Mackinaw River Watershed Total Maximum Daily Load

DRAFT Stage 1 Report

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Acronyms and Abbreviations

AFOs	animal feeding operations
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
STP	sewage treatment plant
TMDL	total maximum daily load
TSS	total suspended solids
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WQS	water quality standards
WWTP	wastewater treatment plant

1. Introduction

The Clean Water Act and U.S. Environmental Protection Agency (U.S. EPA) regulations require that Total Maximum Daily Loads (TMDLs) be developed for waters that do not support their designated uses. In simple terms, a TMDL is a plan to attain and maintain water quality standards in waters that are not currently meeting them. This TMDL study addresses the approximately 1,149 square miles Mackinaw River watershed located in central Illinois. Several waters within the Mackinaw River watershed area have been placed on the State of Illinois 303(d) list and require the development of a TMDL.

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

Several waters in the Mackinaw River watershed have been placed on the State of Illinois §303(d) list (Table 1 and Figure 1) and require development of TMDLs. A previously completed TMDL for nitrate was developed for Lake Bloomington, which drains to impaired segment DK-17 which is also impaired for nitrate.

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

Name	Segment ID	Segment Length (Miles)	Watershed Area (Sq. Miles)	Designated Uses	Cause of Impairment
Mackinaw River	IL_DK-13	11.47	774	Primary Contact Recreation	**Fecal Coliform**
	IL_DK-17	18.7	490	Public and Food Processing Water Supply	**Nitrogen, Nitrate**
Hickory Grove Ditch	IL_DKB-01	4.42	33	Aquatic Life	**Dissolved Oxygen,** *Manganese,* Sedimentation/Siltation [a]
Prairie Creek	IL_DKF-11	14.96	23	Aquatic Life	Chloride [b], Dissolved Oxygen [b]
East Branch Panther Creek	IL_DKKC-02	13.31	38	Aquatic Life	Dissolved Oxygen [b]
Sixmile Creek	IL_DKN-01	10.15	21	Aquatic Life	**Dissolved Oxygen**, Sedimentation/Siltation [a]
Henline Creek	IL_DKV-01	4.91	41	Aquatic Life	Dissolved Oxygen [b]
Indian Creek	IL_DKD-01	6.38	--	Aquatic Life	Phosphorus (Total) [a], Total Suspended Solids (TSS) [a]
Dillon Creek	IL_DKC-01	18	--	Aquatic Life	Cause Unknown [a]
Lake Bloomington	IL_RDO	635 ac (surface area)	--	Public and Food Processing Water Supply	Total Dissolved Solids [a]

Italics – Based on evaluation of the last ten years of available data (2007–2016), it was determined that this segment is not impaired (see Appendix A – Unimpaired Stream Data Analysis). A TMDL is not provided for this cause of impairment.
a. These causes of impairment are not being addressed as part of this project.
b. Impairment was removed from the 2018 draft 303(d) list and is not addressed further in this report.
BOLD – TMDLs are addressed in this Stage 1 report.

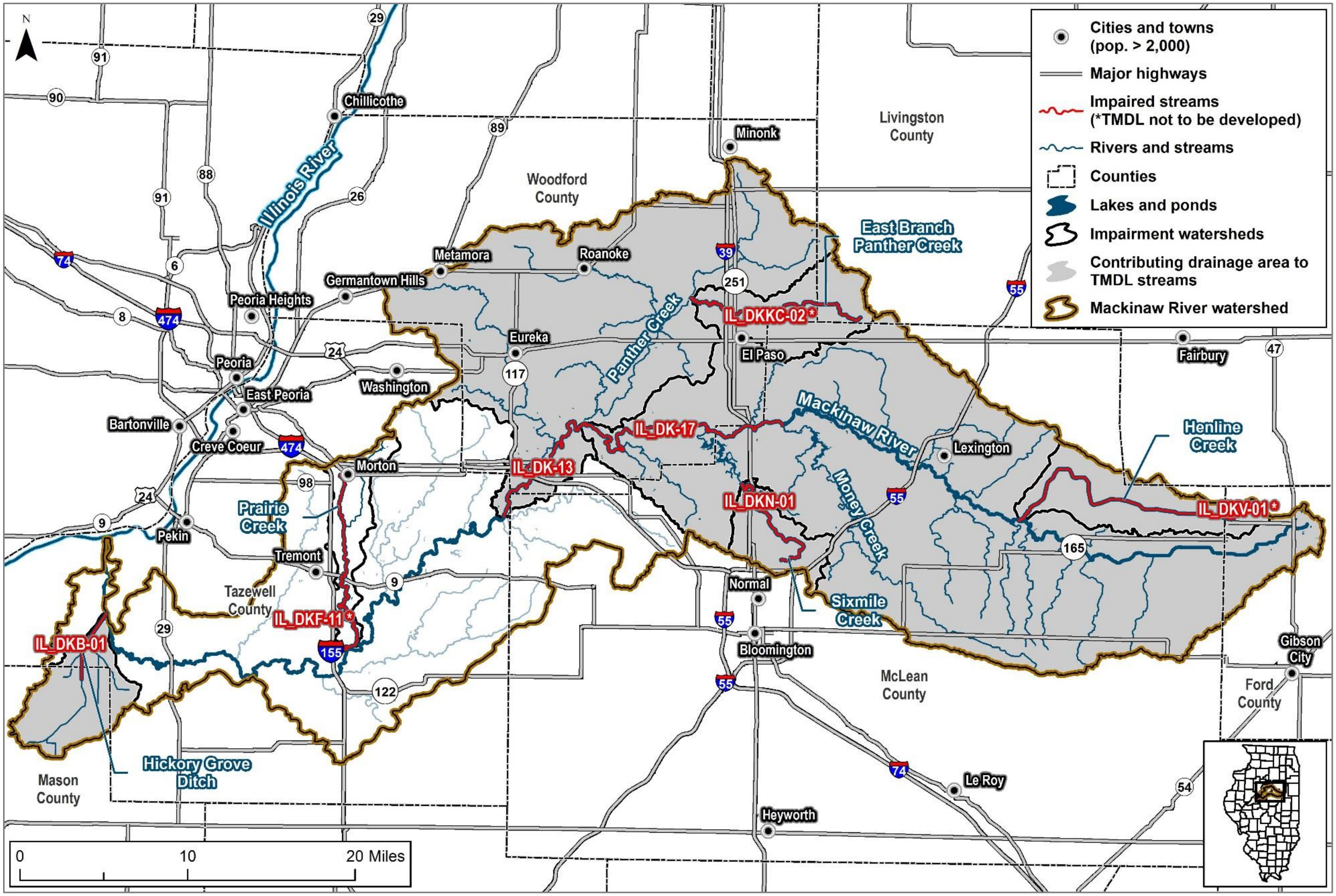

Figure 1. Mackinaw River watershed, TMDL project area.

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 water bodies in the Mackinaw 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.

Public and food processing water supply standards – These standards are cumulative with the general use standards and apply to waters of the state at any point at which water is withdrawn for treatment and distribution as a potable supply to the public or for food processing.

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(s) 302 and 611 contain water quality standards promulgated by the IPCB for general use and public and food processing water supply, respectively. This section presents the standards applicable to impairments in the study area. Water quality standards and TMDL endpoints to be used for TMDL development are listed in Table 2.

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

Parameter	Units	Water Quality Standard
General Use		
Fecal Coliform [a]	#/100 ml	400 in <10% of samples [b]
		Geometric mean < 200 [c]
Dissolved Oxygen [d]	mg/L	For most waters: 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 For enhanced protection waters (): March-July > 5.0 min. and > 6.25- 7-day mean Aug-Feb > 4.0 min, > 4.5- 7-day mean and > 6.0- 30-day mean
Public and Food Processing Water Supply		
Nitrogen, Nitrate	mg/L	10 - maximum contaminant level (MCL)

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.
d. 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. Enhanced dissolved oxygen criteria are found in 35 Ill Adm. Code 302.206, including the list of waters with enhanced dissolved oxygen protection and methods for assessing attainment of dissolved oxygen minimum and mean values

General Use Standards

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). 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 are 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 water body 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.

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; Illinois EPA 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 (USEPA

2002 and www.epa.gov/waterscience/criteria/wqcriteria.html). In a minority of streams for which biological information is unavailable, aquatic life use assessments are based primarily on physicochemical water data.

When a stream segment is determined to be Not Supporting aquatic life use, generally one exceedance of an applicable Illinois 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 Illinois Pollution Control Board's Environmental Register at http://www.ipcb.state.il.us/ecll/environmentalregister.asp).

