.

Table 8. Climate summary for Carlyle Lake (1962–2016)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average High ºF	37	41	53	65	75	84	87	86	79	68	54	42
Average Low ºF	19	23	34	45	55	64	67	65	57	45	35	25
Mean Temperature ºF	25	28	39	51	60	69	72	69	61	50	40	30
Average Precipitation (in)	2.2	2.2	3.6	4.2	4.4	4.5	3.8	3.0	3.4	3.0	3.5	3.1
Average Snowfall (in)	3.5	2.9	1.7	0.2	0.0	0.0	0.0	0.0	0.0	0	0.7	2.2

Source: NOAA Global Historical Climatology Network Database

2.3 Land Use and Land Cover

Land use in the watershed is heavily influenced by agriculture (Figure 2). Urban area is located near the city of Vandalia and several small towns in the watershed. Land use in the watershed includes agriculture – cultivated crops and pasture/hay (approximately 63 percent), forest (approximately 24 percent), and urban (approximately 8 percent). Corn and soybeans are the most common crops, with much smaller areas of spring wheat, alfalfa and other crops. Table 9 presents area and percent by land cover type as provided in the 2011 National Land Cover Database (MRLC 2015).

Table 9. Watershed land use summary

Land Use / Land Cover Category	Acres	Percentage
Cultivated Crops	292,084	48.3%
Deciduous Forest	144,502	23.9%
Hay/Pasture	86,656	14.3%
Developed, Open Space	35,643	5.9%
Open Water	28,869	4.8%
Developed, Low Intensity	8,196	1.4%
Woody Wetlands	3,615	0.6%
Herbaceous	2,472	0.4%
Developed, Medium Intensity	1,528	0.3%
Emergent Herbaceous Wetlands	1,228	0.2%
Developed, High Intensity	357	<0.1%
Evergreen Forest	104	<0.1%
Barren Land	60	<0.1%

Source: 2011 National Land Cover Database

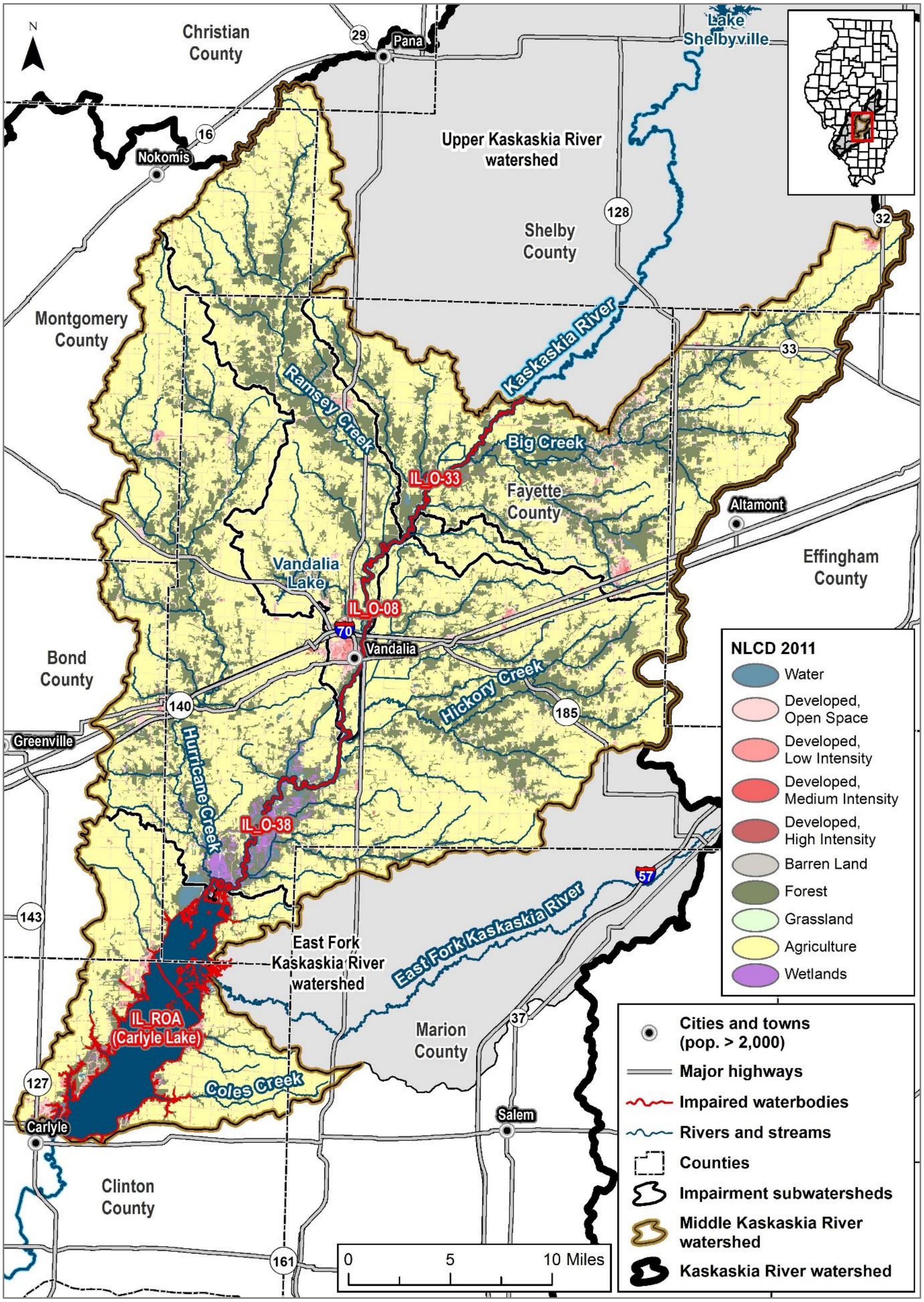

Figure 2. Middle Kaskaskia River watershed land cover (2011 National Land Cover Database).

2.4 Topography

Topography is an important factor in watershed management because stream types, precipitation, and soil types can vary dramatically by slope and elevation. The Middle Kaskaskia River watershed varies in elevation from 802 to 438 feet (Figure 3). The Kaskaskia River water elevation varies from 492 feet to 447 feet and is 54 miles long upstream of the inlet to Carlyle Lake, resulting in a river gradient of 0.8 feet per mile. The highest elevations in the watershed are in the headwaters of Ramsey Creek and Hurricane Creek. The watershed topography consists of gently rolling terrain with steeper areas surrounding tributary streams. In the floodplain of Kaskaskia River, the topography is mostly flat (Carlyle Lake Watershed Technical and Planning Committees 2000).

2.5 Soils

The National Cooperative Soil Survey publishes soil surveys for each county in the U.S. These soil surveys contain predictions of soil behavior for selected land uses. The surveys also highlight limitations and hazards inherent in the soil, general improvements needed to overcome the limitations, and the impact of selected land uses on the environment. The soil surveys are designed for many different uses, including land use planning, the identification of special practices needed to ensure proper performance, and mapping of hydrologic soil groups (HSGs).

HSGs refer to the grouping of soils according to their runoff potential. Soil properties that influence the HSGs include depth to seasonal high water table, infiltration rate and permeability after prolonged wetting, and depth to a slower permeable layer (e.g., finer grained). There are four groups of HSGs: Group A, B, C, and Group D. Table 10 describes those HSGs found in the Middle Kaskaskia River watershed. Figure 4 and Table 11 summarizes the composition of HSGs in the watershed. Soils are predominantly C, C/D and D in the watershed. The high proportion of C, C/D and D type soils coupled with agricultural land uses indicate the likelihood of tile drainage.

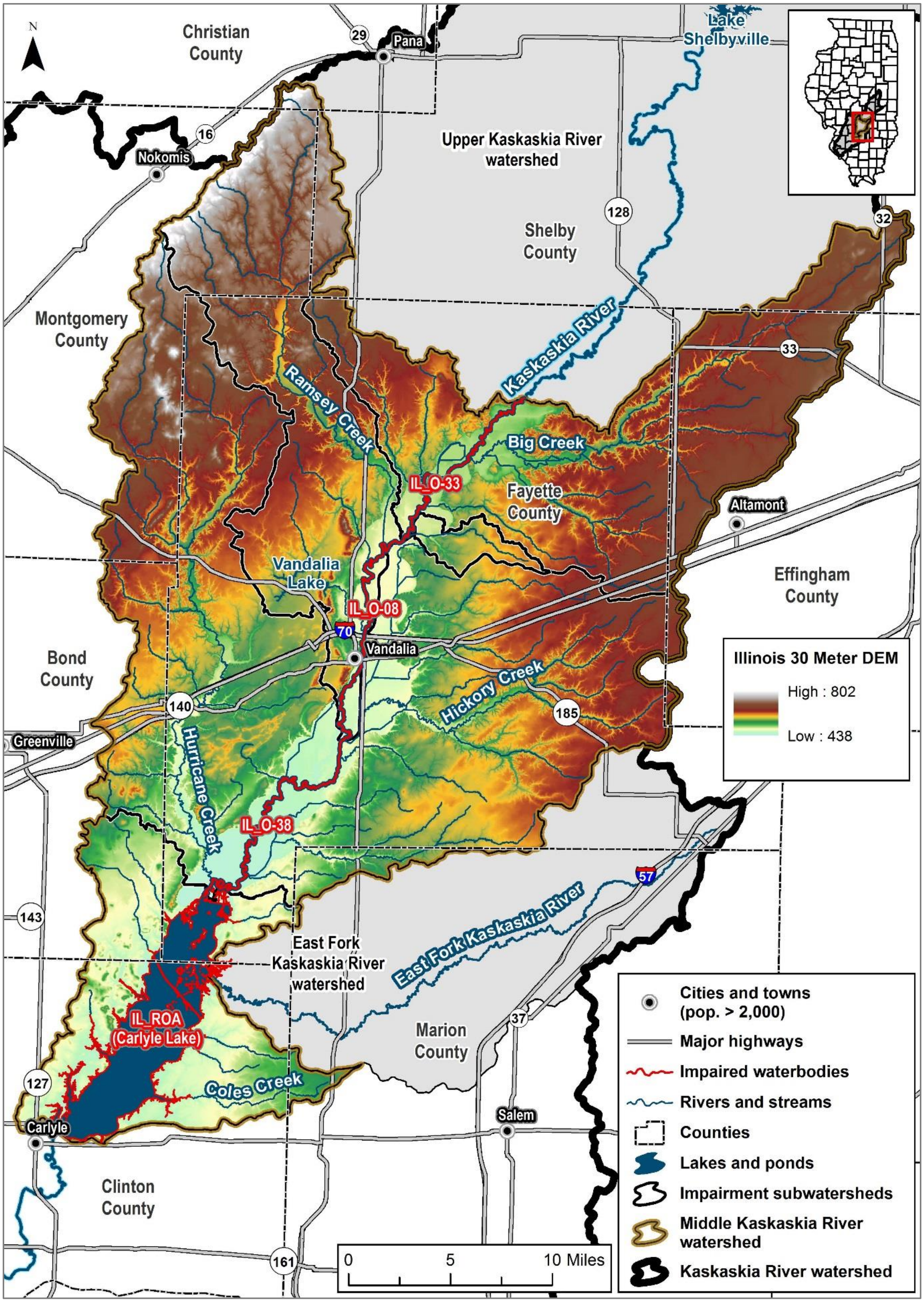

Figure 3. Middle Kaskaskia River watershed land elevations (ISGS 2003).

Table 10. Hydrologic soil group descriptions

HSG	Group Description
A	Sand, loamy sand or sandy loam types of soils. Low runoff potential and high infiltration rates even when thoroughly wetted. Consist chiefly of deep, well to excessively drained sands or gravels with a high rate of water transmission.
B	Silt loam or loam. Moderate infiltration rates when thoroughly wetted. Consist chiefly or moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.
C	Soils are sandy clay loam. Low infiltration rates when thoroughly wetted. Consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine structure.
D	Soils are clay loam, silty clay loam, sandy clay, silty clay or clay. Group D has the highest runoff potential. Low infiltration rates when thoroughly wetted. Consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface and shallow soils over nearly impervious material.
A-C/D	Dual Hydrologic Soil Groups. Certain wet soils are placed in group D based solely on the presence of a water table within 24 inches of the surface even though the saturated hydraulic conductivity may be favorable for water transmission. If these soils can be adequately drained, then they are assigned to dual hydrologic soil groups (A/D, B/D, and C/D) based on their saturated hydraulic conductivity and the water table depth when drained. The first letter applies to the drained condition and the second to the undrained condition.

Table 11. Percent composition of hydrologic soil groups in watershed

Hydrologic Soil Group (HSG)	Acres	Percentage
B	41,917	6.9%
B/D	26,590	4.4%
C	249,614	41.2%
C/D	128,345	21.2%
D	130,517	21.6%
No Data	28,337	4.7%

Source: NRCS SSURGO Database 2011

A commonly used soil attribute is the K-factor, or the soil erodibility index. The distribution of K-factor values in the Middle Kaskaskia River watershed range from 0.26 to 0.53, with an average value of 0.39 (Figure 5). The higher the K-factor, the more susceptible the soil is to erosion.

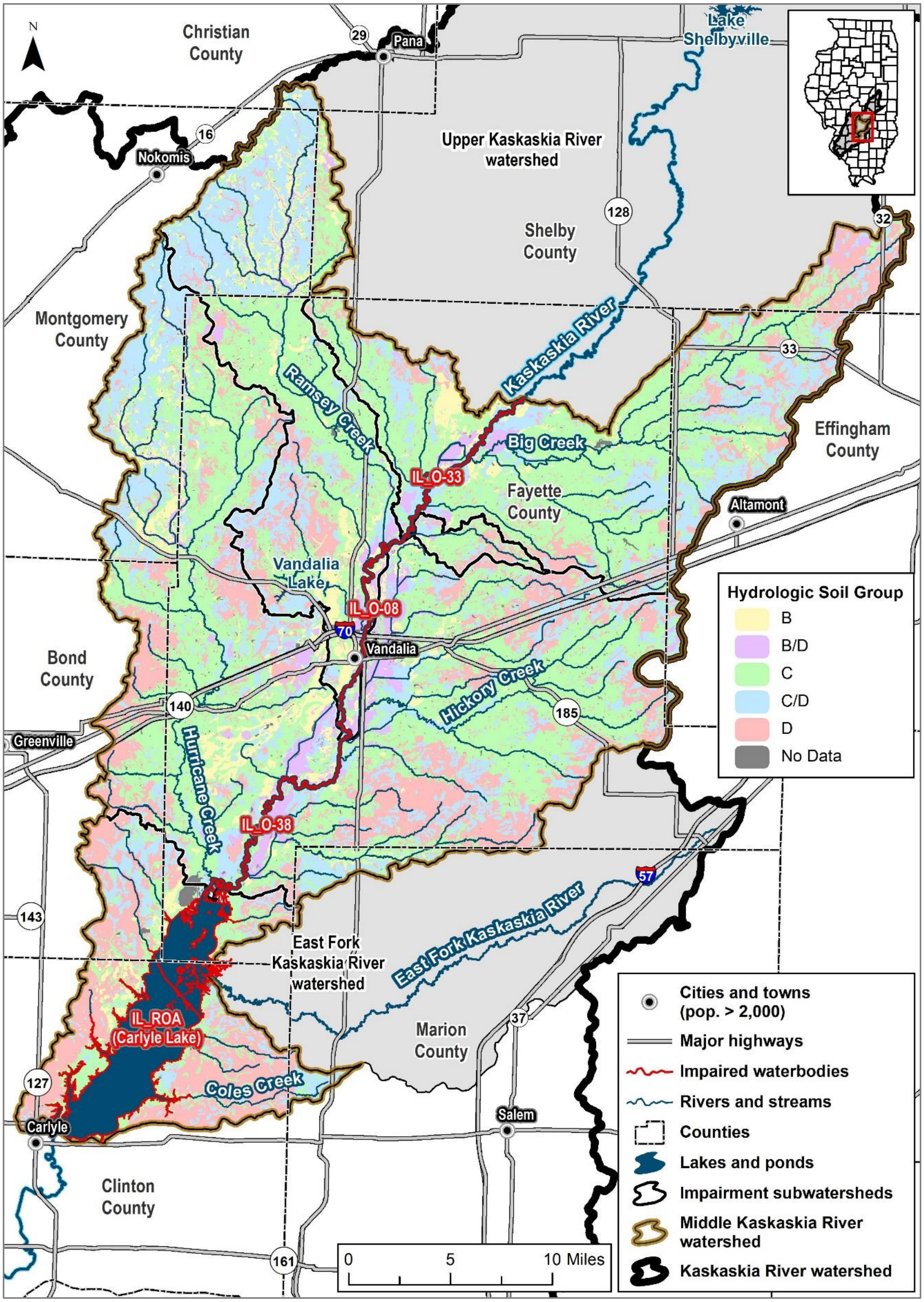

Figure 4. Middle Kaskaskia River watershed hydrologic soil groups (Soil Surveys for Bond, Christian, Clinton, Effingham, Fayette, Marion, Montgomery and Shelby Counties, Illinois; NRCS SSURGO Database 2011).