Public and Food Processing Water Supply Use Standards

Attainment of public and food processing water supply use is assessed only in waters in which the use is currently occurring, as evidenced by the presence of an active public-water supply intake. The assessment of public and food processing water supply use is based on conditions in both untreated and treated water. By incorporating data through programs related to both the federal Clean Water Act and the federal Safe Drinking Water Act, Illinois EPA believes that these guidelines provide a comprehensive assessment of public and food processing water supply use. Assessments of public and food processing water supply use recognize that characteristics and concentrations of substances in Illinois surface waters can vary and that a single assessment guideline may not protect sufficiently in all situations. Using multiple assessment guidelines helps improve the reliability of these assessments. When applying these assessment guidelines, Illinois EPA also considers the water-quality substance, the level of treatment available for that substance, and the monitoring frequency of that substance in the untreated water. Table 5 includes the assessment guidelines for waters with public and food processing water supply designated uses.

Table 5. Guidelines for assessing public water supply in waters of the State (IEPA 2016)

Degree of Use Support	Guidelines
Fully Supporting (Good)	For each substance in untreated water[a], for the most-recent three years of readily available data or equivalent dataset, a) < 10% of observations exceed an applicable Public and Food Processing Water Supply Standard[b]; and b) for which the concentration is not readily reducible by conventional treatment, i) no observation exceeds by at least fourfold the treated-water Maximum Contaminant Level threshold concentration[c] for that substance; and ii) no quarterly average concentration exceeds the treated-water Maximum Contaminant Level threshold concentration[c] for that substance; and iii) no running annual average concentration exceeds the treated-water Maximum Contaminant Level threshold concentration[d] for that substance; and[d] For each substance in treated water, no violation of an applicable Maximum Contaminant Level[c] occurs during the most recent three years of readily available data.
Not Supporting (Fair)	For any single substance in untreated water[a], for the most-recent three years of readily available data or equivalent dataset, a) > 10% of observations exceed a Public and Food Processing Water Supply Standard[b]; or b) for which the concentration is not readily reducible by conventional treatment, i) at least one observation exceeds by at least fourfold the treated-water Maximum Contaminant Level threshold concentration[c] for that substance; or ii) the quarterly average concentration exceeds the treated-water Maximum Contaminant Level threshold concentration[c] for that substance; or iii) the running annual average concentration exceeds the treated-water Maximum Contaminant Level threshold concentration[c] for that substance.

Degree of Use Support	Guidelines
	or, For any single substance in treated water, at least one violation of an applicable Maximum Contaminant Level[3] occurs during the most recent three years of readily available data.
Not Supporting (Poor)	Closure to use as a drinking-water resource (cannot be treated to allow for use).

a. Includes only the untreated-water results that were available in the primary computer database at the time data were compiled for these assessments
b. 35 I11. Adm. Code 302.304, 302.306 (http://www.ipcb.state.il.us/SLR/IPCBandIEPAEnvironmentalRegulations-Title35.aspx)
c. 35 I11. Adm. Code 611.300, 611.301, 611.310, 611.311, 611.325.
d. Some waters were assessed as Fully Supporting based on treated-water data only.

One of the assessment guidelines for untreated water relies on a frequency-of-exceedance threshold (10 percent) because this threshold represents the true risk of impairment better than does a single exceedance of a water quality criterion. Assessment guidelines also recognize situations in which water treatment that consists only of "*...coagulation, sedimentation, filtration, storage and chlorination, or other equivalent treatment processes*" (35 Ill. Adm. Code 302.303; hereafter called "conventional treatment") may be insufficient for reducing potentially harmful levels of some substances. To determine if a Maximum Contaminant Level (MCL) violation in treated water would likely occur if treatment additional to conventional treatment were not applied (see 35 Ill. Adm. Code 302.305), the concentration of the potentially harmful substance in untreated water is examined and compared to the MCL threshold concentration. If the concentration in untreated water exceeds an MCL-related threshold concentration, then an MCL violation could reasonably be expected in the absence of additional treatment.

Compliance with an MCL for treated water is based on a running 4-quarter (i.e., annual) average, calculated quarterly, of samples collected at least once per quarter (Jan.-Mar., Apr.-Jun., Jul.-Sep., and Oct.-Dec.). However, for some untreated-water intake locations sampling occurs less frequently than once per quarter; therefore, statistics comparable to quarterly averages or running 4-quarter averages cannot be determined for untreated water. Rather, for substances not known to vary regularly in concentration in Illinois surface waters (untreated) throughout the year, a simple arithmetic average concentration of all available results is used to compare to the MCL threshold. For substances known to vary regularly in concentration in surface waters during a typical year (e.g., nitrate), average concentrations in the relevant sub-annual (e.g., quarterly) periods are used.

2. Watershed Characterization

The Mackinaw River watershed is located in central Illinois (Figure 1). The headwaters for the watershed begin north of Gibson City, IL. The Mackinaw River then flows just north of Bloomington, IL before joining the Illinois River south of Peoria, IL. The watershed covers 1,149 square miles; major tributaries of the river include Henline Creek, Money Creek, Sixmile Creek, Panther Creek, Mud Creek, Prairie Creek, Little Mackinaw River and Dillon Creek.

2.1 Jurisdictions and Population

Counties with land located in the watershed area include Ford, Livingston, Mason, McLean, Tazewell, and Woodford. Portions of the cities of Bloomington and Normal, IL are located along the south-central boundary of the watershed and Morton Village in the outskirts of Peoria, IL is located almost entirely in the watershed at the headwaters of Prairie Creek. Bloomington, Normal and Peoria are major government units with jurisdiction in the Mackinaw River watershed area. Populations are area weighted to the watershed in Table 6. The McLean County and Tazewell County population numbers were adjusted to only account for the portion of the cities of Bloomington and Normal and Peoria in the watershed, respectively.

Table 6. Area weighted county populations in watershed

County	2000	2010	Percent Change
Ford	299	296	-1%
Livingston	479	471	-2%
Mason	326	298	-9%
McLean	20,702	21,445	4%
Tazewell	13,186	13,518	3%
Woodford	9,774	10,654	9%
TOTAL	***44,766***	***46,682***	***4%***

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 USC00116200 is located in Normal, IL along the south-central boundary of the watershed. Daily data from 1977–2016 for temperature, precipitation and snowfall are summarized in Table 7. In general, the climate of the region is continental with hot, humid summers and cold winters. The average high winter temperature was 36 °F and the average high summer temperature was 85°F. The annual average precipitation at Normal was approximately 38 inches, including approximately 22 inches of snowfall. In general, larger volumes of precipitation tend to occur between the months of April and September.

Table 7. Climate summary for Normal (1977–2016)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average High ºF	33	37	50	63	74	84	86	85	79	66	51	37
Average Low ºF	16	19	29	40	51	61	65	62	54	43	32	21
Mean Temperature ºF	24	27	38	49	61	70	73	71	63	52	40	28
Average Precipitation (in)	2.0	1.9	2.6	3.8	4.4	4.0	4.1	3.9	3.2	3.1	3.0	2.4
Average Snowfall (in)	6.9	6.6	2.2	0.6	0.0	0.0	0.0	0.0	0.0	0	0.6	4.9

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 cities of Normal and Morton and several small towns in the watershed. Land use in the watershed includes cultivated crops and pasture/hay (approximately 85 percent), forest (approximately 6 percent), and urban (approximately 8 percent). Corn and soybeans are the most common crops, with much smaller areas of winter wheat, alfalfa and other crops. Table 8 presents area and percent by land cover type as provided in the 2011 National Land Cover Database (MLRC 2015).

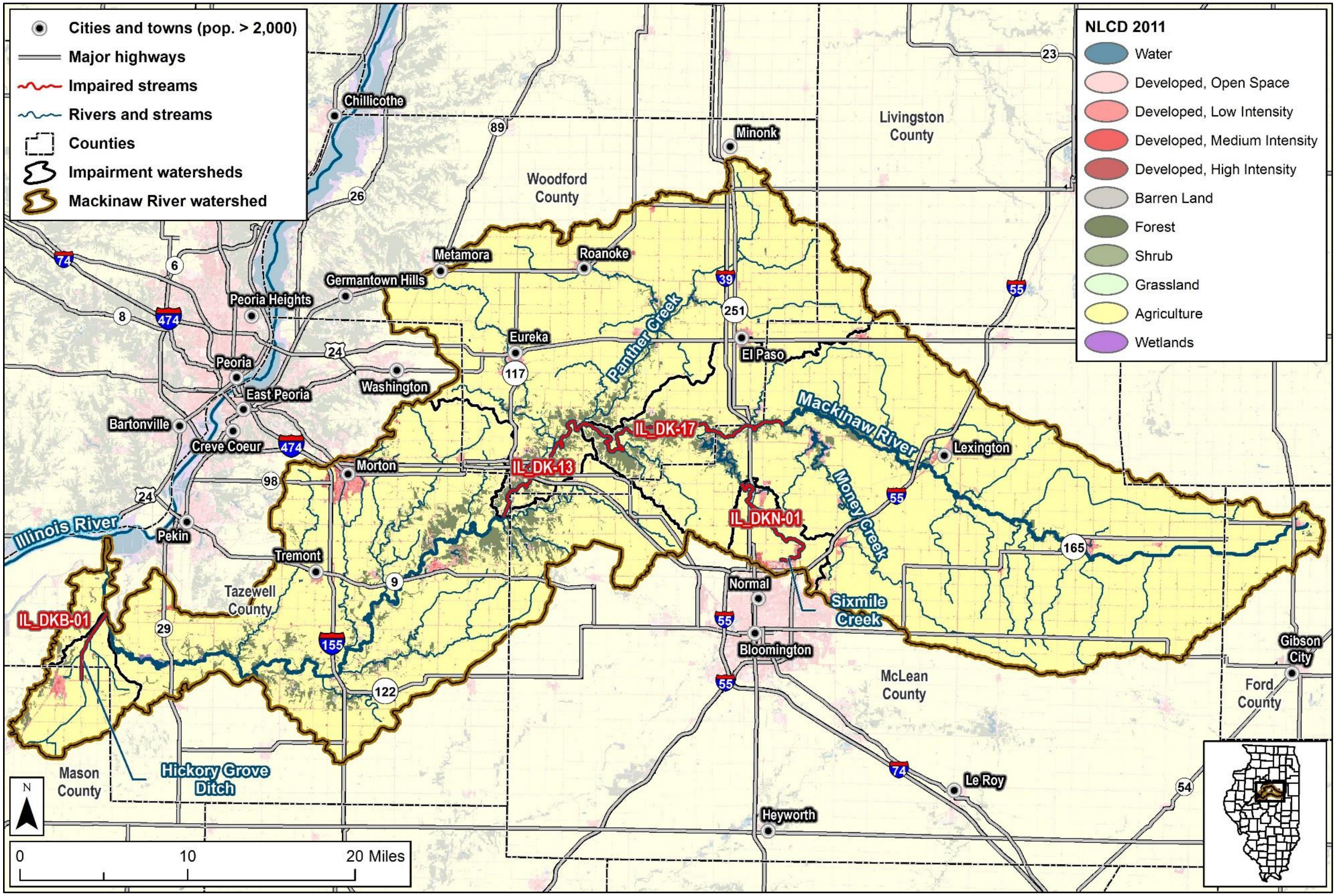

Figure 2. Mackinaw River watershed land cover (2011 National Land Cover Database).

Table 8. Watershed land use summary

Land Use / Land Cover Category	Acres	Percentage
Cultivated Crops	594,603	80.9%
Deciduous Forest	42,519	5.8%
Hay/Pasture	30,178	4.1%
Developed, Low Intensity	27,302	3.7%
Developed, Open Space	26,830	3.6%
Developed, Medium Intensity	5,917	0.8%
Open Water	3,054	0.4%
Woody Wetlands	1,869	0.3%
Herbaceous	1,480	0.2%
Developed, High Intensity	1,382	0.2%
Barren Land	189	<0.1%
Emergent Herbaceous Wetlands	52	<0.1%
Evergreen Forest	23	<0.1%
Shrub/Scrub	19	<0.1%

Source: 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 Mackinaw River watershed varies in elevation from 436 to 956 feet (Figure 3). The Mackinaw River water elevation varies from 815 feet to 645 feet and is 63 miles long upstream of the inlet of Panther Creek and water elevation varies from 645 feet to 440 feet and is 66 miles long from Panther Creek to the inlet to the Illinois River, resulting in an upper watershed stream gradient of 2.6 feet per mile and lower watershed stream gradient of 3.2 feet per mile. The watershed topography is a combination of high ridges, low elevation stream valleys and abandoned river terraces resulting from the last continental glaciation (Weibel and Nelson 2009).

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 9 describes those HSGs found in the Mackinaw River watershed. Figure 4 and Table 10 summarizes the composition of HSGs in the watershed. Soils are predominantly B, B/D, C and C/D in the watershed and transition to more A and B type soils towards the outlet to the Illinois River. The high proportion of B/D type soils coupled with agricultural land uses indicate the likelihood of tile drainage.

Table 9. 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 10. Percent composition of hydrologic soil groups in watershed

Hydrologic Soil Group (HSG)	Acres	Percentage
A	18,260	2.5%
A/D	1,123	0.2%
B	175,164	23.8%
B/D	210,222	28.5%
C	146,951	20.0%
C/D	177,022	24.1%
D	173	<0.1%
No Data	6,502	0.9%

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 Mackinaw River watershed range from 0.02 to 0.50, with an average value of 0.37 (Figure 5). The higher the K-factor, the more susceptible the soil is to erosion.

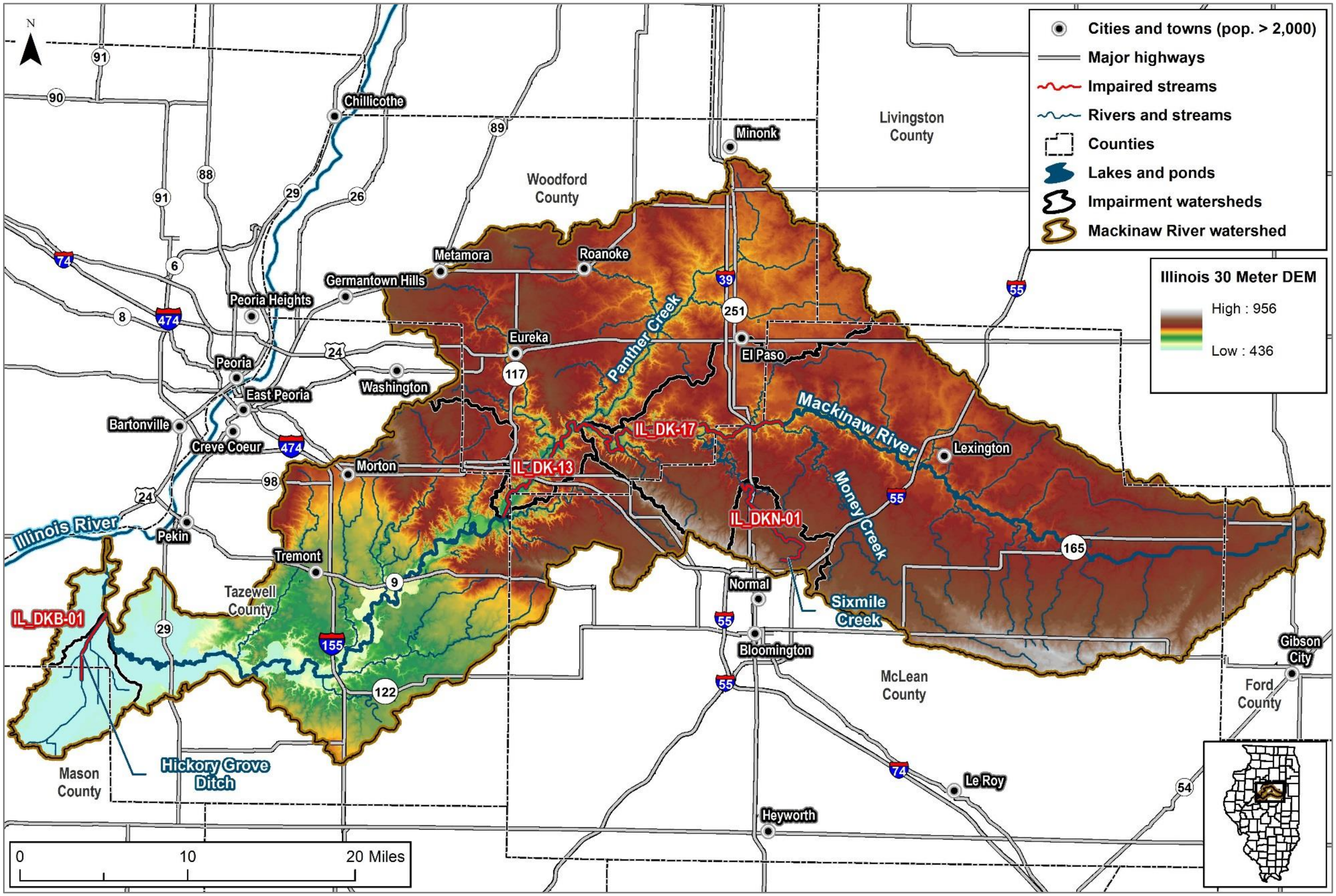

Figure 3. Mackinaw River watershed land elevations (ISGS 2003).