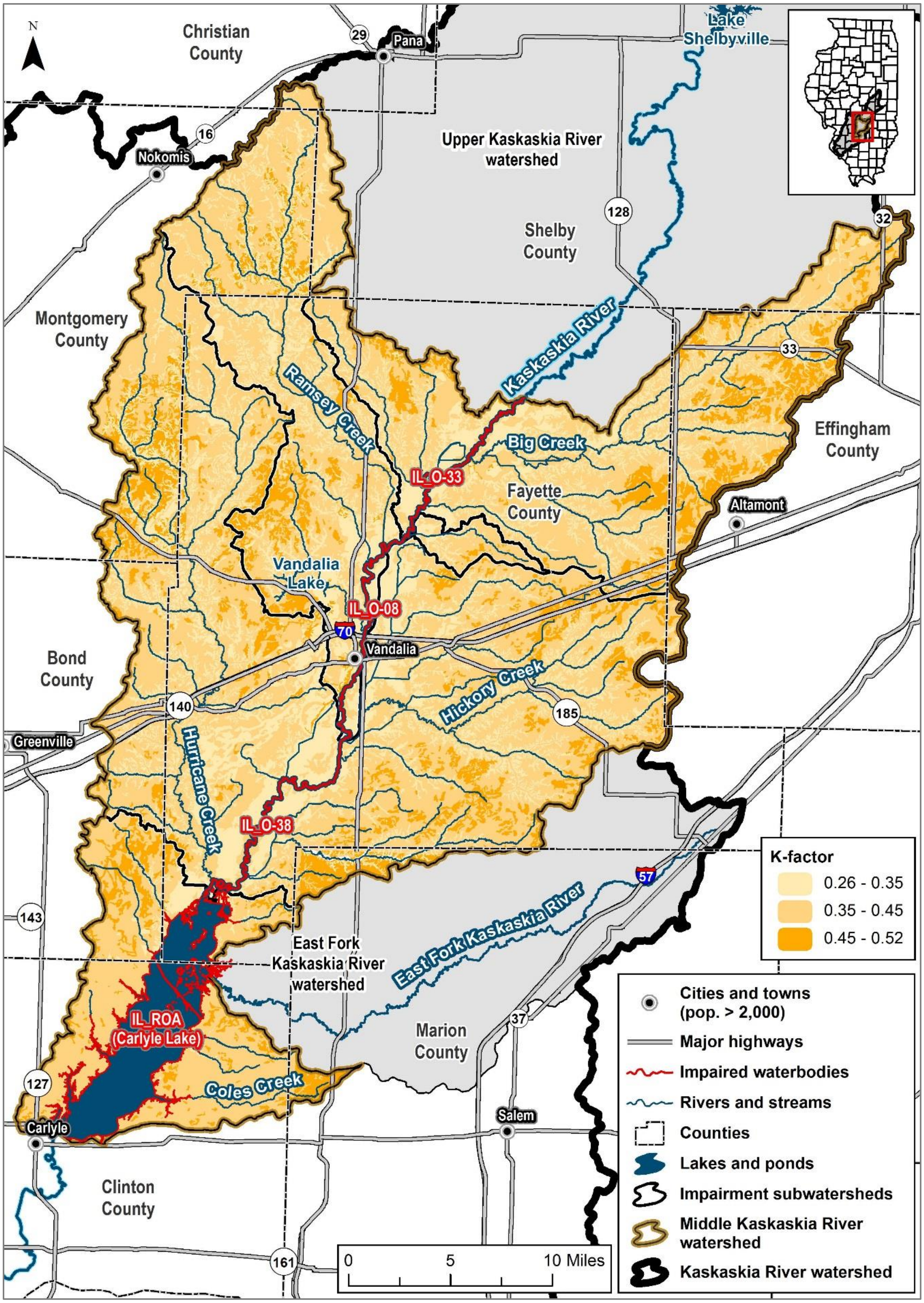

Figure 5. Middle Kaskaskia River watershed soil K-factor values (Soil Surveys for Bond, Christian, Clinton, Effingham, Fayette, Marion, Montgomery and Shelby Counties, Illinois; NRCS SSURGO Database 2011).

2.6 Hydrology

Hydrology plays an important role in evaluating water quality. The hydrology of the Middle Kaskaskia River watershed is driven by local climate conditions and the landscape. The U.S. Geological Survey (USGS) has been collecting flow and water quality data in this watershed since the early 1900s (Table 12 and Figure 9). There are four active USGS gages in the watershed.

The daily average, peak history, and monthly flow data show the inherent variability associated with hydrology. Flow duration curves provide a way to address that variability and flow related water quality patterns. Duration curves describe the percentage of time during which specified flows are equaled or exceeded. Flow duration analysis looks at the cumulative frequency of historic flow data over a specified period, based on measurements taken at uniform intervals (e.g., daily average or 15-minute instantaneous). Duration analysis results in a curve that relates flow values to the percent of time those values have been met or exceeded. Low flows are exceeded a majority of the time, whereas floods are exceeded infrequently. A flow duration curve for active USGS gage 05592500 is presented in Figure 6.

Table 12. USGS gages in impairment watersheds

Gage ID	Watershed Area (mi.^{2})	Location	Period of Record	Impaired Segment
05592300	47.9	Wolf Creek near Beecher City, IL	1908-1982	-
05592350	87.3	Big Creek at Wrights Corner, IL	1961-1963	**-**
05592355	95.4	Big Creek near Post Oak, IL	1980-1981	-
05592360	35.3	South Fork near Pruett, IL	1980-1981	-
05592370	19.5	Ash Creek near Ramsey, IL	1980-1981	-
05592380	8.93	Bolt Creek near Ramsey, IL	1980-1981	-
05592400	97.3	Ramsey Creek near Ramsey, IL	1980-1981	-
05592500	**1,940**	**Kaskaskia River at Vandalia, IL**	**1908-2016**	**IL_O-08**
05592575	**44.2**	**Hickory Creek near Brownstown, IL**	**1988-2016**	**-**
05592600	77.6	Hickory Creek near Bluff City, IL	1977-1997	-
05592700	0.14	Hurricane Creek tributary near Witt, IL	1956-1980	-
05592800	**152**	**Hurricane Creek near Mulberry Grove, IL**	**1970-2016**	**-**
383706089210701	**2,717**	**Kaskaskia River at Carlyle Lake, IL (in-lake)**	**2017-2018**	**IL_ROA**
383715089204501	- [a]	Carlyle Lake Site 2	1991-1991 [b]	IL_ROA
384408089160001	- [a]	Carlyle Lake	1991-1992 [b]	IL_ROA

BOLD – indicates active USGS gage
a. Lake monitoring station.
b. Water quality data only, no flow data available.

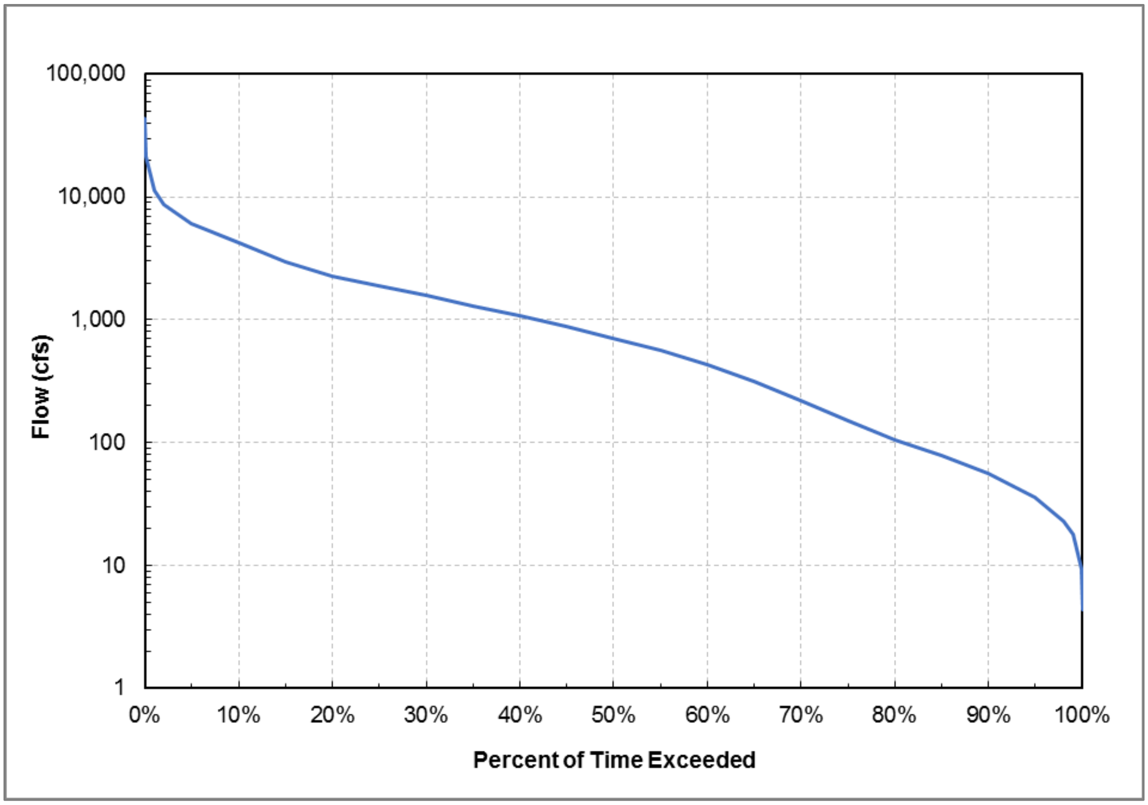

Figure 6. Flow duration curve for USGS gage 05592500, Kaskaskia River at Vandalia, IL (1908-2016).

An evaluation of annual flow at USGS gage 05592500 from 1908–2016 showed that annual flow in 2001 was nearly at the median; thus, it is assumed that 2001 is a typical year. Flow at USGS gage 05592500 is plotted with precipitation from the NOAA Global Historical Climatology Network Database Station USC00111290 (Carlyle Lake) in Figure 7. Flows in the Kaskaskia River decrease significantly during the late summer and early fall with decreasing precipitation.

There are no active flow gages on the Kaskaskia River or other incoming tributaries immediately upstream of Carlyle Lake. Flows through Carlyle Lake are monitored by the U.S. Army Corps of Engineers (USACE) using the water surface elevation. A minimum and maximum water surface elevation is managed by the USACE at the dam to control flooding in and downstream of the lake and to maintain adequate water levels for recreation (USACE 2017).

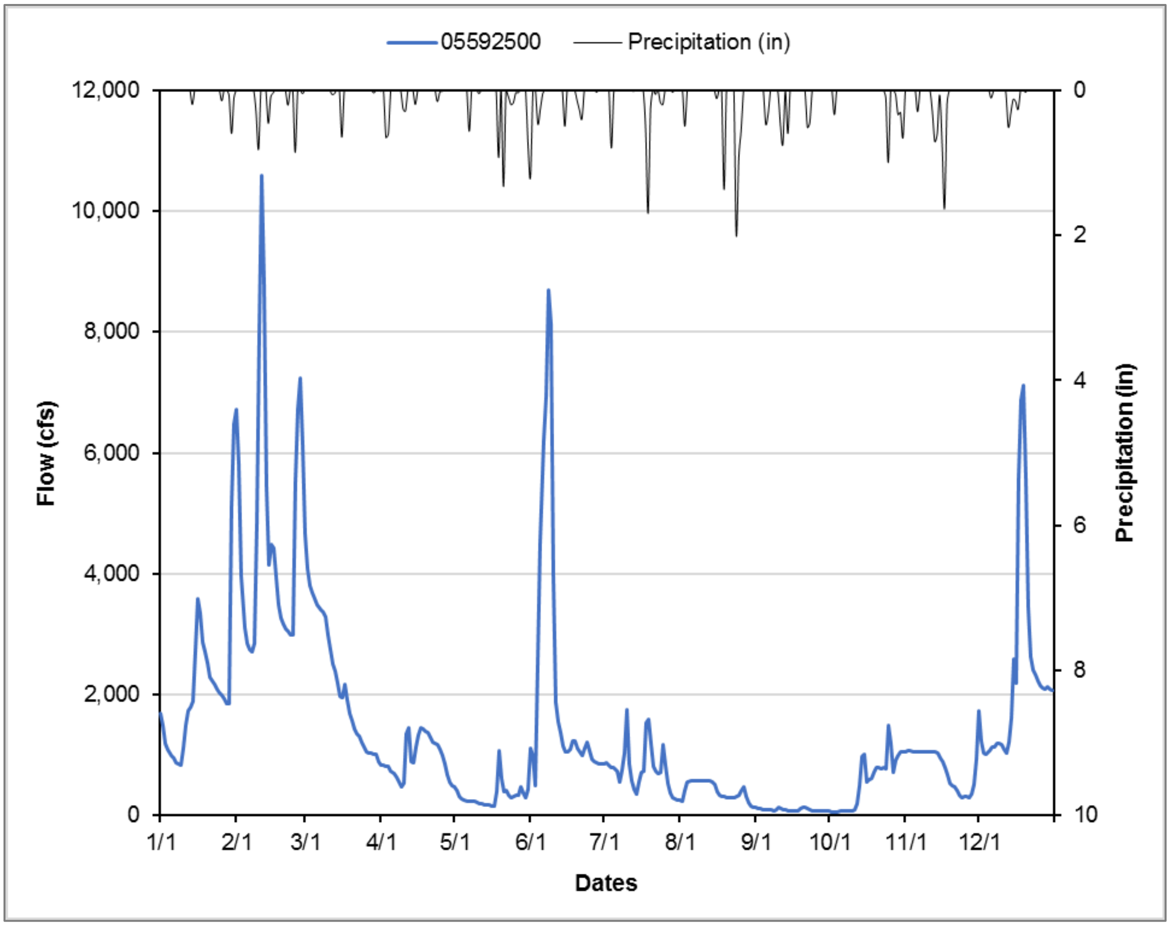

Figure 7. Daily flow in the Kaskaskia River with daily precipitation at Carlyle Lake (USC00111290), 2001.

2.7 Watershed Studies and Other Watershed Information

This section describes several of the studies that have been completed in the watershed. Many will be useful in the development of the TMDL implementation plan.