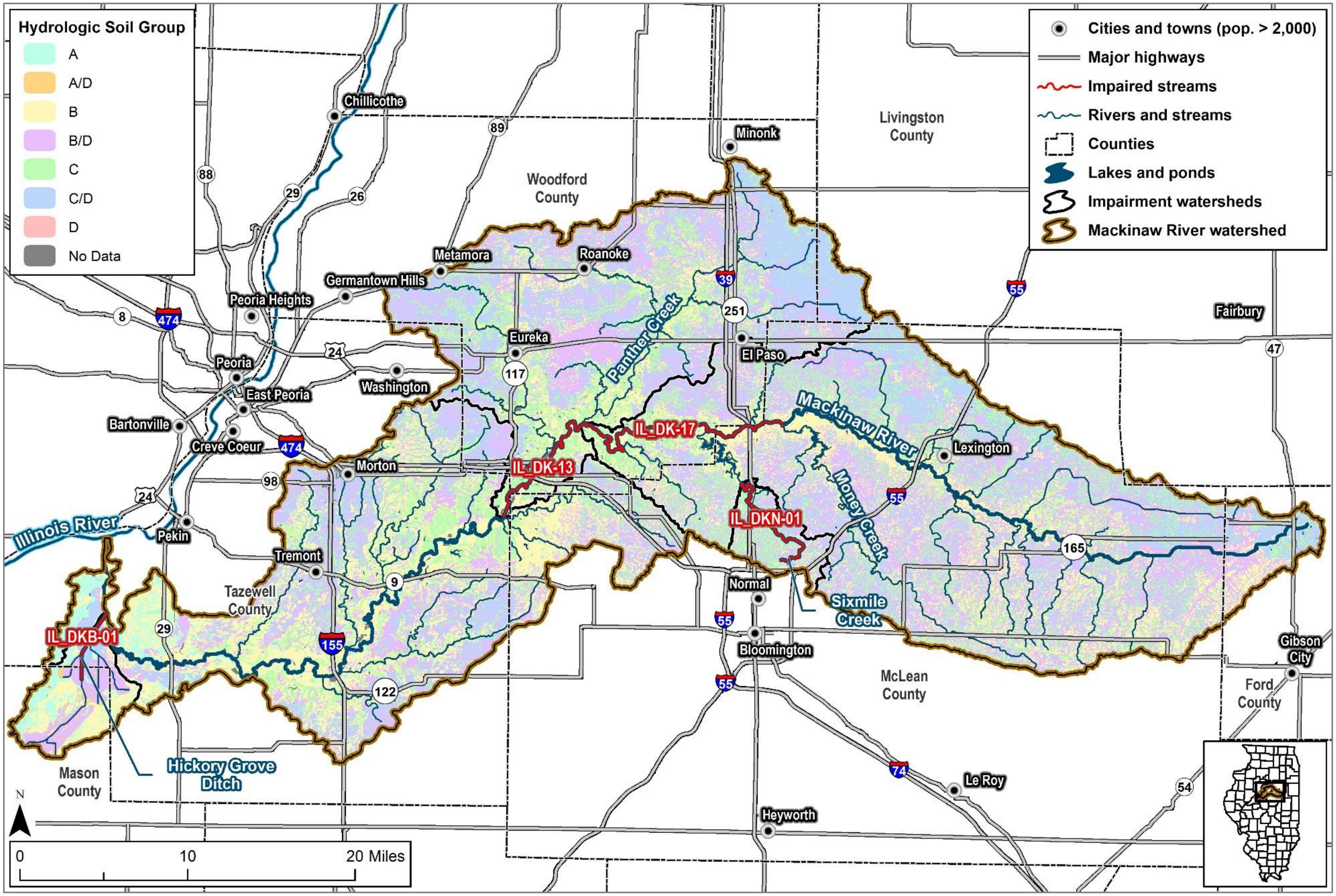

Figure 4. Mackinaw River watershed hydrologic soil groups (Soil Surveys for Ford, Livingston, Mason, McLean, Tazewell and Woodford Counties, Illinois; NRCS SSURGO Database 2011).

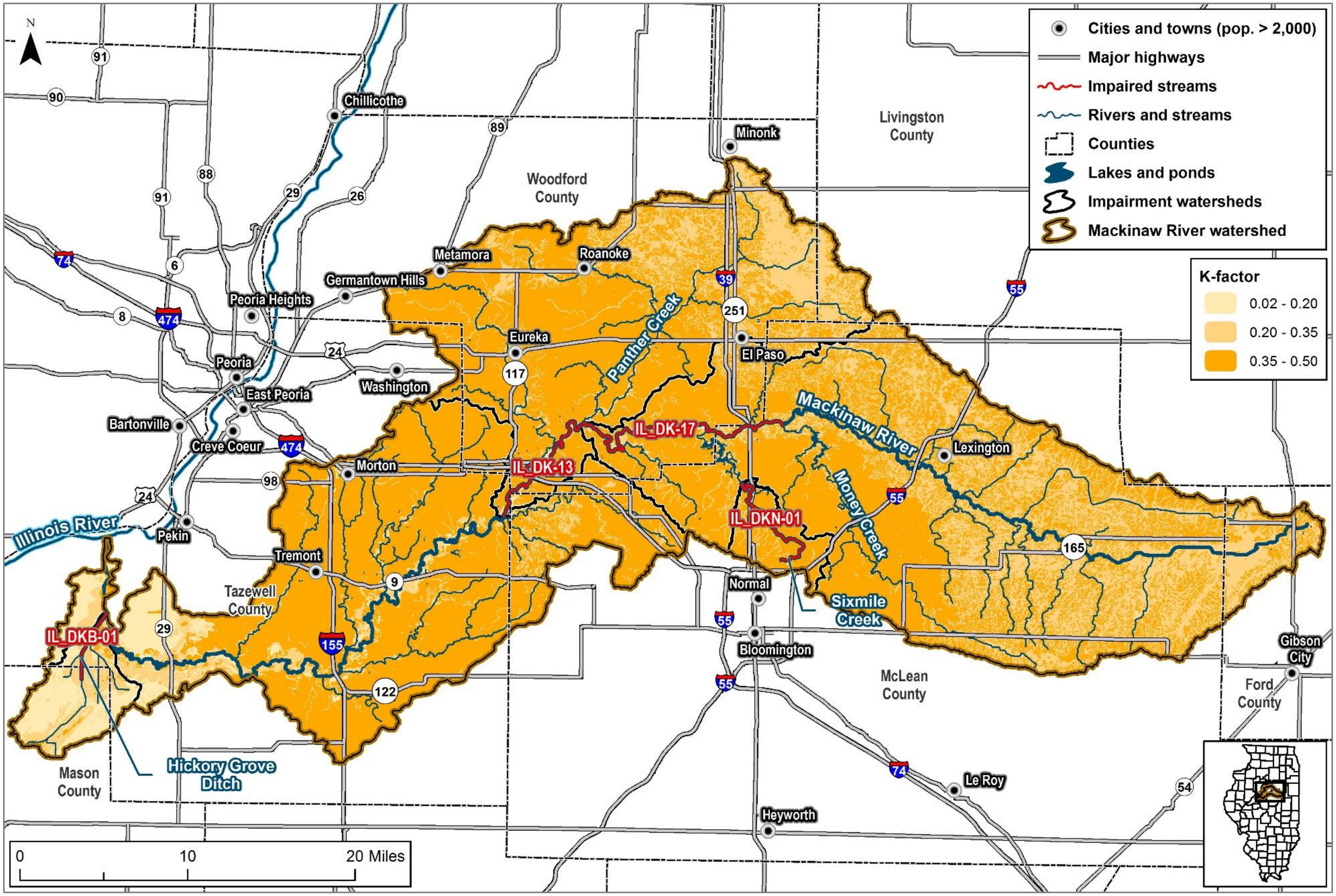

Figure 5. Mackinaw River watershed soil K-factor values (Soil Surveys for Ford, Livingston, Mason, McLean, Tazewell and Woodford Counties, Illinois; NRCS SSURGO Database 2011).

2.6 Hydrology

Hydrology plays an important role in evaluating water quality. The hydrology of the Mackinaw River watershed is driven by local climate conditions and the landscape. The U.S. Geological Survey (USGS) has collected flow and water quality data in this watershed since the 1930s (Table 11 and Figure 10). There is one active USGS gage 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 05567500 is presented in Figure 6.

Table 11. USGS stream gages in impairment watersheds

Gage ID	Watershed Area *(mi.^{2})*	Location	Period of Record	Located on Impaired Segment
05564200	87.6	Mackinaw River at Colfax, IL	1980-1981	-
05564300	309	Mackinaw River near Kappa, IL	1997	-
05564400	49	Money Creek near Towanda, IL	1958-1983	-
05564500	53.1	Money Creek above Lake Bloomington, IL	1933-1958 [a]	-
05565000	9.81	Hickory Creek above Lake Bloomington, IL	1938-1958 [a]	-
05565500	69.1	Money Creek at Lake Bloomington, IL	1956-1958 [a]	-
05565700	18.5	Sixmile Creek at Hudson, IL	- [b]	IL_DKN-01
05566000	6.3	East Branch Panther Creek near Gridley, IL	1949-1972 [a]	-
05566500	30.5	East Branch Panther Creek at El Paso, IL	1949-1982	-
05567000	93.9	Panther Creek near El Paso, IL	1949-1998	
05567400	687	Mackinaw River above Congerville, IL	- [b]	IL_DK-13
05567448	- [b]	Walnut Creek at Eureka, IL	1991-1992 [a]	-
05567450	- [b]	Walnut Creek near Mackinaw Dells, IL	- [b]	-
05567500	**767**	**Mackinaw River near Congerville, IL**	**1944-2016**	**IL_DK-13**
05567510	776	Mackinaw River below Congerville, IL	1978-1986	IL_DK-13

BOLD – indicates active USGS gage
a. Flow data only, no water quality data available
b. Information unavailable on USGS National Water Information System (NWIS)

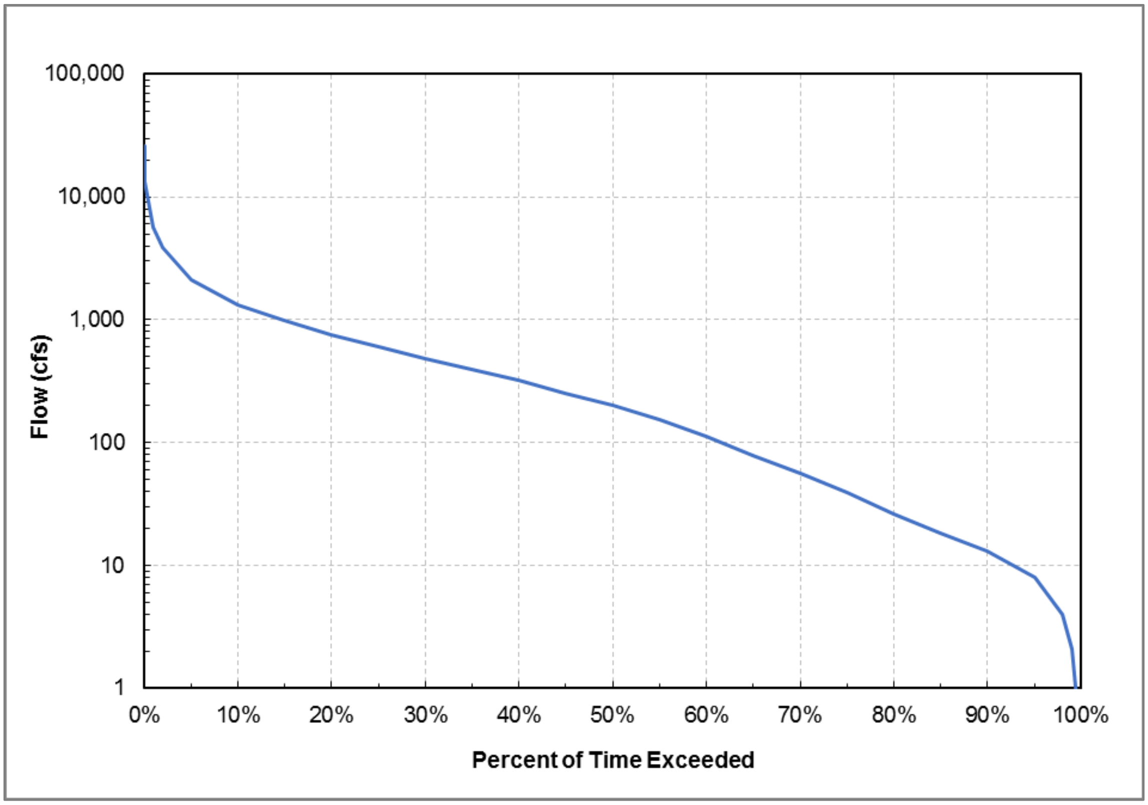

Figure 6. Flow duration curve for USGS gage 05567500, Mackinaw River near Congerville, IL (1944–2016).

An evaluation of annual flow at USGS gage 05567500 from 1944–2016 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 05567500 is plotted with precipitation from the NOAA Global Historical Climatology Network Database Station USC00116200 (Normal) in Figure 7. Flows in the Mackinaw River decrease significantly during the late summer and early fall with decreasing precipitation.

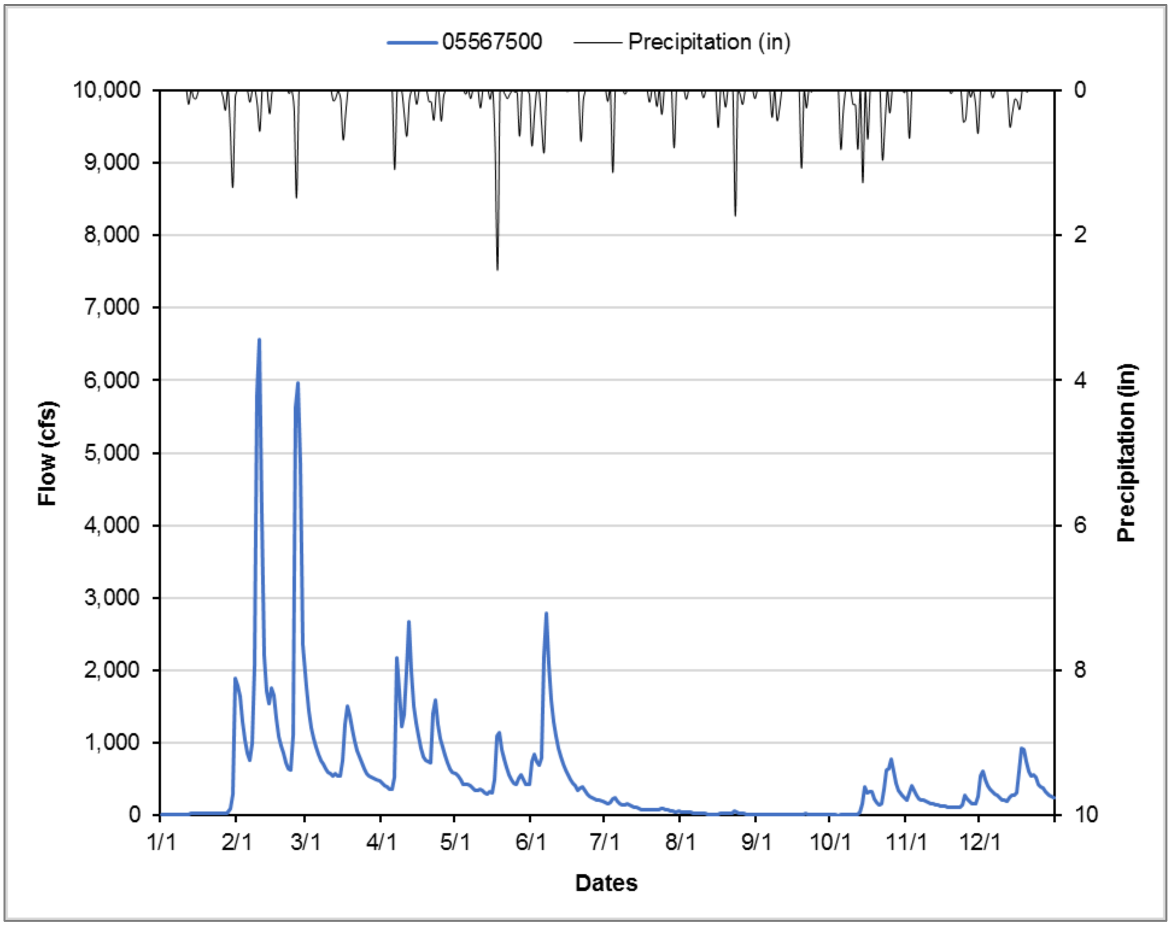

Figure 7. Daily flow in the Mackinaw River with daily precipitation at Normal (USC00116200), 2001.