- **Carlyle Lake Watershed Plan** (Carlyle Lake Watershed Technical and Planning Committees 2000)

  The Carlyle Lake Watershed Plan provides an approach to environmental improvement based on current data and analysis for the Carlyle Lake watershed. The plan was a collaborative effort between the Carlyle Lake Watershed Committee, local SWCDs, and the public. It established goals, concerns, and recommendations for land use and recreation in the watershed. Funding was provided by an Illinois Department of Natural Resources Conservation 2000 Ecosystems Project grant.

- **Carlyle Lake Master Plan** (USACE 2017)

  The Carlyle Lake Master Plan has been developed for use as a guide for resource development impacting Carlyle Lake. The plan was first developed by the United States Army Corps of Engineers in 1962 and has been updated and revised in 1974, 1979, 1986, 1997 and 2016. A description of Carlyle Lake and the land use, development pressures, and other important features of the Carlyle Lake watershed are included in the plan as well as a specific plan for resource development. Ongoing water quality, high water, fisheries, recreation and other issues are also discussed.

- **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% 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.

- **Vandalia Lake TMDL** (CDM 2004)

  This previous TMDL provides information on nutrient loading from Vandalia Lake.

- **Kaskaskia River–North Fork TMDL** (Limno Tech 2007)

  This previous TMDL provides information on pH, manganese, iron, and dissolved oxygen in the North Fork Kaskaskia River, which drains into Carlyle Lake.

- **Evaluating Watershed Health Through Integrated Water Quality Analysis and Community Capacity Assessments** (Williard 2017)

  This plan considers water quality and health risk, the impact of land use, community planning and conservation practices, and outreach techniques for the Carlyle Lake area.

- **Bank Erosion and Historical River Morphology Study of the Kaskaskia, Shelbyville to Carlyle Lake** (USACE 2003)

  This study analyzes the river evolution of the Middle and Lower sections of the Kaskaskia River and compares and recommends corrective actions for erosion problems.

- **Report on Carlyle Reservoir Wildlife Management Area Study** (USACE n.d.)

  This report examines methods of protecting the levee from flash flooding from Hurricane Creek, a tributary to Carlyle Lake.

- **Report of Sedimentation 1999 Resurvey Carlyle Reservoir** (USACE 2000)

  This report provides depth data on Carlyle Lake from its inception to 1999.

- **Carlyle Lake Watershed Plan** (CLA Technical Committee 1999)

  This report provides an overview of the Carlyle Lake watershed morphology, problems facing the watershed, and recommended actions.

- **Analysis of the Operation of Lake Shelbyville and Carlyle Lake to Maximize Agricultural and Recreational Benefits** (Illinois State Water Survey 1975)

  This survey discusses the lake and how it was functioning fie years after it was created.

- **Water Quality Evaluation, Carlyle Lake 2006-2010** (USACE 2011) and **2014 Carlyle Lake Water Quality Report** (USACE 2015)

  These reports provide USACE water quality monitoring data for Carlyle Lake.

- **2016 Lake Shelbyville Masterplan Updat**e (USACE 2016)

  This report reviews current and future upgrades to the Carlyle Lake Project.

- **Historical River Morphology Study of the Kaskaskia River Headwaters to Lake Shelbyville** (USACE 2010)

  This report analyzes the river evolution upstream of the Middle Kaskaskia River watershed and compares and recommends corrective actions for erosion problems.

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 listed pollutants (i.e., fecal coliform and phosphorus) in the Middle Kaskaskia River watershed.

3.1 Pollutants of Concern

Pollutants of concern evaluated in this source assessment include fecal coliform and phosphorus. These pollutants can originate from an array of sources including point and nonpoint sources. 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, CAFOs, or regulated storm water including municipal separate storm sewer systems (MS4s).

3.2.1 NPDES Facilities (Non-CAFO or stormwater)

NPDES facilities in the study area include municipal and industrial wastewater treatment and public water supply facilities. There are 15 individual NPDES permitted facilities in the project area (Table 14 and Figure 9). Average and maximum design flows and downstream impairments are included in the facility summaries. Three municipal wastewater facilities (IL0023574, IL0025933 and IL0061697) and one public water supply facility (ILG640114) drain directly to impaired waterbodies. The remaining facilities in Table 14 discharge to upstream unimpaired tributaries and are therefore not contributing to project impairments.

Eight wastewater treatment facilities have disinfection exemptions in the watershed which allow a facility to discharge wastewater without disinfection during a specified period. Facilities with disinfection exemptions may be required to provide Illinois EPA with updated information to demonstrate compliance with these requirements. No disinfection exempt facilities directly discharge into fecal-impaired segments.

3.2.2 Municipal Separate Storm Sewer Systems

Regulated storm water 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 storm water. Impervious areas associated with developed land uses can result in higher peak flow rates, higher runoff volumes and larger pollutant loads. Storm water runoff often contains sediment, nutrients, and bacteria 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 storm water management in new development and redevelopment, and pollution prevention/good housekeeping for municipal operations. Regulated entities operating under the General Storm Water Permit in the impairment watersheds are identified in Table 13 and Figure 8.

Table 13. Permitted MS4s in impairment watersheds

Permit ID	Regulated Entity	Receiving Waters
ILR400052	Foster Township MS4	Kaskaskia River (O-38) and Carlyle Lake (ROA)
ILR400152	Wheatland Township MS4	Kaskaskia River (O-38) and Carlyle Lake (ROA)
ILR400619	Beecher Village MS4	Kaskaskia River (O-33, O-08, O-38) and Carlyle Lake (ROA)

Table 14. 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)	Disinfection Exemption
IL0023574	**Vandalia STP**	**STP**	**Kaskaskia River**	**O-08, O-38, ROA**	**1.3**	**8.25**	**No**
IL0025933	**Corps of Engr-Carlyle Boulder**	**STP**	**Carlyle Lake**	**ROA**	**0.02**	**-**	**No**
IL0032271	*Marathon Petroleum-St. Elmo*	*Water softener backwash, boiler blowdown and stormwater runoff*	*Unnamed ditch to East City reservoir*	*O-33, O-08, O-38, ROA*	*0.35*	*-*	*NA [a]*
IL0037974	*Ramsey Lake State Park*	*STP*	*Unnamed tributary to Ramsey Creek*	*O-08, O-38, ROA*	*0.015*	*0.0375*	*Yes*
IL0050156	*Fillmore STP*	*STP*	*Lanes Branch*	*O-38, ROA*	*0.049*	*0.195*	*Yes*
IL0053996	*IL DNR-Eldon Hazlet State Park*	*STP*	*Unnamed tributary of Carlyle Lake*	*ROA*	*0.045*	*0.11*	*No*
IL0061697	**Hickory Shores Resort**	**STP**	**Carlyle Lake**	**ROA**	**0.01**	**0.02**	**No**
IL0063878	*Beecher City STP*	*STP*	*Wolf Creek*	*O-33, O-08, O-38, ROA*	*0.052*	*0.105*	*Yes*
ILG580027	*Brownstown STP*	*STP*	*Unnamed tributary to Camp Creek North*	*O-38, ROA*	*0.1*	*0.327*	*Yes*
ILG580163	*Stewardson STP*	*STP*	*Wolf Creek*	*O-33, O-08, O-38, ROA*	*0.11*	*2.75*	*Yes*
ILG580191	*Mulberry Grove SD STP*	*STP*	*Owl Creek*	*O-38, ROA*	*0.0864*	*2.37*	*Yes*
ILG580222	*Ramsey STP*	*STP*	*Little Ramsey Creek*	*O-08, O-38, ROA*	*0.171*	*0.632*	*Yes*
ILG582016	*St. Elmo STP*	*STP*	*St. Elmo Ditch*	*O-33, O-08, O-38, ROA*	*0.343*	*1.31*	*Yes*
ILG640114	**Vandalia WTP**	**Public water supply**	**Kaskaskia River**	**O-08, O-38, ROA**	**0.12 [b]**	**-**	**NA [a]**
ILG640141	*Ramsey WTP*	*Public water supply*	*Little Ramsey Creek*	*O-08, O-38, ROA*	*0.014 [b]*	*-*	*NA [a]*

BOLD – NPDES facility drains directly to impaired water
Italics – NPDES facility draining to unimpaired segment.
STP – Sewage treatment plant
WTP– Water treatment plant
MGD – Million gallons per day
a. These facilities are not expected to contribute fecal coliform.
b. Average of DMR flows (2014-2016)

3.2.3 CAFOs

The area that produces manure, litter, or processed wastewater as the result of CAFOs is considered a point source that is regulated through the NPDES Program. In Illinois, the CAFO program is administered by the Illinois EPA through general permit number ILA01. The federal regulations for all CAFOs can be found in 40 CFR Parts 9, 122, and 412.U.S. EPA requires that CAFOs receive a wasteload allocation as part of the TMDL development process. The wasteload allocation is typically set at zero for all pollutants. There is one CAFO in the Middle Kaskaskia watershed: Wilder - South (ILA010051; Figure 8). The facility is located in the Hurricane Creek watershed. Hurricane Creek drains to fecal coliform-impaired segment O-38 of the Kaskaskia River.

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 has identified several sources as contributing to the Middle Kaskaskia River watershed impairments (Table 15).

Table 15. Potential sources in project area based on the Draft 2016 305(b) list

Watershed	Segment	Sources
Kaskaskia River	IL_O-08	Source unknown
	IL_O-33	Source unknown
	IL_O-38	Source unknown
Carlyle Lake	IL_ROA	Source unknown, littoral/shore area modifications (non-riverine), other recreational pollution sources, and crop production (crop land or dry land)

A summary of the potential nonpoint sources of pollutants is provided below, additional information on the primary pollutant sources follow. Potential nonpoint sources of fecal coliform in the Kaskaskia River include animal feeding operations (AFOs), onsite wastewater treatment systems, wildlife and stormwater and agricultural runoff. Nonpoint sources potentially contributing to Carlyle Lake's phosphorus impairment include stormwater and agricultural runoff, stream channel and shoreline erosion (and associated particulate phosphorus), and internal loading.

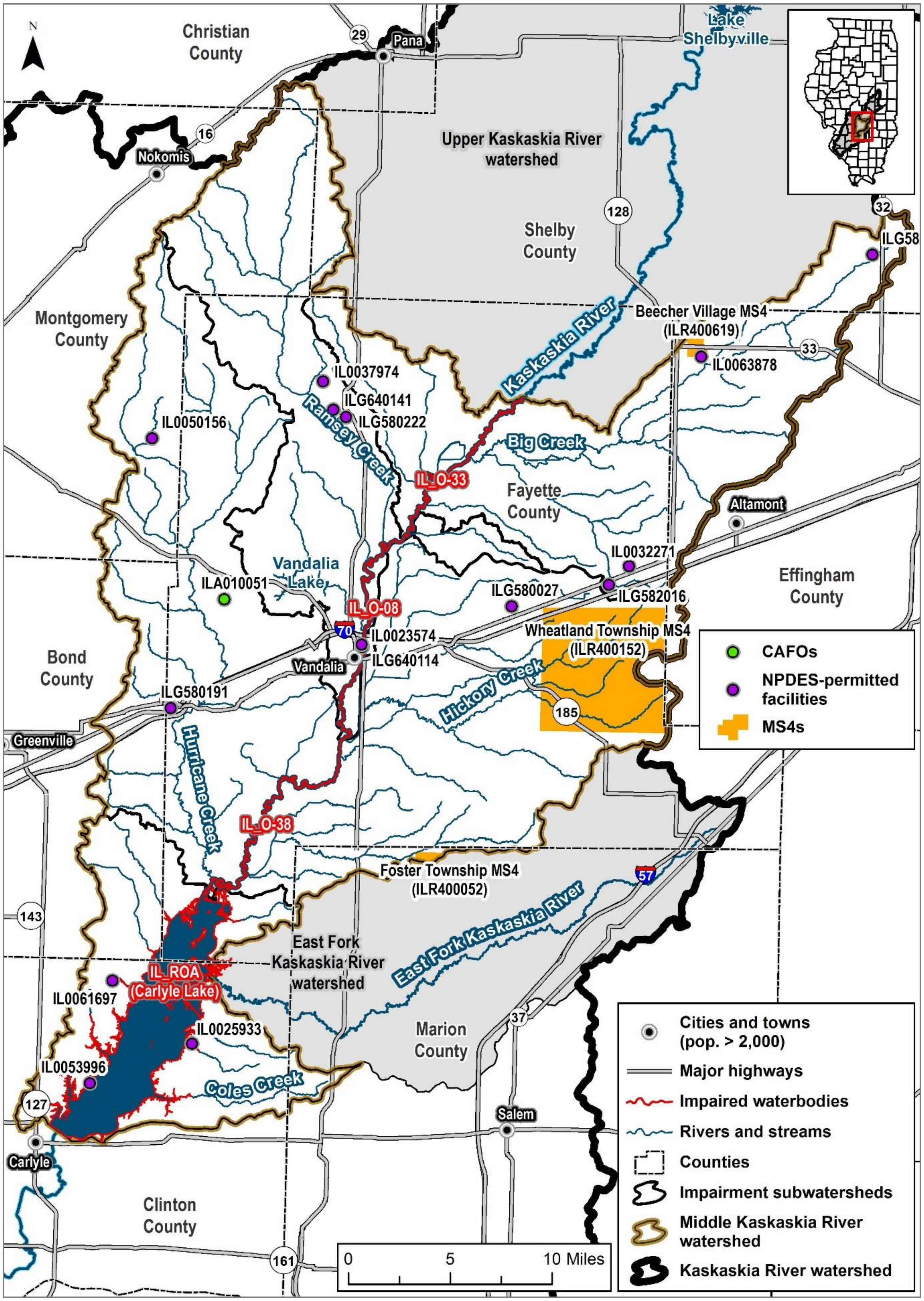

Figure 8. Point sources in impairment watersheds.

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 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 96,587 animals are in the project area.

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 which 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. County health departments were contacted for information on septic systems and unsewered communities. Responses were received from Bond, Christian, Effingham, and Fayette Counties. Effingham county reported 4,862 installed septic systems since 1985 and Fayette reported permitting 605 installed septic systems since 2009. Christian and Fayette counties reported three and six unsewered communities, respectively. Bond county requires inspection of newly installed septic systems, but does not have a total count of installed systems or unsewered communities. No information was provided on failure rates or results of compliance testing.

3.3.3 Wildlife

Wildlife such as deer, raccoon, and waterfowl also contribute to fecal coliform loading in the watershed; however, these sources are not typically managed. While no specific information is available on wildlife populations in the watershed or their potential to impact fecal coliform loadings, according to the University of Illinois–Extension, the highest densities of white tail deer in the state are found in wooded areas in watersheds of major rivers. White tail deer are also known to reside in areas with intensively farmed land (University of Illinois–Extension 2017).

3.3.4 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.

3.3.5 Stream Channel and Shoreline Erosion

Various forms of erosion are a common source of sediment and associated pollutants such as phosphorus. Erosion may contribute to phosphorus impairment in Carlyle Lake because phosphorus is typically bound to sediment. Bank and channel erosion refers to the wearing away of the banks and channel of a stream or river. High rates of bank and channel erosion can often be associated with water flow and sediment dynamics being out of balance. This can result from land use activities that either alter flow regimes, adversely affect the floodplain and streamside riparian areas, or a combination of both. The USACE (2017) notes significant sediment entering Carlyle Lake from the Kaskaskia River. In a lake environment, shoreline erosion can be caused by changing water levels and wave action.

3.3.6 Internal Loading

Internal phosphorus loading from lake bottom sediments can be a substantial component of the phosphorus budget in lakes. Phosphorus in the sediment 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 including:

- 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 depths 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.

The USACE (2017) reports that Carlyle Lake does not typically stratify during the summer months due to the presence of high winds and the overall shallow depth of the lake. If the lake does stratify, release of phosphorus in the anoxic portion of the lake could occur. The USACE (2017) also notes that low dissolved oxygen concentrations often occur in the lake due to algal blooms during periods of high temperatures and low wind.