2.7 Watershed Studies and Other Watershed Information

This section describes some of the studies that have been completed in the watershed.

- **Mackinaw River Watershed Management Plan** (Mackinaw River Project 1998)

  Plan was developed through a collaborative effort with townspeople, farmers, state agencies, and The Nature Conservancy to develop a voluntary watershed plan to address sedimentation and wetland loss. Sources of pollution were identified as agriculture, construction erosion, urban runoff, hydrologic modifications, and resource extraction activities. Strategies, achievable goals, and specific recommendations were made for agriculture, biological diversity, issues in the community, education, and agency coordination. The Mackinaw River Watershed Council, the precursor to the Mackinaw River Ecosystem Partnership, was created along with the development of this plan.

- **Geology of the Mackinaw River Watershed, McLean, Woodford, and Tazewell Counties** (Weibel and Nelson 2009)

  Guidebook was developed for the University of Illinois at Urbana Champaign Institute of Natural Resources Sustainability. Includes overview of the geologic framework, history, regional drainage, natural resources (minerals and groundwater), and natural areas from the Moraine View State Park, to the Mackinaw River near Heritage Lake.

- **Lake Bloomington Watershed TMDL** (Tetra Tech 2008)

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

- **Evergreen Lake Watershed TMDL** (CDM 2006)

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

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 to the Mackinaw River watershed.

3.1 Pollutants of Concern

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

3.2 Point Sources

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

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

Under the CWA, all point sources are regulated under the 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). There are no permitted CAFOs in the watershed.

3.2.1 NPDES Facilities (Non-Stormwater)

NPDES facilities in the study area include municipal and industrial wastewater treatment; bacteria and nutrients can be found in these discharges. In addition, permitted facilities may contribute to low dissolved oxygen impairments. There are also public water supply facilities in the watershed.

There is one individual NPDES permitted facility that discharges directly to an impaired segment (IL0074365 [DKN-01]) and 20 other facilities that discharge in the contributing drainage area of the impaired segments (Table 12 and Figure 10). The Prairie View Homeowners Association STP (IL0074365) discharges into the upper reach of Sixmile Creek (DKN-01), which is impaired due to dissolved oxygen. Manito STP (IL0035904) discharges to IL_DKB-01 approximately two miles upstream of where Manito Ditch tributary outlets to Hickory Grove Ditch, and could be contributing to impairment on IL-DKB-01.

The remaining facilities that discharge to upstream unimpaired tributaries are assumed to not contribute to project impairments. Note that there are additional NPDES permitted facilities in the Mackinaw River watershed, but these do not discharge directly to or are located in the drainage area to an impaired water.

Table 12. 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)
IL0021521	*Metamora South WWTP*	*STP*	*Walnut Creek*	*DK-13*	*0.38*	*0.96*
IL0025119	*City of Eureka STP*	*STP*	*Walnut Creek*	*DK-13*	*0.59*	*1.84*
IL0025666	*East Bay Camp Conference Center STP*	*STP*	*Lake Bloomington*	*DK-17, DK-13*	*0.03*	*0.05*
IL0035904	*Village of Manito STP*	*STP*	*Manito Ditch tributary to Hickory Grove Ditch*	*DKB-01*	*0.2*	*0.5*
IL0036391	*Comlara Park STP*	*STP*	*Evergreen Lake*	*DK-17, DK-13*	*0.022*	*0.055*
IL0040762	*I-74 South Mackinaw Dells Rest Area STP*	*STP*	*Unnamed tributary of Mackinaw River*	*DK-13*	*0.003*	*0.0075*
IL0048054	*Goodfield STP*	*STP*	*Unnamed tributary of Mackinaw River*	*DK-13*	*0.2*	*0.4*
IL0053899	*Forestview Utilities Corporation STP*	*STP*	*Unnamed tributary of Mackinaw River*	*DK-13*	*0.01*	*0.25*
IL0073032	*Westwind Estates STP*	*STP*	*Unnamed tributary of Mackinaw River*	*DK-17, DK-13*	*0.024*	*0.048*
IL0074365	**Prairie View Homeowners Association STP**	**STP**	**Sixmile Creek**	**DKN-01, DK-17, DK-13**	**0.007**	**0.017**
ILG551035	*ILDOT-I74 Woodford Co N WWTP*	*STP*	*Unnamed tributary of Mackinaw River*	*DK-13*	*0.015*	*0.03*
ILG551095	*Timberline MHP WWTP*	*STP*	*Unnamed tributary to Walnut Creek*	*DK-17, DK-13*	*0.051*	*0.128*
ILG580074	*Roanoke WWTP*	*STP*	*West Branch Panther Creek*	*DK-13*	*0.22*	*0.8*
ILG580078	*Village of Colfax WWTP*	*STP*	*Mackinaw River*	*DK-17, DK-13*	*0.11*	*0.28*
ILG580102	*Village of Gridley WWTP*	*STP*	*Buck Creek*	*DK-17, DK-13*	*0.188*	*0.47*
ILG582005	*City of El Paso WWTP*	*STP*	*East Branch Panther Creek*	*DK-13*	*0.461*	*1.15*
ILG640120	*Secor WTP*	*Public water supply*	*Olive Branch*	*DK-13*	*--*	*--*
ILG640167	*Anchor WTP*	*Public water supply*	*Mackinaw River*	*DK-17, DK-13*	*--*	*--*
ILG640231	*Eureka WTP*	*Public water supply*	*Walnut Creek*	*DK-13*	*--*	*--*
ILG640278	*City of Bloomington WTP*	*Public water supply*	*Money Creek*	*DK-17, DK-13*	*0.09*	*--*
ILG840187	*Amigoni Construction – Bachman Pit*	*Stormwater and pit pump discharge*	*Unnamed tributary to Panther Creek*	*DK-13*	*--*	*--*

Italics – NPDES facility draining to unimpaired segment; **BOLD** – NPDES facility draining to impaired segment
STP – Sewage treatment plant; MGD – Million gallons per day