4. Water Quality

Routine water quality monitoring is a key part of the Illinois EPA assessment program. The goals of Illinois EPA surface water monitoring programs are to determine whether designated uses are supported, identify causes of pollution (toxics, nutrients, sedimentation) and sources (point or nonpoint) of surface water impairments, determine the overall effectiveness of pollution control programs, and identify long term resource quality trends. Illinois EPA has operated a widespread, active long-term monitoring network in Illinois since 1977, known as the Ambient Water Quality Monitoring Network (AWQMN). The AWQMN is utilized by the Illinois EPA to provide baseline water quality information, to characterize and define trends in the physical, chemical and biological conditions of the state's waters, to identify new or existing water quality problems, and to act as a triggering mechanism for special studies or other appropriate actions.

Additional uses of the data collected by the Illinois EPA through the AWQMN program include the review of existing water quality standards and establishment of water quality based effluent limits for NPDES permits. The AWQMN is integrated with other Illinois EPA chemical and biological stream monitoring programs including Intensive River Basin Surveys, Facility –Related Stream Surveys, Fish Contaminant Monitoring, Toxicity Testing Program and Pesticide Monitoring Subnetwork which are more regionally based (specific watersheds or point source receiving stream) and cover a shorter span of time (e.g. one year) to evaluate compliance with water quality standards and determine designated use support. Information from this program is compiled by Illinois EPA into a biennial report, known as the Illinois Integrated Water Quality Report and Section 303(d) List, required by the Federal CWA.

Along the impaired waterbodies, data were found for numerous stations that are part of AWQMN (Figure 9 and Table 16). Parameters sampled on the waterbodies include field measurements (e.g., water temperature) as well as those that require lab analyses (e.g., fecal coliform, nutrients, and total suspended solids). Data were obtained directly from Illinois EPA.

Table 16. Illinois EPA water quality data for impaired waterbodies

Waterbody	Impaired Segment	AWQMN Sites	Location	Period of Record
Kaskaskia River	O-08	**O-08**	RM 135.7, RT 40-51 Br. (Gallatin St.) SE edge of Vandalia	*1999–2006*, 2007-2016, 2018
		O-39	3 Mi. N Vandalia	-*
		O-51	7 Mi. upstream Vandalia	-*
	O-33	O-64	4 Mi. NE of Vera at Co Rd 2150N	-*
		O-09	6 Mi. S of Herrick	-*
		O-33	RM 157.7, Co Rd 2700N Br. 7 Mi. E Ramsey upstream Big Creek	*2002*, 2007, 2012, 2017
	O-38	O-38	Co Rd 900N Br. 4 Mi. W Shobonieer and 7 Mi. SW Vandalia	-*
Carlyle Lake [a]	ROA	**ROA-1**	No site description	2011 (4 days), 2016 (1 day)
		ROA-2	Site 2 0.5 Mi. offshore from Carlyle	2011 (4 days), 2016 (1 day)
		ROA-3	Site 3 0.5 Mi. off Hazlet State Park South Shelter	2011 (4 days), 2016 (1 day)
		ROA-4	Site 4 2200 ft. NW access area	2011 (4 days), 2016 (1 day)
		ROA-5	Site 5 6000 ft. N into Hazlet State Park	2011 (4 days), 2016 (1 day)
		ROA-6	Site 6 50 ft. S large west arm	2011 (4 days), 2016 (1 day)
		ROA-99	No site description	2011 (2 days)
		Multiple other in-lake sites	-	-*

BOLD – Indicates station with data relevant to impairment
Italics – Data are greater than 10 years old
-* No data available for station in 1999–2016 water quality data received from Illinois EPA
a. Additional data are available from the USACE; see discussion below.
RM – River Mile

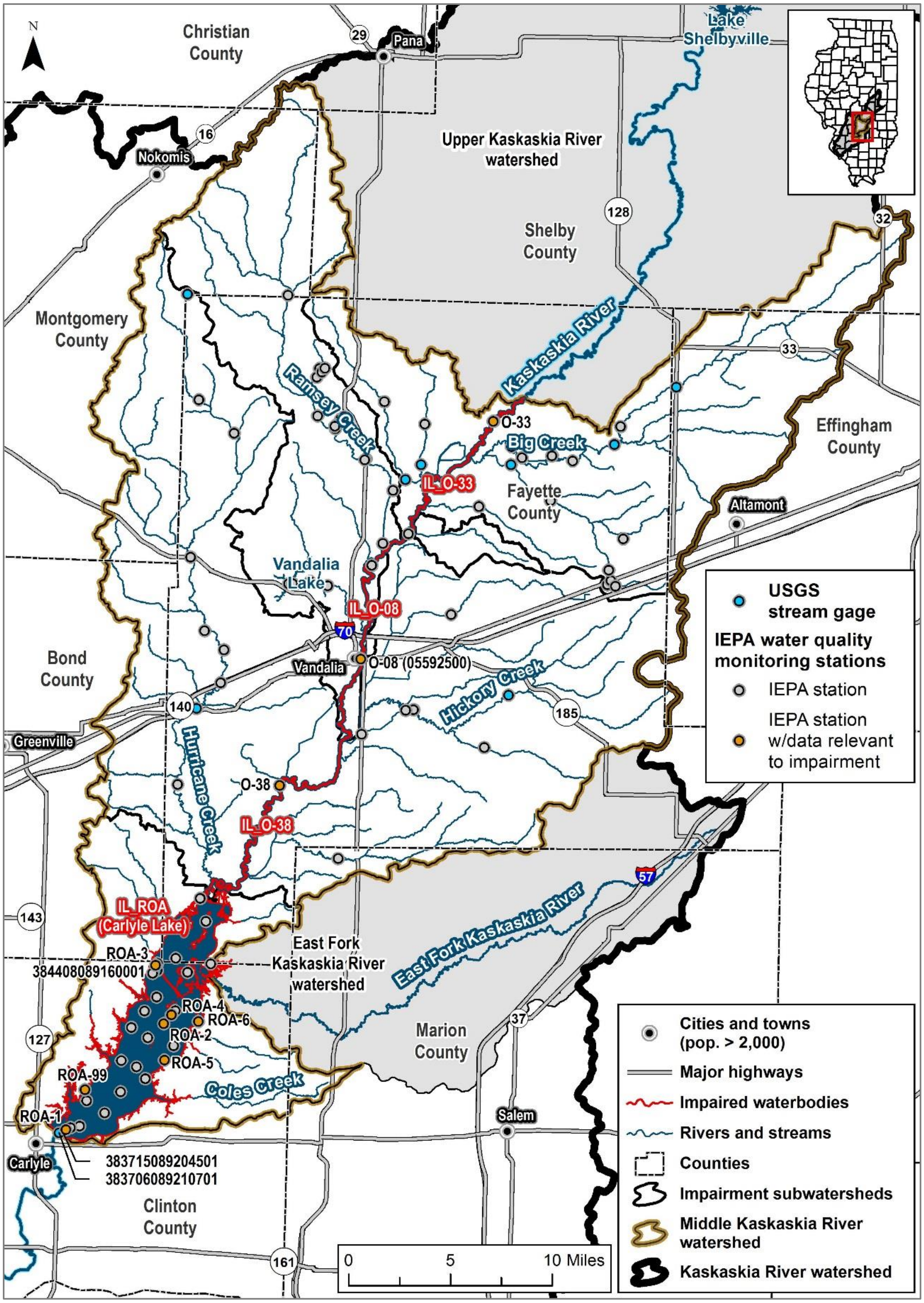

Figure 9. USGS stream gages and Illinois EPA water quality sampling sites in impairment watersheds and along impaired waterbodies.

Monitoring stations on impaired waterbodies with water quality data used in impairment assessment are labeled. Additional monitoring sites on Carlyle Lake are available from the USACE; see discussion below.

4.1 Data Analysis

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. The most recent 10 years of data collection, 2007–2016, were used to evaluate impairment for Carlyle Lake (ROA), and the last 5 years of data collection were used to evaluate Kaskaskia River impairments. Annual data requirements for impairment assessment were also included for Carlyle Lake; see Section 1.2.2. Each data point was reviewed to ensure the use of quality data in the analysis below.

4.1.1 Kaskaskia River

The Kaskaskia River is listed as impaired along three segments—O-33 for aquatic life due to low levels of dissolved oxygen, and O-08 and O-38 for primary contact recreation due to fecal coliform. There is one Illinois EPA sampling site with relevant data on O-33 and O-08 and no sampling sites with relevant data on O-38.

Dissolved oxygen measurements were collected on segment O-33 in 2012 and 2017. Dissolved oxygen in July 2012 violated the standard, and the dissolved oxygen impairment on O-33 is confirmed (Figure 10).

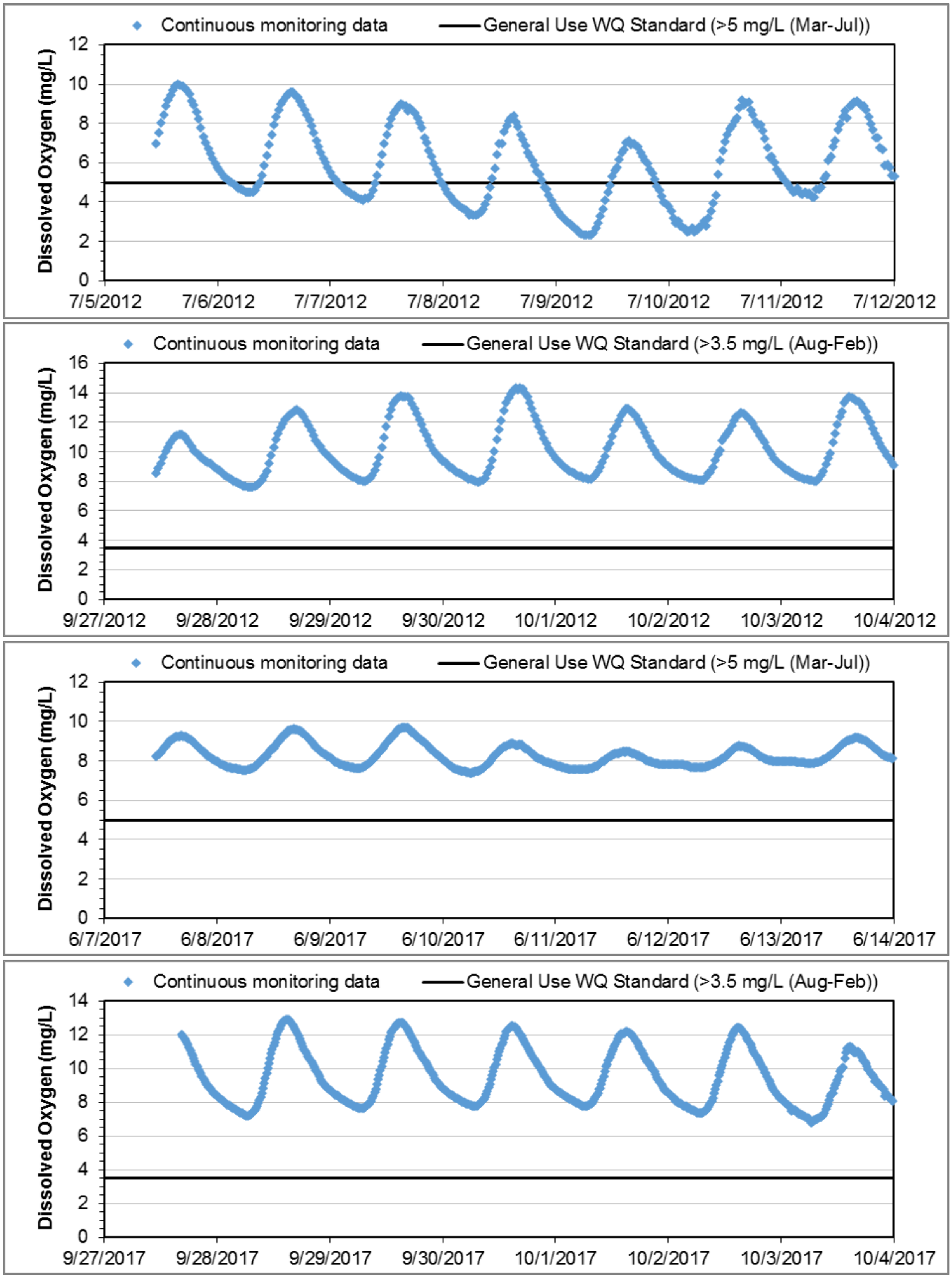

Figure 10. Continuous dissolved oxygen time series, Kaskaskia River O-33 segment (site O-33)

Seventeen fecal coliform samples were collected at O-08 between 2012 and 2016 (Table 17 and Figure 11). Eight exceedances of the single sample maximum standard were observed, with an average reported value above the standard at 1,387 cfu/100 mL. Additional data were collected at O-08 in 2018, and the geometric mean of the five samples taken within a 30-day period is greater than the monthly geometric mean standard (Figure 12). Recreational use impairment is verified for the segment.

Fecal coliform data from site O-08 were used to assess impairment on segment O-38. Site O-08 is located approximately five miles north of segment O-38. Recreational use impairment is verified for the segment.

Table 17. Data summary, Kaskaskia River O-08

Sample Site	No. of samples	Minimum (cfu/100 mL)	Average (cfu/100 mL)	Maximum (cfu/100 mL)	Number of exceedances of single sample maximum standard (400 cfu/100 mL)
Fecal Coliform					
O-08	17	78	1,387	10,000	8

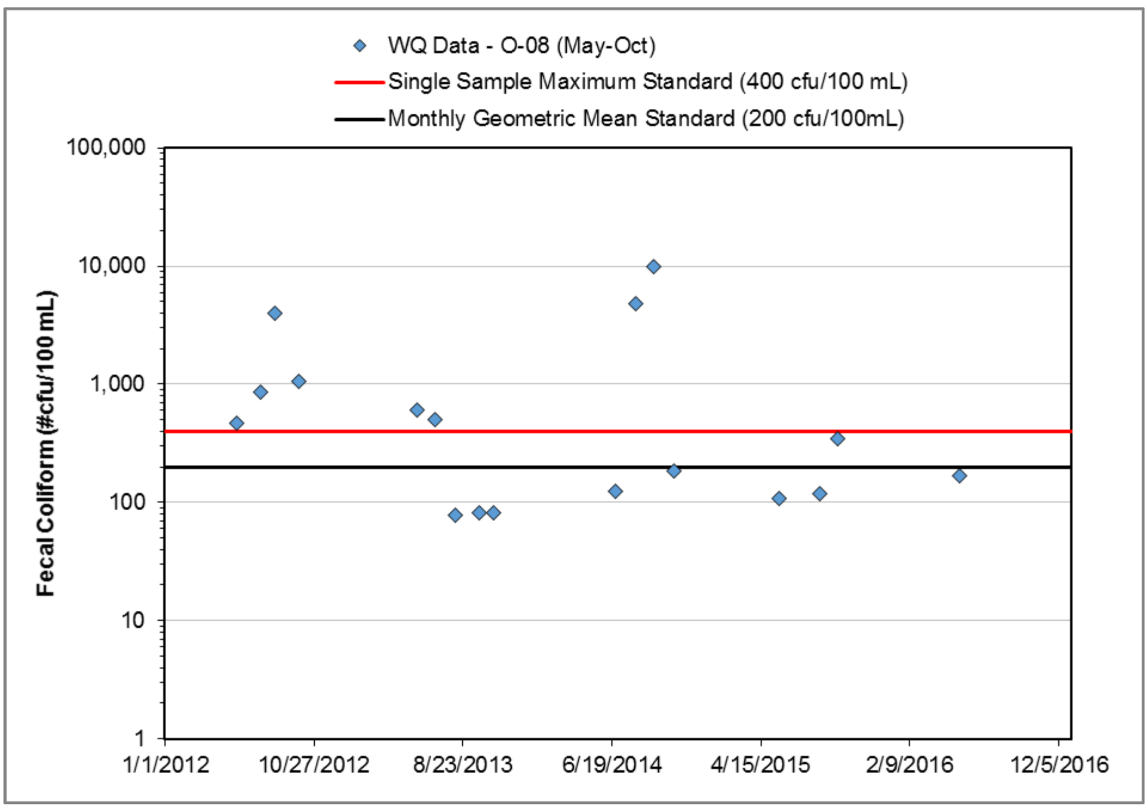

Figure 11. Fecal coliform water quality time series (2012–2015), Kaskaskia River O-08 segment.

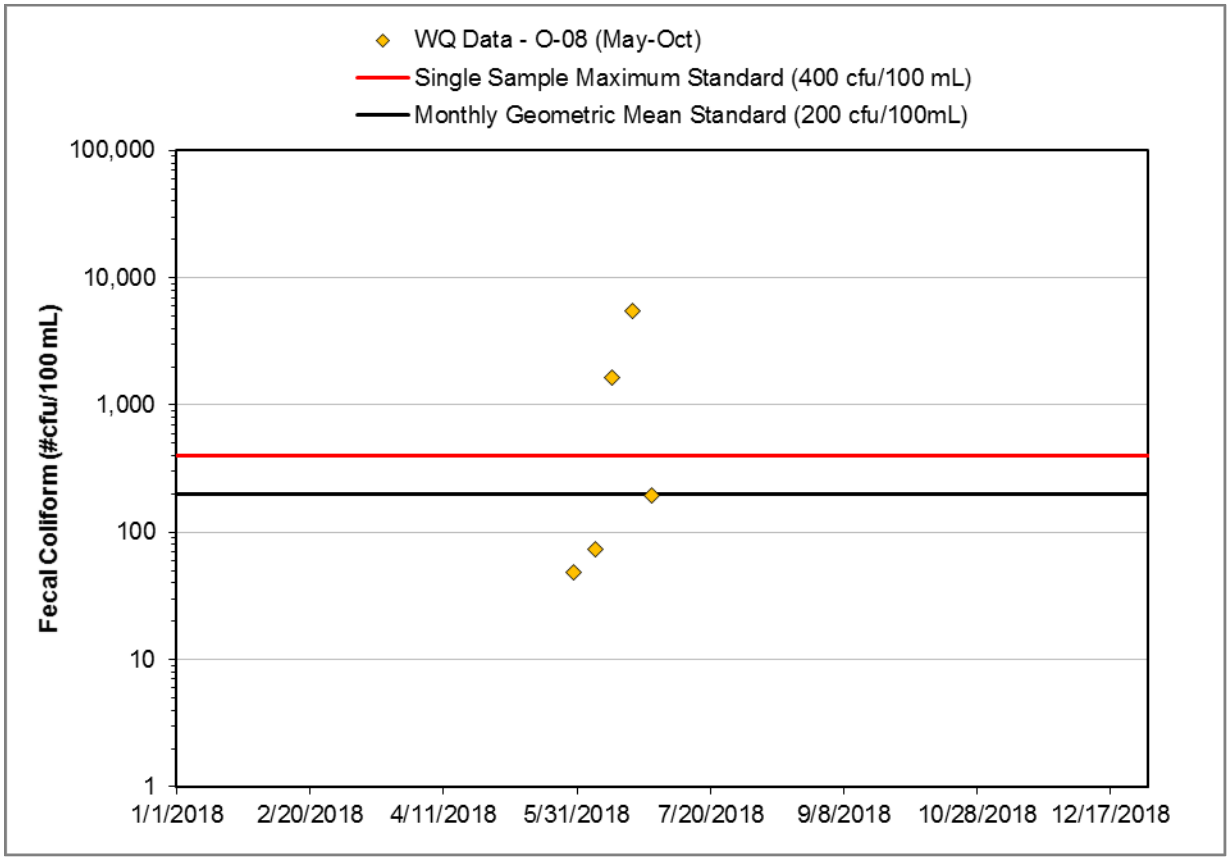

Figure 12. Fecal coliform water quality time series (2018), Kaskaskia River O-08 segment.

4.1.2 Carlyle Lake (ROA)

Carlyle Lake is a 9,947-hectare reservoir located 0.5 miles north of the city of Carlyle, IL and is the largest reservoir in the state of Illinois. It was created in 1967 by impounding the Kaskaskia River and is used for recreation, with approximately 12,000 acres of public land surrounding the shoreline. The USACE maintains an average depth of 40 feet with a maximum depth of 58 feet during flood conditions at the dam outlet, however, depth of the lake varies throughout (USACE 2017).

Carlyle Lake (ROA) is listed as impaired for aesthetic quality due to elevated levels of total phosphorus. Seven Illinois EPA sampling sites with relevant data were identified in the lake (Figure 9). Thirty-seven lake samples were collected at the sampling sites between 2011 and 2016 (Table 18). Figure 13 provides the water quality data collected during 2011. All samples exceed the general use water quality standard of 0.05 mg/L, with an average value across all sites of over three times the standard at 0.19 mg/L. Aesthetic quality impairment is confirmed for Carlyle Lake.

Additional phosphorus and chlorophyll-*a* data are available from the USACE from 2005–2017 at eight monitoring sites. Up to five samples were collected per year at each site.

Table 18. Illinois EPA data summary, Carlyle Lake
Additional data are available from the USACE.

Sample Site	Location	No. of samples	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	Number of Exceedances
Phosphorus (Total)						
ROA-1	South end of lake	10 [a]	0.116	0.205	0.332	10
ROA-2	Center of lake	5	0.115	0.176	0.257	5
ROA-3	Western side of lake	5	0.116	0.209	0.262	5
ROA-4	Center of lake	5	0.117	0.194	0.282	5
ROA-5	Eastern side of lake	5	0.122	0.186	0.288	5
ROA-6	Eastern side of lake	5	0.108	0.181	0.288	5
ROA-99	Western side of lake	2	0.124	0.134	0.143	2

a. Two samples were taken on each of 5 days from this sampling station.

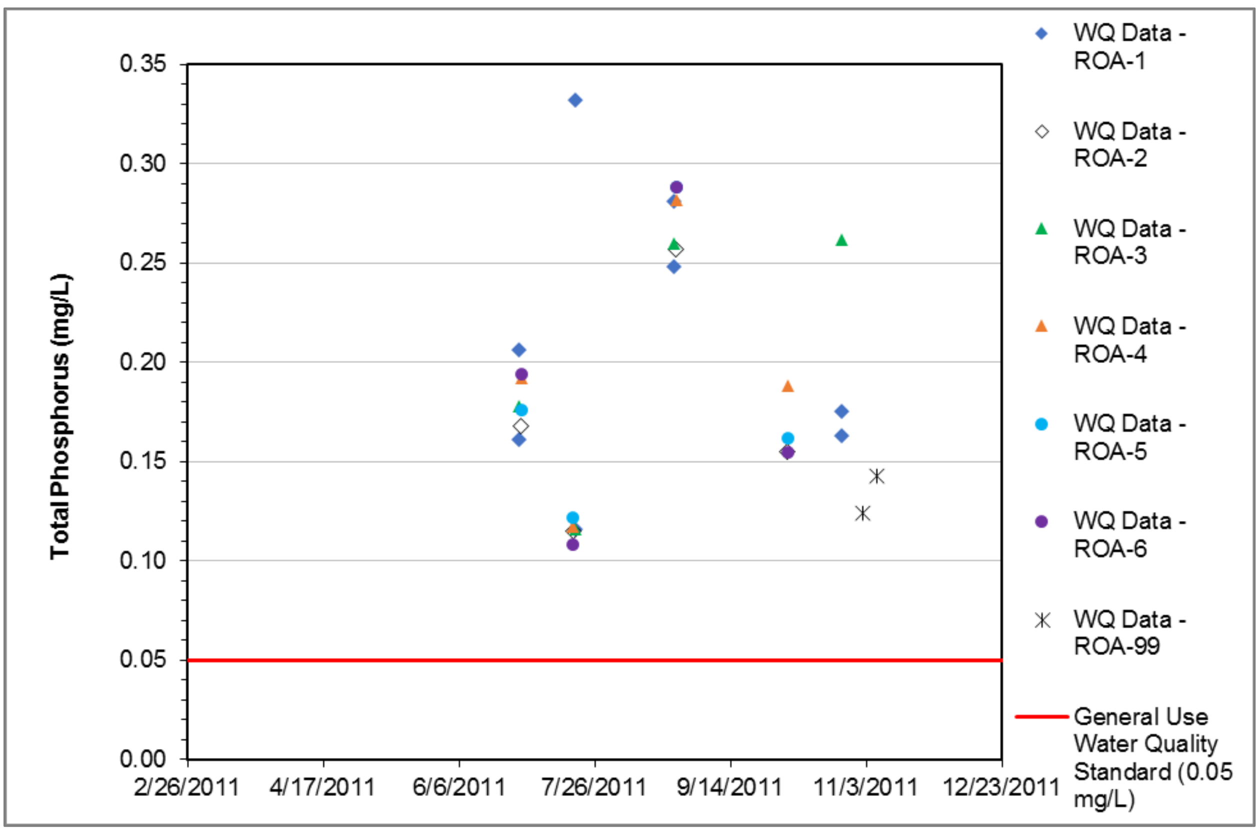

Figure 13. Total phosphorus water quality data, 2011, Carlyle Lake (ROA).

5. TMDL Methods and Data Needs

The first stage of this project has been 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.

5.1 Stream and Lake Impairments

TMDLs are proposed for all segments with verified impairments (Table 19). A duration curve approach is suggested to evaluate the relationships between hydrology and water quality and calculate the TMDLs for fecal coliform impairments; a Bathtub model is proposed for Carlyle Lake (ROA). For the dissolved oxygen impairment, 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 or the effect of hydromodification).

Table 19. Proposed model summary

Name	Segment ID	Designated Uses	TMDL Parameter(s)	Proposed Model	Proposed Pollutant
Kaskaskia River	IL_O-08	Primary contact recreation	Fecal coliform	Load duration curve	Fecal coliform
	IL_O-33	Aquatic life	Dissolved oxygen	Load duration curve or 4C classification	Phosphorus or non-pollutant
	IL_O-38	Primary contact recreation	Fecal coliform	Load duration curve	Fecal coliform
Carlyle Lake	IL_ROA	Aquatic life	Phosphorus (Total)	Bathtub	Phosphorus (Total)

5.1.1 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* (USEPA 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 20 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 20. 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		

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 CWA 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.

5.1.2 Bathtub

The Bathtub model is recommended to support TMDL development for Carlyle 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 USACE. The model requires nutrient loading inputs from the contributing watershed and atmospheric deposition, morphometric data for the lake, and estimates of mixing depth and nonalgal turbidity. A series of linked models will be developed, depending on the availability of bathymetry and other datasets. Data from 2005 through 2017 will be used to calibrate and validate the model.

5.2 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 21 summarizes the additional data needed for each impaired segment.

Table 21. Additional data needs

Name	Segment ID	Designated Uses	TMDL Parameters	Additional Data Needs
Kaskaskia River	IL_O-08	Primary contact recreation	Fecal coliform	None
	IL_O-33	Aquatic life	Dissolved oxygen	To determine relationship with eutrophication
	IL_O-38	Primary contact recreation	Fecal coliform	None
Carlyle Lake	IL_ROA	Aquatic life	Phosphorus (Total)	None
All	All	All	All	Implementation plan development

Specific data needs include:

Determine Relationship with Eutrophication on O-33—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 (site O-33) 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 to ensure that critical conditions are captured.

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 Kaskaskia River: IL_O-08, IL_O-33, IL_O-38
- Lakeshore assessment of Carlyle 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, and others. The public comment period closed on January 12, 2019. One set of comments were provided; these and a response to comments are provided in Appendix B. The draft Stage 1 report was updated based on comments received.

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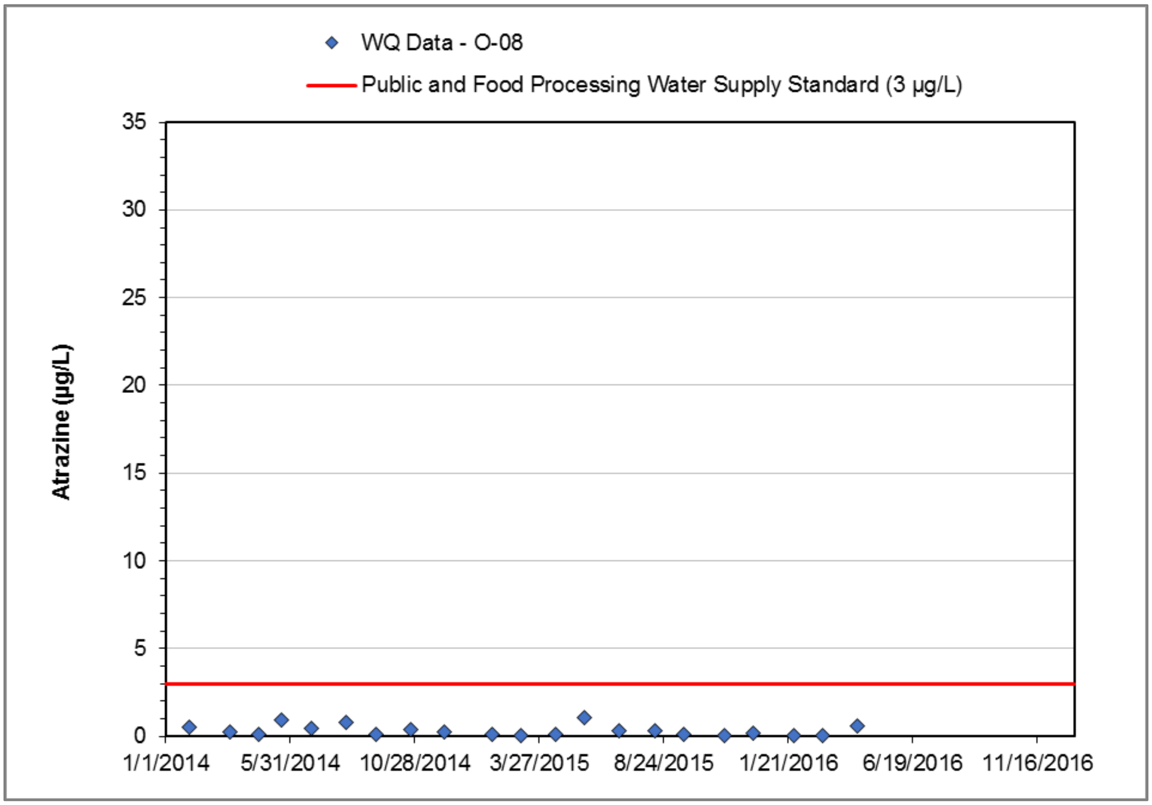
Appendix A – Unimpaired Stream Data Analysis

Kaskaskia River (O-08)

Kaskaskia River segment O-08 is listed for not supporting Public and Food Processing Water Supplies due to elevated levels of atrazine. One Illinois EPA sampling site was identified on the segment, O-08. No samples over the last three years of data collection (2014–2016) were recorded above the 3 µg/L drinking water protection MCL. It is therefore recommended that the segment be delisted for atrazine and no TMDL be developed.