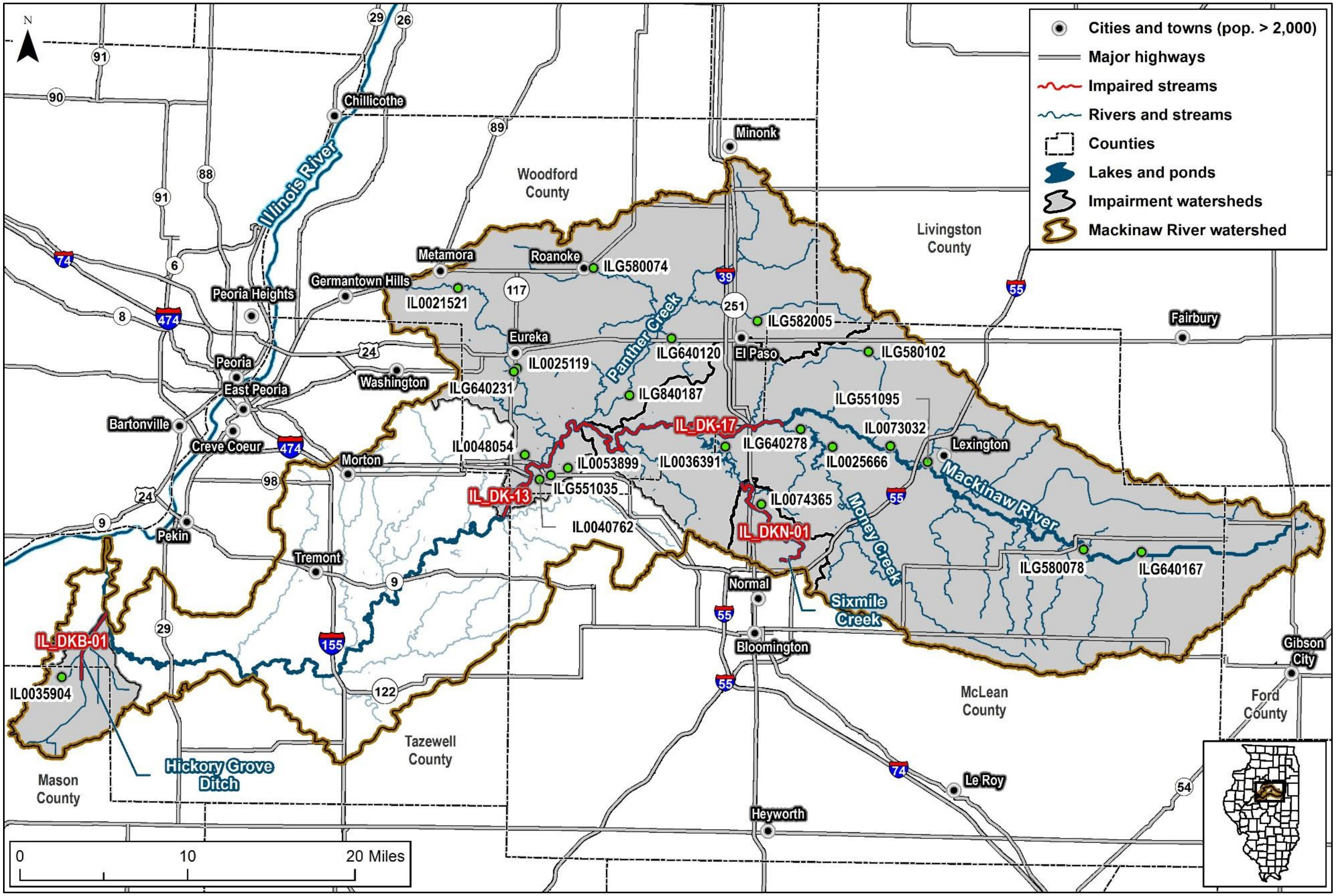

Figure 8. NPDES permitted facilities upstream of impaired segments.

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 amongst 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 minimum 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 9.

Table 13. Permitted MS4s in impairment watersheds

Permit ID	Regulated Entity	Downstream Receiving Waters
ILR400296	Bloomington City MS4	Sixmile Creek (DKN-01) and Mackinaw River (DK-17, DK-13)
ILR400041	Dry Grove Township MS4	Sixmile Creek (DKN-01) and Mackinaw River (DK-17, DK-13)
ILR400265	McLean County MS4	Sixmile Creek (DKN-01) and Mackinaw River (DK-17, DK-13)
ILR400097	Normal Township MS4	Sixmile Creek (DKN-01) and Mackinaw River (DK-17, DK-13)
ILR400399	Normal, Town MS4	Sixmile Creek (DKN-01) and Mackinaw River (DK-17, DK-13)
ILR400598	Old Town Township MS4	Sixmile Creek (DKN-01) and Mackinaw River (DK-17, DK-13)
ILR400610	Sand Prairie Township MS4	Hickory Grove Ditch (DKB-01)
ILR400146	Washington Township MS4	Mackinaw River (DK-13)
ILR400158	Worth Township MS4	Mackinaw River (DK-13)
ILR400493	Illinois Department of Transportation (road authority)	Sixmile Creek (DKN-01), and Mackinaw River (DK-17, DK-13)

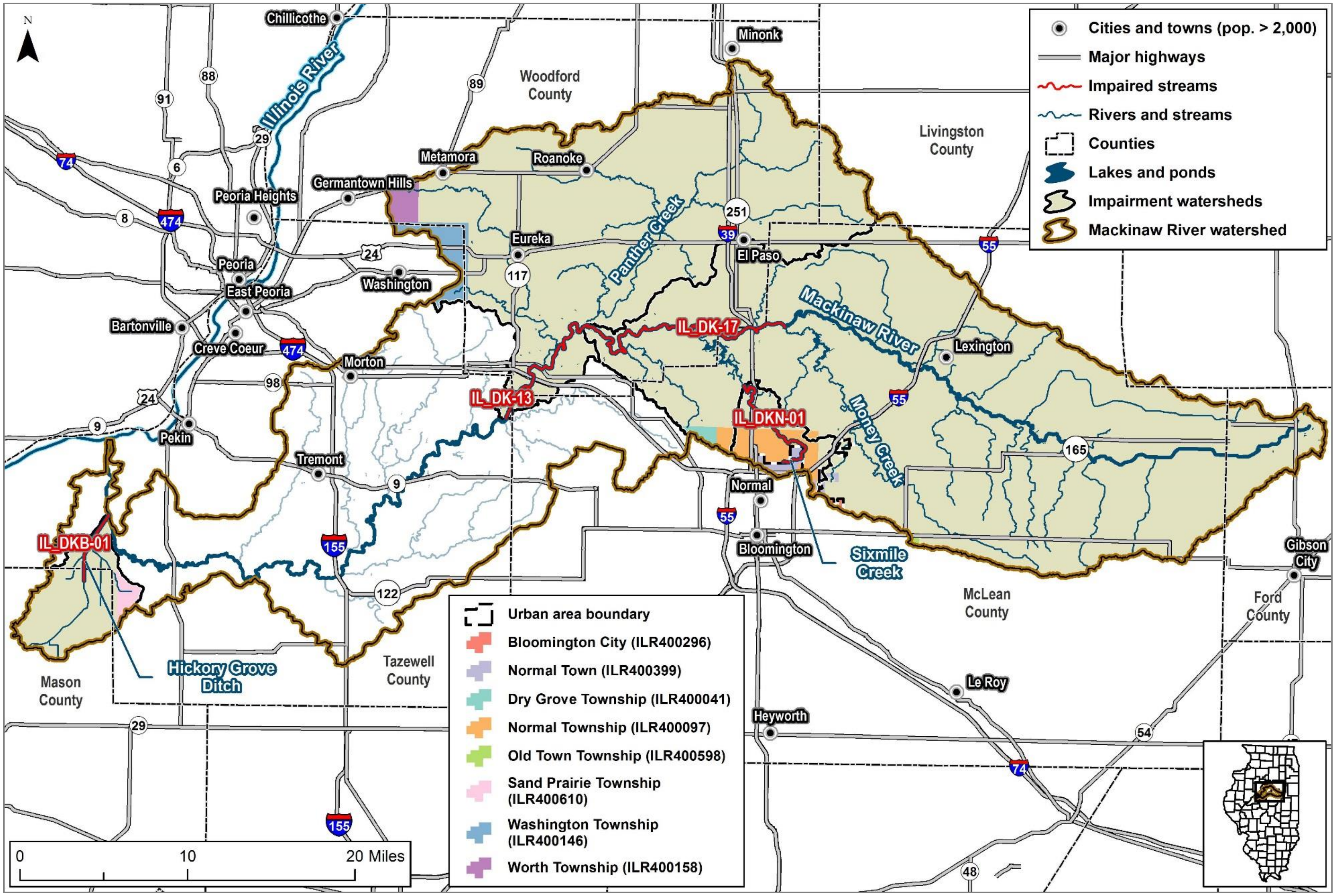

Figure 9. Municipal Separate Storm Sewer Systems (MS4s) in impairment subwatersheds.
McLean County and ILDOT are also regulated MS4s.

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 Mackinaw River watershed impairments (Table 14).

Table 14. Potential sources in project area based on the Draft 2016 305(b) list

Watershed	Segment	Pollutant of Concern	Sources
Mackinaw River	IL_DK-13	Fecal coliform	Source unknown
	IL_DK-17	Nitrate nitrogen	Source unknown
Hickory Grove Ditch	IL_DKB-01	Dissolved oxygen	Channelization, crop production (crop land or dry land), agriculture and source unknown
Sixmile Creek	IL_DKN-01	Dissolved oxygen	Channelization, dam or impoundment, source unknown, crop production (crop land or dry land), and agriculture

A summary of the potential nonpoint sources of pollutants is provided below, additional information on the primary pollutant sources follow.

- Potential nonpoint sources of pollution to fecal coliform in the Mackinaw River (DK-13) include stormwater runoff, onsite wastewater treatment systems, animal agriculture, and wildlife.

- Nonpoint sources of nitrate in the Mackinaw River (DK-17) are primarily related to agricultural runoff and tile discharge as a result of nitrogen fertilizer application. Cropland makes up the majority of the contributing watershed, and the presence of potentially wet soils indicates that tiling is likely common. In addition, stormwater runoff and onsite wastewater treatment systems can also contribute to nitrogen loading.

- Nonpoint sources potentially contributing to low dissolved oxygen conditions in Hickory Grove Ditch (DKB-01) include stormwater and agricultural runoff, onsite wastewater treatment systems, animal agriculture activities, sediment oxygen demand, and channelization. Pollutants typically of concern include phosphorus (leading to eutrophication), ammonia, and carbonaceous biochemical oxygen demand. Sediment oxygen demand, often a result of decaying organic matter, can significantly contribute to low dissolved oxygen conditions. Channelization is a non-pollutant source. Channelization can result in low dissolved oxygen conditions due to lack of in-stream structure that would reaerate the water column. The entire length of Hickory Grove Ditch has been channelized.