Atrazine data summary, Kaskaskia River O-08

Sample Site	Date	Result (µg/L)	Quarterly Average (µg/L)
Atrazine			
O-08	1/30/2014	0.55	0.4
	3/19/2014	0.26	
	4/23/2014	0.13	0.5
	5/21/2014	0.92	
	6/26/2014	0.44	
	8/7/2014	0.77	0.4
	9/11/2014	0.09	
	10/23/2014	0.39	0.3
	12/3/2014	0.27	
	1/29/2015	0.11	0.1
	3/5/2015	0.08	
	4/16/2015	0.10	0.6
	5/21/2015	1.10	
	7/2/2015	0.29	0.26
	8/13/2015	0.34	
	9/17/2015	0.15	
	11/5/2015	0.06	0.12
	12/10/2015	0.17	
	1/28/2016	0.05	0.05
	3/3/2016	0.05	
	4/14/2016	0.61	0.61



Atrazine water quality time series, Kaskaskia River O-08.

Appendix B – Stage 1 Response to Comment

Response to comments are provided in blue below each comment.

Carlyle Lake Association Comments to
Draft TMDL Report-Middle Kaskaskia River
3 December 2018

General – There are several omissions in the draft report which inhibit a major direction of the way forward for this study. The stakeholder groups represented by the Carlyle Lake Association request that these be corrected and the considerations therein be included the further studies and recommended remediation efforts. These are:

1. By federal law and the USACE Carlyle Project Master Plan, Carlyle Lake has four purposes; three of which are applicable to the TMDL studies, and should be so stated. These purposes are flood control, recreation, public water supply, and wildlife conservation. The recreation component is very popular with hundreds of people participating for over 20 weekends per year in “primary contact recreation” from five swimming beaches, numerous jet ski and waterskiing motor craft, swimming from anchored pontoon boats, kayaking, and over 50 small sailing craft. Therefore, “primary contact recreation” must be cited everywhere applicable in the report for Carlyle Lake. Also, by mandate from the State of Illinois, 39,000 acre feet of water from the lake are available for public and industrial water system use. This certainly should be a consideration in any study involving water quality.

   Section 1.2.1 identifies the designated uses applicable to the Middle Kaskaskia watershed and includes primary contact recreation. Additional text has been added to this section that references the purposes of the project as defined in USACE’s Master Plan. Public and food processing water supply standards have been added for Carlyle Lake.

   The TMDL study is only applicable to specific impairments, none of which include impairments to aquatic recreation. Table 1 includes the designated use that is applicable to the cause of impairment addressed in this TMDL report. For Carlyle Lake, this report only addresses the Aesthetic Quality designated use. Other uses can support and guide selection of implementation activities but are not applicable to TMDL development.

   Information on recreational uses of Carlyle Lake was also added to section 2.

2. Based upon the work of Dr. Karl Williard of Southern Illinois University, and supported by grants from the Kaskaskia Watershed Association, one of the major causes of greater than allowable phosphorous levels in Carlyle Lake is from siltation. This is primarily caused by bank erosion during periods of bank-full high flows. This situation should be more prominently featured in the report, and the work of Dr. Williard prominently featured including in the bibliography. Also, it

appears that the information recommended from the USACE M30 report, and that from the Dr. Karl Williard studies were not used in this report.

Section 3.3.5 Stream Channel Erosion and Shoreline Erosion addresses sediment as a source of phosphorus to Carlyle Lake and cites a USACE 2017 Report. Recommendations that are relevant from the M30 report will be included in the implementation planning portion of the project, to be developed.

Studies conducted by Dr. Willard were not available at the time of this report, but data and findings may be incorporated as part of the Stage 3 document if provided. We have added one report by Dr. Willard into section 2.7, if other reports exist, these may be added when available. Please provide copies of any relevant reports that can be used to obtain copies.

Specific Changes

1. Section 1.1: Total suspended solids definitely should be addressed in this report as it is a major source of phosphorous.

   Sediment and erosion are identified as a pollutant source to Carlyle Lake in section 3.3.5 of the draft Stage 1 report.

2. Table 1, Add designated uses for Carlyle Lake, in addition to aesthetic quality, for Primary Contact Recreation, and for Public Water Supply. Total suspended solids definitely should be addressed in this report as it is a major source of phosphorous. Why was atrazine removed from the 303 list, and hence, not addressed in the report?

   Table 1 includes the designated uses that are applicable to the impairments being addressed in this TMDL report only. Additional text has been added to section 1.2.1 (Designated uses).

   Sediment and erosion are identified as a pollutant source to Carlyle Lake in section 3.3.5 of the Stage 1 report.

   Water quality data did not indicate impairment for atrazine in segment O-08, see Appendix A.

3. Section 1.2.2: Add small craft sailing and jet ski operation to the activities included in primary contact recreation. Also boat harbors, launching ramps in coves should be given priority for aesthetic quality sampling as this is the first view of the lake that users experience. Also, these are the areas that are most prone to algae blooms.

   Added language on additional recreational activities.

4. Table 2: The allowable of 0.05 for phosphorous is for lakes only, the allowable for streams is higher, and should be specified at 0.16, I believe.
   Table 2 has been clarified.

5. Section 2.7: Was the previous TMDL study for the North Fork of the Kaskaskia considered? It is not listed in this section. Also, USACE Report M-30, about bank erosion is not listed. It should be as it is most definitive about this critical problem that leads to siltation and elevated phosphorous levels as identifies by the Carlyle Lake Watershed Plan, which is listed in the section.

   Additional reports have been added to the watershed studies section as provided by stakeholders (see below).
   - Carlyle Lake Watershed Plan
   - Carlyle Lake Master Plan
   - Kaskaskia River Watershed, An Ecosystem Approach to Issues and Opportunities
   - Vandalia Lake TMDL
   - Kaskaskia River–North Fork TMDL
   - Evaluating Watershed Health Through Integrated Water Quality Analysis and Community Capacity Assessments
   - Bank Erosion and Historical River Morphology Study of the Kaskaskia, Shelbyville to Carlyle Lake
   - Report on Carlyle Reservoir Wildlife Management Area Study
   - Report of Sedimentation 1999 Resurvey Carlyle Reservoir
   - Carlyle Lake Watershed Plan
   - Analysis of the Operation of Lake Shelbyville and Carlyle Lake to Maximize Agricultural and Recreational Benefits
   - Water Quality Evaluation, Carlyle Lake 2006-2010
   - 2014 Carlyle Lake Water Quality Report
   - 2016 Lake Shelbyville Masterplan Update
   - Historical River Morphology Study of the Kaskaskia River Headwaters to Lake Shelbyville

   As additional studies and reports are identified such as the 2018 water quality report, we will add these to the draft report.

6. Section 3.1: Add sedimentation to the pollutants of concern.

   This section is only addressing the pollutants that have been listed as impaired. Phosphorus loading from sedimentation is included in source assessment section 3.3.5.

7. Section 4.1.2: The average depth of Carlyle Lake at normal summer pool of 445 ft. NDVG is around 18 ft. downstream of the railroad trestle not 40 ft. based on the USACE Sedimentation Survey of 1999. Upstream of the trestle the average depth is 2 – 4 ft. at most.

Thank you for this information. Additional clarification was added to this section to account for varying depths.

8. Table 19: Add designated uses for Carlyle Lake, in addition to aquatic life, for Primary Contact Recreation and for Public Water Supply.

   Table 19 only includes the impaired designated uses that are being addressed in this TMDL study. Additional information on Carlyle Lake’s other uses have been added to section 1.2.1.

9. References: Add USACE Report M 30 and Dr. Karl Williard material.

   The references have been updated to include the new reports.

Theodor Beier
President, Carlyle Lake Association

Appendix B – Stage 2 Data

Illinois Environmental Protection Agency Laboratory

825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	08/08/19 16:15 by LAUREN AIELLO
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190807INHS	Visit Number:	001	Monitoring Program:	TMDL

Client Sample ID:	CHLOROPHYLL	Collected By:	MFS	Lab Sample ID:	**19H0418-01**
Sample Medium:	Water	PWS Intake:		Date/Time Collected:	08/08/19 13:05
Sample Fraction:	Total	Chlorophyll volume filtered (ml):	200	Sample Depth:	

Chlorophyll by Standard Method 10200 H

Method: 10200 H

Units: ug/L

Prepared: 08/21/19 12:09

Analyzed: 08/28/19 10:40

Analyte	Result	Qualifier	Reporting Limit	MDL
Chlorophyll-A (corr)	**17.4**		0.50	
Chlorophyll-A (unco)	**15.2**		0.50	
Chlorophyll-B	**2.52**		0.50	
Chlorophyll-C	ND		0.50	
Pheophytin-A	ND		0.50	

Reported:

08/30/19 16:17

Illinois Environmental Protection Agency Laboratory

825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	08/08/19 16:15 by LAUREN AIELLO
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190807INHS	Visit Number:	001	Monitoring Program:	TMDL

Notes and Definitions

ND Analyte NOT DETECTED at or above the method detection limit

* Non-NELAP accredited

Report Authorized by:

Tom Weiss
Laboratory Manager

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Reported:
08/30/19 16:17

Illinois Environmental Protection Agency Laboratory

825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	07/25/19 16:35 by ADAM LUCCHESI
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	2.00
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190724INHS	Visit Number:	001	Monitoring Program:	TMDL

Client Sample ID:	TOTAL	Collected By:	VIT	Lab Sample ID:	**19G0884-01**
Sample Medium:	Water	PWS Intake:		Date/Time Collected:	07/25/19 10:10
Sample Fraction:	Total	Chlorophyll volume filtered (ml):		Sample Depth:	

Phosphorus, All Forms, Colorimetric, Automated, by EPA Method 365.1

Method:	EPA 365.1	Prepared:	08/19/19 09:00
Units:	mg/L	Analyzed:	08/21/19 11:08

Analyte	Result	Qualifier	Reporting Limit	MDL
Phosphorus as P	**0.111**		0.0050	0.0042

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Reported:

08/30/19 16:32

Illinois Environmental Protection Agency Laboratory

825 N. Rutledge Springfield, Illinois 62702   217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	07/25/19 16:35 by ADAM LUCCHESI
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	2.00
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190724INHS	Visit Number:	001	Monitoring Program:	TMDL

Notes and Definitions

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Laboratory Manager

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Reported:
08/30/19 16:32

Illinois Environmental Protection Agency Laboratory

825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	07/25/19 16:35 by ADAM LUCCHESI
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190724INHS	Visit Number:	001	Monitoring Program:	TMDL

Client Sample ID:	CHLOROPHYLL	Collected By:	VIT	Lab Sample ID:	**19G0885-01**
Sample Medium:	Water	PWS Intake:		Date/Time Collected:	07/25/19 10:10
Sample Fraction:	Total	Chlorophyll volume filtered (ml):	200	Sample Depth:	

Chlorophyll by Standard Method 10200 H

Method: 10200 H

Units: ug/L

Prepared: 08/12/19 10:46

Analyzed: 08/15/19 10:55

Analyte	Result	Qualifier	Reporting Limit	MDL
Chlorophyll-A (corr)	**24.0**		0.50	
Chlorophyll-A (unco)	**24.7**		0.50	
Chlorophyll-B	ND		0.50	
Chlorophyll-C	**1.19**		0.50	
Pheophytin-A	ND		0.50	

Reported:

08/16/19 08:19

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	07/25/19 16:35 by ADAM LUCCHESI
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190724INHS	Visit Number:	001	Monitoring Program:	TMDL

Notes and Definitions

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Reported:
08/16/19 08:19

Illinois Environmental Protection Agency Laboratory

825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	07/25/19 16:35 by ADAM LUCCHESI
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	2.00
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190724INHS	Visit Number:	001	Monitoring Program:	TMDL

Client Sample ID:	TOTAL	Collected By:	MFS	Lab Sample ID:	**19G0886-01**
Sample Medium:	Water	PWS Intake:		Date/Time Collected:	07/25/19 13:17
Sample Fraction:	Total	Chlorophyll volume filtered (ml):		Sample Depth:	

Phosphorus, All Forms, Colorimetric, Automated, by EPA Method 365.1

Method:	EPA 365.1	Prepared:	08/19/19 09:00
Units:	mg/L	Analyzed:	08/21/19 11:09

Analyte	Result	Qualifier	Reporting Limit	MDL
Phosphorus as P	**0.106**		0.0050	0.0042

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Reported:
08/30/19 16:32

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702   217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	07/25/19 16:35 by ADAM LUCCHESI
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	2.00
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190724INHS	Visit Number:	001	Monitoring Program:	TMDL

Notes and Definitions

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Laboratory Manager

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Reported:
08/30/19 16:32

Illinois Environmental Protection Agency Laboratory

825 N. Rutledge Springfield, Illinois 62702   217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	07/25/19 16:35 by ADAM LUCCHESI
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190724INHS	Visit Number:	001	Monitoring Program:	TMDL

Client Sample ID:	CHLOROPHYLL	Collected By:	MFS	Lab Sample ID:	**19G0887-01**
Sample Medium:	Water	PWS Intake:		Date/Time Collected:	07/25/19 13:17
Sample Fraction:	Total	Chlorophyll volume filtered (ml):	200	Sample Depth:	

Chlorophyll by Standard Method 10200 H

Method:	10200 H	Prepared:	08/12/19 10:46
Units:	ug/L	Analyzed:	08/15/19 10:55

Analyte	Result	Qualifier	Reporting Limit	MDL
Chlorophyll-A (corr)	**26.7**		0.50	
Chlorophyll-A (unco)	**27.0**		0.50	
Chlorophyll-B	ND		0.50	
Chlorophyll-C	ND		0.50	
Pheophytin-A	ND		0.50	

Reported:

08/16/19 08:19

Illinois Environmental Protection Agency Laboratory

825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	07/25/19 16:35 by ADAM LUCCHESI
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190724INHS	Visit Number:	001	Monitoring Program:	TMDL

Notes and Definitions

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Tom Weiss
Laboratory Manager

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Reported:
08/16/19 08:19

Illinois Environmental Protection Agency Laboratory

825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	08/01/19 16:30 by ADAM LUCCHESI
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	3.00
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190731INHS	Visit Number:	001	Monitoring Program:	TMDL

Client Sample ID:	TOTAL	Collected By:	MFS	Lab Sample ID:	**19H0046-01**
Sample Medium:	Water	PWS Intake:		Date/Time Collected:	08/01/19 10:20
Sample Fraction:	Total	Chlorophyll volume filtered (ml):		Sample Depth:	

Phosphorus, All Forms, Colorimetric, Automated, by EPA Method 365.1

Method:	EPA 365.1	Prepared:	08/27/19 10:00
Units:	mg/L	Analyzed:	08/27/19 14:46

Analyte	Result	Qualifier	Reporting Limit	MDL
Phosphorus as P	**0.0960**		0.0050	0.0042

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Reported:
08/30/19 16:27

Illinois Environmental Protection Agency Laboratory

825 N. Rutledge Springfield, Illinois 62702   217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	08/01/19 16:30 by ADAM LUCCHESI
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	3.00
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190731INHS	Visit Number:	001	Monitoring Program:	TMDL

Notes and Definitions

ND   Analyte NOT DETECTED at or above the method detection limit

*   Non-NELAP accredited

Report Authorized by:

Tom Weiss
Laboratory Manager

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Reported:
08/30/19 16:27

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	08/01/19 16:30 by ADAM LUCCHESI
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	3.00
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190731INHS	Visit Number:	001	Monitoring Program:	TMDL

Client Sample ID:	TOTAL	Collected By:	MFS	Lab Sample ID:	**19H0047-01**
Sample Medium:	Water	PWS Intake:		Date/Time Collected:	08/01/19 13:15
Sample Fraction:	Total	Chlorophyll volume filtered (ml):		Sample Depth:	

Phosphorus, All Forms, Colorimetric, Automated, by EPA Method 365.1

Method:	EPA 365.1	Prepared:	08/27/19 10:00
Units:	mg/L	Analyzed:	08/27/19 14:47

Analyte	Result	Qualifier	Reporting Limit	MDL
Phosphorus as P	**0.0910**		0.0050	0.0042

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Reported:
08/30/19 16:27

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	08/01/19 16:30 by ADAM LUCCHESI
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	3.00
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190731INHS	Visit Number:	001	Monitoring Program:	TMDL

Notes and Definitions

ND Analyte NOT DETECTED at or above the method detection limit

* Non-NELAP accredited

Report Authorized by:

Tom Weiss
Laboratory Manager

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Reported:
08/30/19 16:27

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	08/01/19 16:30 by LAUREN AIELLO
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190731INHS	Visit Number:	001	Monitoring Program:	TMDL

Client Sample ID:	CHLOROPHYLL	Collected By:	MFS	Lab Sample ID:	**19H0087-01**
Sample Medium:	Water	PWS Intake:		Date/Time Collected:	08/01/19 10:20
Sample Fraction:	Total	Chlorophyll volume filtered (ml):	200	Sample Depth:	

Chlorophyll by Standard Method 10200 H

Method:	10200 H	Prepared:	08/20/19 10:13
Units:	ug/L	Analyzed:	08/21/19 10:41

Analyte	Result	Qualifier	Reporting Limit	MDL
Chlorophyll-A (corr)	**29.4**		0.50	
Chlorophyll-A (unco)	**36.1**		0.50	
Chlorophyll-B	ND		0.50	
Chlorophyll-C	**2.15**		0.50	
Pheophytin-A	**8.94**		0.50	

Reported:
08/30/19 16:25

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702   217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	08/01/19 16:30 by LAUREN AIELLO
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190731INHS	Visit Number:	001	Monitoring Program:	TMDL

Notes and Definitions

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Report Authorized by:

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Laboratory Manager

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Reported:
08/30/19 16:25

Illinois Environmental Protection Agency Laboratory

825 N. Rutledge Springfield, Illinois 62702   217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	08/01/19 16:30 by LAUREN AIELLO
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190731INHS	Visit Number:	001	Monitoring Program:	TMDL

Client Sample ID:	CHLOROPHYLL	Collected By:	VIT	Lab Sample ID:	**19H0088-01**
Sample Medium:	Water	PWS Intake:		Date/Time Collected:	08/01/19 13:25
Sample Fraction:	Total	Chlorophyll volume filtered (ml):	200	Sample Depth:	

Chlorophyll by Standard Method 10200 H

Method:	10200 H	Prepared:	08/20/19 10:13
Units:	ug/L	Analyzed:	08/21/19 10:41

Analyte	Result	Qualifier	Reporting Limit	MDL
Chlorophyll-A (corr)	**9.34**		0.50	
Chlorophyll-A (unco)	**9.16**		0.50	
Chlorophyll-B	ND		0.50	
Chlorophyll-C	ND		0.50	
Pheophytin-A	ND		0.50	

Reported:
08/30/19 16:24

Illinois Environmental Protection Agency Laboratory

825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	08/01/19 16:30 by LAUREN AIELLO
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190731INHS	Visit Number:	001	Monitoring Program:	TMDL

Notes and Definitions

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Reported:
08/30/19 16:24

Illinois Environmental Protection Agency Laboratory

825 N. Rutledge Springfield, Illinois 62702   217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	08/08/19 16:15 by Scott Clark
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	3.00
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190807INHS	Visit Number:	001	Monitoring Program:	TMDL

Client Sample ID:	TOTAL	Collected By:	VIT	Lab Sample ID:	**19H0409-01**
Sample Medium:	Water	PWS Intake:		Date/Time Collected:	08/08/19 10:16
Sample Fraction:	Total	Chlorophyll volume filtered (ml):		Sample Depth:	

Phosphorus, All Forms, Colorimetric, Automated, by EPA Method 365.1

Method:	EPA 365.1	Prepared:	08/28/19 09:00
Units:	mg/L	Analyzed:	08/29/19 11:40

Analyte	Result	Qualifier	Reporting Limit	MDL
Phosphorus as P	**0.120**		0.0050	0.0042

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Reported:
09/12/19 14:31

Illinois Environmental Protection Agency Laboratory

825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	08/08/19 16:15 by Scott Clark
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	3.00
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190807INHS	Visit Number:	001	Monitoring Program:	TMDL

Notes and Definitions

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Reported:
09/12/19 14:31

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	08/08/19 16:15 by LAUREN AIELLO
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	3.00
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190807INHS	Visit Number:	001	Monitoring Program:	TMDL

Client Sample ID:	TOTAL	Collected By:	MFS	Lab Sample ID:	**19H0410-01**
Sample Medium:	Water	PWS Intake:		Date/Time Collected:	08/08/19 13:05
Sample Fraction:	Total	Chlorophyll volume filtered (ml):		Sample Depth:	

Phosphorus, All Forms, Colorimetric, Automated, by EPA Method 365.1

Method:	EPA 365.1	Prepared:	08/28/19 09:00
Units:	mg/L	Analyzed:	08/29/19 11:41

Analyte	Result	Qualifier	Reporting Limit	MDL
Phosphorus as P	**0.124**		0.0050	0.0042

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Reported:
09/12/19 14:31

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LABORATORY RESULTS

Station Code:	O-33			Received :	08/08/19 16:15 by LAUREN AIELLO
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	3.00
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190807INHS	Visit Number:	001	Monitoring Program:	TMDL

Notes and Definitions

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Reported:
09/12/19 14:31

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LABORATORY RESULTS

Station Code:	O-33			Received :	08/08/19 16:15 by LAUREN AIELLO
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190807INHS	Visit Number:	001	Monitoring Program:	TMDL

Client Sample ID:	CHLOROPHYLL	Collected By:	VIT	Lab Sample ID:	**19H0417-01**
Sample Medium:	Water	PWS Intake:		Date/Time Collected:	08/08/19 10:16
Sample Fraction:	Total	Chlorophyll volume filtered (ml):	200	Sample Depth:	

Chlorophyll by Standard Method 10200 H

Method:	10200 H	Prepared:	08/21/19 12:09
Units:	ug/L	Analyzed:	08/28/19 10:40

Analyte	Result	Qualifier	Reporting Limit	MDL
Chlorophyll-A (corr)	**5.34**		0.50	
Chlorophyll-A (unco)	**11.5**		0.50	
Chlorophyll-B	ND		0.50	
Chlorophyll-C	ND		0.50	
Pheophytin-A	**9.61**		0.50	

Reported:
08/30/19 16:17

Illinois Environmental Protection Agency Laboratory
825 N. Rutledge Springfield, Illinois 62702 217.782.9780

LABORATORY RESULTS

Station Code:	O-33			Received :	08/08/19 16:15 by LAUREN AIELLO
Waterbody Name:	KASKASKIA RIVER	County:	FAYETTE	Temperature C:	
Funding Code:	WP06			Monitoring Unit:	TMDL
Trip ID:	20190807INHS	Visit Number:	001	Monitoring Program:	TMDL

Notes and Definitions

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Laboratory Manager

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Reported:
08/30/19 16:17

Appendix C– Recommendation for Delisting

The Kaskaskia River (IL_O-33) was listed as impaired for aquatic life due to low levels of dissolved oxygen. Continuous dissolved oxygen data were previously collected in 2012 and 2017, and four instantaneous samples were collected in 2017. Exceedances were measured during July 2012 (Figure C - 1, next page). The 2017 data did not indicate impairment; additional dissolved oxygen data were collected during July and August 2019 to confirm these findings.

Data were collected by IEPA and the Illinois State Water Survey in 2019 in the Kaskaskia River (IL_O-33). Data sondes were used to measure dissolved oxygen concentrations. The sondes were deployed once in the morning and once in the afternoon on each day of sampling. The data were averaged for each morning and each afternoon (Table C - 1).

Table C - 1. Dissolved oxygen data (Kaskaskia River at IL_O-33)

Date	Time of day	Dissolved oxygen (mg/L)
7/25/2019	AM	7.79
	PM	8.18
8/1/2019	AM	7.46
	PM	7.85
8/8/2019	AM	6.83
	PM	7.05

Both the morning and afternoon measurements from July 25, 2019, were greater than the 5.0 mg/L instantaneous minimum standard for March through July (refer to the Stage 1 report for a discussion of standards). Both sets of morning and afternoon averages from August 2019 were greater than the 3.5 mg/L instantaneous minimum standard for August through February. IEPA provided new guidelines in 2020 to assess streams using continuous dissolved oxygen data and recommended that a shorter window of time be considered. Specifically, for assessment in 2020, IEPA considers data collected between 2015 and 2017. As the 2017 and 2019 data do not indicate impairment, this segment was recommended for delisting and no further TMDL work has been conducted. IEPA delisted Kaskaskia River segment IL_O-33 for dissolved oxygen in Illinois's 2020/2022 Integrated Report.

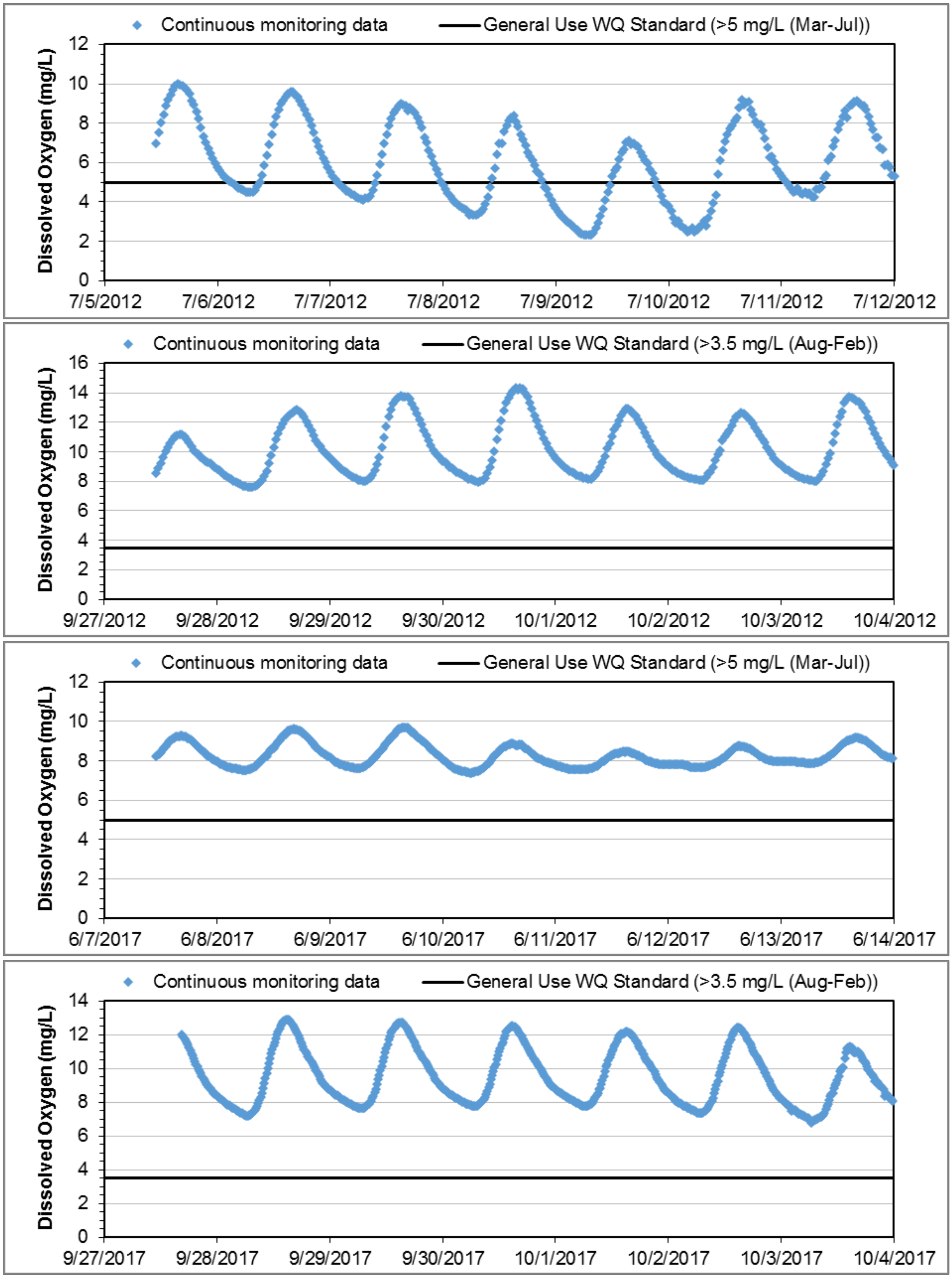

Figure C - 1. Continuous dissolved oxygen time series, Kaskaskia River O-33 segment (site O-33)

Appendix D – Carlyle Lake Model Report

TETRA TECH

MEMORANDUM

To:	File	**Date:**	August 3, 2020
From:	Hillary Yonce, Jennifer Olson	**Subject:**	Carlyle Lake TMDL: BATHTUB Modeling

This memorandum summarizes inputs and analyses conducted using the BATHTUB model (version 6.20) as part of the TMDL analysis for Carlyle Lake. The Carlyle Lake BATHTUB model was constructed for simulation of the following parameters: total phosphorus (TP), chlorophyll-*a* (Chl-*a*), and transparency. The simulation or "averaging" period is one year as the intention is to capture the annual average conditions of the lake.

BATHTUB model inputs are detailed in the sections below. For more detailed information on parameters and how they are used in the model, please refer to the BATHTUB user's manual available online.

Global Variables

Key global variables include annual average precipitation, evaporation, and atmospheric loading of phosphorus. As summarized in the Middle Kaskaskia River Stage 1 Report, NOAA Global Historical Climatology Network station USC00111290 data from 1962-2016 reveals an annual average precipitation of 41 inches (1.04 m/yr). Annual average pan evaporation at Carlyle Lake is approximately 41 inches as well (NOAA Tech Report NWS 34, 1982)[1].

Atmospheric loading of phosphorus to the lake was estimated based on National Atmospheric Deposition Program (NADP) data for the central Illinois site Bondville. Phosphorus deposition data from 1992-2017 was used to approximate an average loading of 18 mg/m^2-yr and CV of 0.04[2].

Morphometry

The Carlyle Lake BATHTUB model was segmented based on the earthen barrier which bisects the lake for the Burlington and Northern Railroad (RR) Crossing. North of the RR crossing is model "segment 1", which flows south into the deeper pool of lake, or model "segment 2". The two segments of Carlyle Lake are connected by 4 flow-through areas, the largest connection of which is the most northwestern location near Keyesport (Figure 1). Each lake segment is characterized in the model with specific morphometry

[1] https://www.nws.noaa.gov/oh/hdsc/Technical_reports/TR34.pdf
[2] http://nadp.slh.wisc.edu/data/sites/siteDetails.aspx?net=AIRMoN&id=IL11

including surface area, length, mean depth, and mixed layer depth. The full size of Carlyle Lake (sum of both segments) at normal pool is 24,710 acres (USACE, 2018)[3].

Based on GIS analyses, segment 1 of Carlyle Lake north of the RR crossing has a surface area of 7,332 acres (29.7 km^2), and a length of 4 miles (7 km). Segment 2 of the lake has a surface area of 17,378 acres (70.3 km^2), and a length of 8 miles (13 km). Average depth conditions generally reported for the lake are based on measurements observed downstream of the RR crossing. The average depth reported in the Carlyle Lake Fishing Guide[4] is 11 ft (3.4 m) which was used in the model for the average depth for segment 2. Segment 1 is described as shallow, and a cross-section from a sedimentation report[5] in that area appears to show an average depth of about 5 ft (1.5 m). Inputs related to the mixed layer depth were set to model-suggested values based on input morphology.

Observed Water Quality

Water quality data are available from both Illinois EPA (ILEPA) and USACE at a series of in-lake sampling locations that fall largely near the water's edge at key points of interest such as marinas. All of these sampling locations are located in segment 2 of Carlyle Lake. There are also water quality sampling sites located along tributaries to Carlyle Lake which can be used to parameterize inflows to the lake (see section Watershed Loading).

The in-lake surface water quality data observations from 2008 – 2018 are summarized in Table 1, all sampling and averages apply to segment 2. The average surface in-lake concentrations of TP and PO_4 used for calibration were long-term averages of all in-lake samples: 0.33 mg/L and 0.15 mg/L respectively, with CV values of 0.05 and 0.06 respectively. The average surface in-lake concentration for Chl-*a* and associated CV is 46.81 µg/L and 0.07 respectively. The average in-lake transparency using Secchi depth and associated CV is 11.5 inches and 0.07 respectively. Model inputs for non-algal turbidity and CV were set to 0.08 and 0.2 for segment 1 and 2.16 and 0.11 for segment 2 as suggested by BATHTUB based on Chl-*a* and Secchi depth data.

Nutrient Limitation

An investigation was conducted to determine the likelihood that Carlyle Lake is nutrient-limited relative to phosphorus or nitrogen. There is limited paired data of nitrogen and phosphorus species, however a number of statistical regression analyses were completed to assess relationships between N, P, and Chl-*a*. Based on N:P ratios, there is reason to suspect that the lake is P-limited at the start of the growing season, becoming increasingly N-limited as the growing season progresses. However, N concentrations do not ever appear to inhibit Chl-*a* growth during this period, therefore N-limitation is not observed. For this reason, nitrogen is not simulated in the model.

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[3] USACE. 2018. 2018 Carlyle Lake WQ Report. St. Louis District Environmental Quality Section – WQ.

[4] Cruse, Larry B. 1998. Carlyle Lake Fishing Guide. Illinois Department of Natural Resources, Division of Fisheries. Revisions by Harry L. Wight, Reservoirs Program Manager.

[5] Resource Technology, Inc. 2000. Report of Sedimentation, 1999 Resurvey, Carlyle Reservoir, Upper Mississippi River Basin, Kaskaskia River, Illinois. Submitted to USACE. RTI Project Number 00-130.

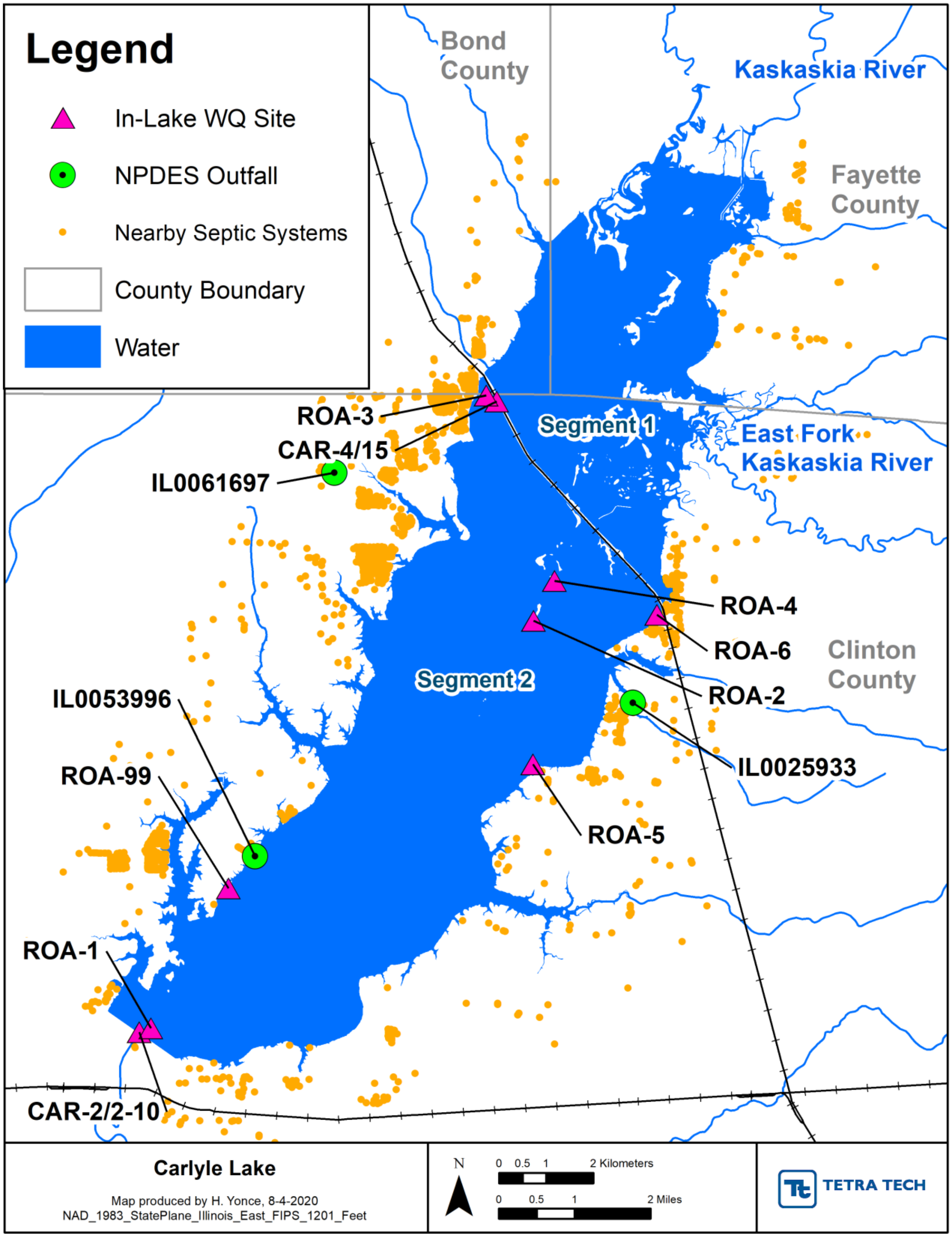

Figure 1. Carlyle Lake and key features (in-lake water quality sampling sites, NPDES discharge locations, nearby septic systems).

Table 1. Summary of surface sampling in-lake ILEPA and USACE water quality data for Carlyle Lake, 2008-2018.

Agency	Site	Description	Secchi (in)		TP (mg/L)		PO_4 (mg/L)		Chl-*a* (μg/L)	
			Count (Years)	Mean	Count (Years)	Mean	Count (Years)	Mean	Count (Years)	Mean
USACE	CAR-2, CAR-2-10	Carlyle Lake upstream of Carlyle Dam, south end of lake	7 (2013, 2018)	17.7	62 (2008-2018)	0.31	62 (2008-2018)	0.17	33 (2008-2018)	40.62
USACE	CAR-4, CAR-15	Carlyle Lake between segments 1 and 2 near Keyesport	7 (2013, 2018)	10.0	64 (2008-2018)	0.39	64 (2008-2018)	0.12	64 (2008-2018)	44.67
ILEPA	ROA-1	Carlyle Lake upstream of Carlyle Dam, south end of lake	4 (2016)	13.0	8 (2011, 2016)	0.24	8 (2011, 2016)	0.16	8 (2011, 2016)	36.10
ILEPA	ROA-2	Carlyle Lake 0.5 miles offshore from Boulder, center of lake	4 (2016)	10.0	8 (2011, 2016)	0.24	8 (2011, 2016)	0.14	8 (2011, 2016)	54.98
ILEPA	ROA-3	Carlyle Lake between segments 1 and 2 near Keyesport, western side of lake	4 (2016)	7.5	8 (2011, 2016)	0.29	8 (2011, 2016)	0.14	8 (2011, 2016)	61.76
ILEPA	ROA-4	Carlyle Lake 2200 ft offshore from Boulder, center of lake	4 (2016)	10.0	4 (2016)	0.33	4 (2016)	0.21	8 (2011, 2016)	57.28
ILEPA	ROA-5	Carlyle Lake north of Coles Creek inflow, eastern side of lake	4 (2016)	10.8	4 (2016)	0.33	4 (2016)	0.22	8 (2011, 2016)	58.79
ILEPA	ROA-6	Carlyle Lake near Boulder, eastern side of lake	4 (2016)	9.3	4 (2016)	0.32	4 (2016)	0.21	8 (2011, 2016)	54.90
ILEPA	ROA-99	Carlyle Lake near southern end of Eldon Hazlet State Park	0	N/A	2 (2011)	0.13	2 (2011)	0.05	2 (2011)	46.00

Pollutant Sources

BATHTUB model inputs for pollutant sources include all sources to the lake such as internal loading, point sources, septic sources, and tributaries or watershed loading. Model inputs for these sources are summarized below.

Internal Loading

The lake is described as a shallow reservoir susceptible to high winds which generally prevent stratification and promote a well-mixed water column (USACE, 2018). The 2012 Carlyle Lake Annual Report indicates that the waterbody is a sink for phosphorus which arrives there, so there is assumed to be no internal loading of phosphorus from the lakebed itself. Additionally, an analysis of paired phosphorus data at surface and depth for ILEPA sampling sites was conducted, and no significant difference was observed.

Point Sources

There are three NPDES permitted point sources which discharge directly to segment 2 of Carlyle Lake. Available discharge data are summarized for 2019 below, as downloaded from the EPA ICIS website. TMDL scenario assumptions for TP concentrations are also provided.

- NPDES ID IL0025933 (Carlyle Boulder STP)
    - Design average flow 0.025 MGD, no design maximum flow
    - Average flow reported monthly for 2019: 0.0157 MGD
    - Average TP concentration reported monthly for 2019: 3.24 mg/L
    - TMDL scenario TP concentration: 1 mg/L
- NPDES ID IL0061697 (Hickory Shores Resort)
    - Design average flow 0.01 MGD, design maximum flow 0.02 MGD
    - Average flow reported monthly for 2019: 0.0158 MGD
    - Average TP concentration reported monthly for 2019: 0.89 mg/L
    - TMDL scenario TP concentration: 4 mg/L
- NPDES ID IL0053996 (Eldon Hazlet State Park Campground STP)
    - Design average flow 0.045 MGD, design maximum flow 0.11 MGD
    - Average flow reported monthly for 2019: 0.0057 MGD
    - TP not monitored, assumed concentration 4 mg/L without dedicated TP removal
    - TMDL scenario TP concentration: 4 mg/L

Septic Sources

Lake loading of phosphorus from septic systems was calculated using a series of assumptions and observations associated with Carlyle Lake. There are 1,402 houses within the 1 mile of the lake which are not within known sewered areas and assumed to be treated by onsite systems:

- Average home population of 2.63 people[6]
- Average water flow of 60 gallons/capita/day[7]

[6] https://www.census.gov/quickfacts/fact/table/US/HCN010212

[7] Lowe et al. 2009. Influent Constituent Characteristics of the Modern Waste Stream from Single Sources. Water Environment Research Foundation (WERF).

- Average septic tank effluent TP concentration of 12.5 mg/L[8]
- Based on average flow and TP concentration, average P produced per capita is 2.28 lbs/cap-yr
- Assumed system failure rate of 20%[9]
- Assumed 10% of conforming system effluent reaches the lake, while 30% of non-conforming system effluent reaches the lake[10]

Based on these assumptions, the total P load that arrives to Carlyle Lake is approximated as a function of P load produced per capita, the shoreline population, and the assumptions related to system failure rate and the percentage of P loading which arrives to the lake based on system status. The total P load that arrives at Carlyle Lake is 1,179 lbs/yr, where 57% of that load is due to conforming systems, and 43% is due to nonconforming systems. In total, this P load represents a total effluent flow of 248.5 acre-feet/yr (0.3 hm^3/yr) with an associated average TP concentration of 1,750 ppb.

Tributary and Watershed Sources

Watershed-based and tributary flow and phosphorus loading to Carlyle Lake were aggregated to each segment based on drainage area weighting of USGS gages on the Kaskaskia River at Vandalia, IL (gage 05592500) and East Fork Kaskaskia River near Sandoval, IL (gage 05592900). Aggregated flow to each segment from both overland flow and tributaries were approximated using these gages. TP and PO_4 inputs to each segment were determined from monitoring data collected by ILEPA at the USGS gages (sites O-08 at gage 05592500 for segment 1 and site OK-01 at gage 05592900 as a proxy for segment 2). Daily average flow into segment 1 is 2,439 cfs (2,178 hm^3/yr) with TP and PO_4 concentrations of 0.33 mg/L and 0.09 mg/L respectively. Daily average flow into segment 2 is 88 cfs (79 hm^3/yr) with flow-weighted mean TP and PO_4 concentrations of 0.43 and 0.20 mg/L. The total watershed area to segment 1 is 6,804 km^2, and the total watershed area to segment 2 is 205 km^2.

BATHTUB Confirmatory Analysis

The BATHTUB model for Carlyle Lake was confirmed (calibrated) by comparing model output to observed in-lake data in segment 2. As a result of calibration, the sedimentation rate for TP was modified from an initial value of 1 to 0.14. The calibrated BATHTUB model had in-lake concentrations of TP and Chl-*a* of 332 ppb and 42 ppb respectively, while the observed values were 332 ppb and 41 ppb respectively.

TMDL Analysis

For the TMDL analysis, the in-lake annual average TP simulated needed to improve from 332 ppb to 50 ppb (0.05 mg/L) by reducing external loads. Watershed loading must be decreased from 330 ppb (to segment 1) and 430 ppb (to segment 2) to at least 50 ppb respectively to meet the same water quality criteria of 50 ppb (0.05 mg/L). A 5% allocated margin of safety (MOS) requires additional external watershed reductions. NPDES point sources are set to their permit limit for TP (or 4 mg/L when there is no permit limit.

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[8] Average of reported range 5-20 mg/L TP associated with Small and Decentralized Wastewater Management Systems (Crites and Tchobanoglous 1998) and USEPA 2002 Onsite Wastewater Treatment Systems Manual

[9] Approximate average of mean failure rates reported for 28 states in the USEPA 2002 Onsite Wastewater Treatment Systems Manual

[10] Barr Engineering Company, 2004. Detailed Assessment of Phosphorus Sources to Minnesota Watersheds. Prepared for Minnesota Pollution Control Agency.

For the TMDL scenario, the total TP load to the lake must be reduced from 1,664,836 to 249,386 lbs/yr which is an overall reduction of 85% to meet the in-lake phosphorus target of 0.05 mg/L (Table 2). Assuming a 5% MOS, the load allocation (LA) was calculated as the loading capacity of the lake minus the MOS and minus the wasteload allocation (WLA). The combined loading from the point sources, septic systems, and atmospheric deposition under existing conditions account for less than 1% of the phosphorus loading to the lake, therefore watershed load reductions are prioritized in the TMDL scenario. The watershed phosphorus load must be reduced by 86% in order to meet the WQS of the tributaries and Carlyle Lake based on the calculations presented in Table 2.

Table 2. Carlyle Lake BATHTUB Model Outputs and TMDL Summary

TMDL Parameter	Existing TP Load (lb/yr)	TMDL TP Load (lb/yr)	TMDL TP Load (lb/day)	Reduction
Nonpoint Sources, Load Allocation	1,664,565	236,187	647	--
Watershed	*1,659,418*	*231,040*	633	86%
Atmospheric Deposition	*3,968*	*3,968*	11	No reduction
Septic Systems	*1,179*	*1,179*	3	No reduction
Point Sources, Wasteload Allocation	271	730	2	No reduction
Margin of Safety (5% of Loading Capacity)	--	12,469	34	--
Existing Load, Loading Capacity	**1,664,836**	**249,386**	**683**	**85%**

Appendix E – Stage 3 Comments and Responses

<to be included once developed>