- Nonpoint sources potentially contributing to low dissolved oxygen conditions in Sixmile Creek (DKN-01) include stormwater and agricultural runoff, onsite wastewater treatment systems, animal agriculture activities, sediment oxygen demand, channelization, and hydrologic modification (dam or impoundment). Pollutants typically of concern include phosphorus (leading to eutrophication), ammonia, and carbonaceous biochemical oxygen demand. Sediment oxygen demand, often a result of decaying organic matter, can significantly contribute to low dissolved oxygen conditions. Channelization and hydrologic modification are non-pollutant sources. Channelization can result in low dissolved oxygen conditions due to lack of in-stream structure that would reaerate the water column. Stormwater ponds are present in the upper part of the watershed which may lead to altered flow conditions.

3.3.1 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.

3.3.2 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 Livingston, Mason and Tazewell Counties. Livingston County reported 6,000 and Tazewell reported 100,000 installed septic systems. No information was provided on failure rates or results of compliance testing. Mason County did not provide specific information on septic systems, but noted that the county is mostly rural in only a few major cities on public sewer systems.

3.3.3 Animal Feeding Operations (AFOs)

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

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

Livestock are potential sources of bacteria and nutrients to streams, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas. Watershed specific data are not available for livestock populations. However, county wide data available from the 2012 Census of

Agriculture were downloaded and area weighted to estimate the animal population in the project area. An estimated 135,333 animals are in the project area.

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 Clean Water Act.

Along the impaired stream segments, data were found for numerous stations that are part of the AWQMN (Figure 10 and Table 15). Parameters sampled on the streams include field measurements (e.g., water temperature) as well as those that require lab analyses (e.g., fecal coliform, nutrients, and total suspended solids). Available data were obtained directly from Illinois EPA.

Table 15. Illinois EPA water quality data along impaired stream segments

Water Body	Impaired Segment	AWQMN Sites	Location	Period of Record
Mackinaw River	DK-13	DK-06	RT 150 Br. 2 Mi. W Congerville	2018
		DK-13	Rocky Ford Br. at River Rd. and Ragar Rd., 4 Mi. SE of Deer Creek	*1999–2006*
		DK-16	RT 150 Br. 1 Mi. NW Congerville	*2000, 2005*, 2010, 2015
	DK-17	DK-02	RT 51 Br. 4.5 Mi. N Hudson	-*
		DK-17	3.5 Mi. NE Congerville	*2000, 2005*, 2010
		DK-18	CO Rd. 9, 5 Mi. WSW Kappa	-*
		DK-25	1.5 Mi. NW Lk. Bloomington	-*
Hickory Grove Ditch	DKB-01	DKB-01	CO Rd. 1100N 4 Mi. NE Manito	*2000, 2005,* 2010, 2015
Sixmile Creek	DKN-01	DKN-01	CO Rd. 12 Br. 0.75 Mi. W Hudson	*2000, 2002*
		DKN-02	CO Rd. 2000N 1.5 Mi. S of Hudson	*2005*, 2010, 2015

Italics – Data are greater than 10 years old
-* Station location provided in GIS shapefile; however, no data available (1999–2016) as provided by Illinois EPA

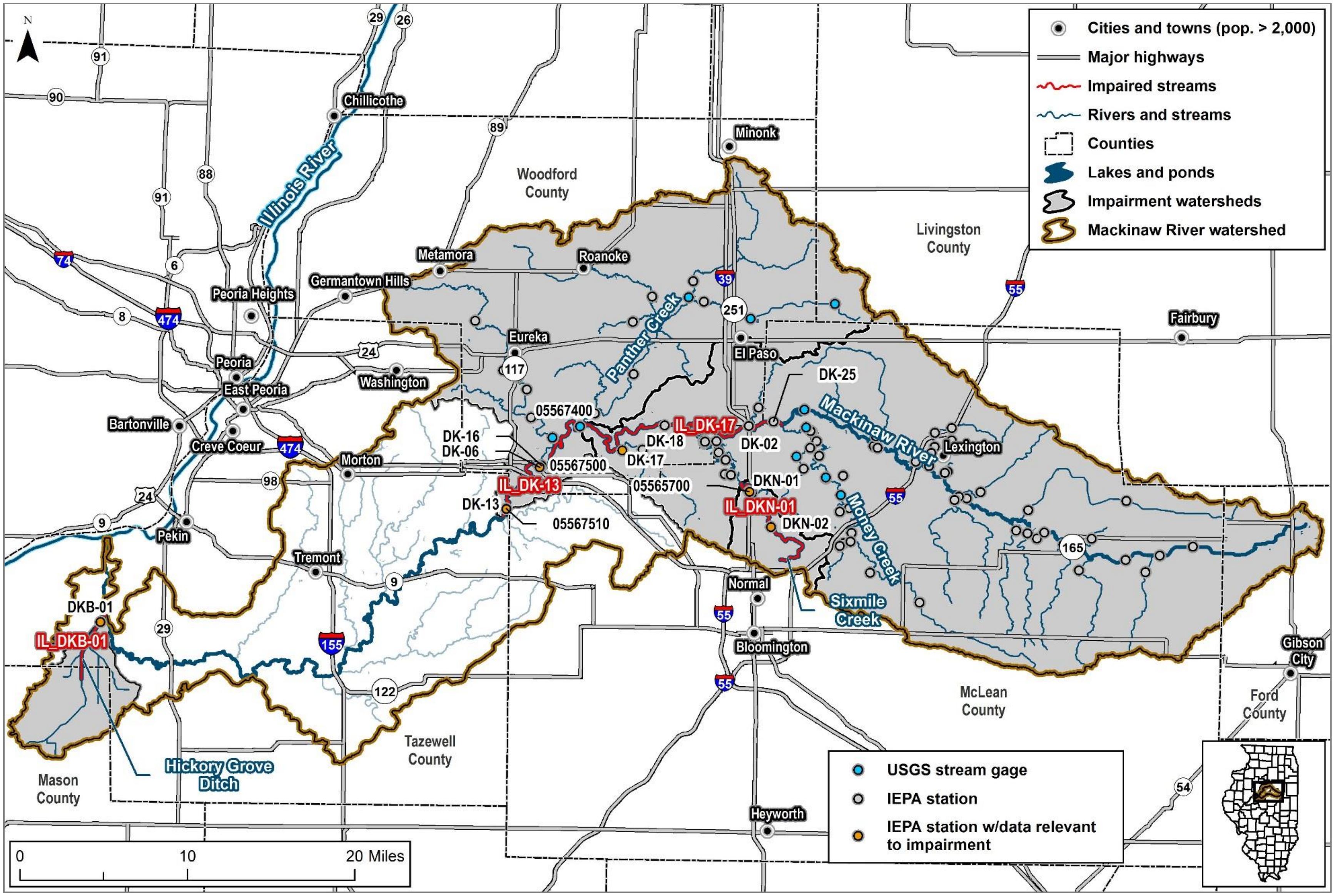

Figure 10. USGS stream gages and Illinois EPA water quality sampling sites in impairment watersheds and along impaired stream segments.
Monitoring stations on impaired segments labeled.

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 status. Data that are greater than 10 years old are only included where future monitoring efforts are needed to evaluate impairment status. Each data point was reviewed to ensure the use of quality data in the analysis below.

4.1.1 Mackinaw River

The Mackinaw River is listed as impaired along two segments—DK-13 and DK-17. Segment DK-13 is impaired for primary contact recreation due to fecal coliform. Segment DK-17 is upstream of DK-13 and is impaired for public and food processing water supply use to due to nitrate nitrogen. The City of Bloomington uses intake IN00400 from segment DK-17 to pump water from the Mackinaw River into Lake Evergreen during times of drought. There are two Illinois EPA sampling sites with relevant data on segment DK-13 and one on segment DK-17.

Forty-three fecal coliform samples were collected at station DK-13 between 1999 and 2006 (Figure 11). However, all samples collected are greater than 5 years old. Additional data were collected at station DK-06 in 2018 to verify impairment (Table 16). Greater than 10 percent of the individual samples exceed the single sample maximum standard, and the geometric mean of the five samples taken within a 30-day period is greater than the monthly geometric mean standard (Figure 12). Primary contact recreation impairment on segment DK-13 is verified.

Five nitrate nitrite (nitrate + nitrite as N) samples were collected at DK-17 in the most recent three years of data collection during 2015 (Table 17 and Figure 13). Greater than 10 percent of samples exceed the 10 mg/L drinking water protection MCL, with two individual exceedances of the MCL observed. The April to June quarterly average also exceeds the MCL. Public and food processing water supply use impairment is verified on this segment.

Table 16. Data summary, Mackinaw River IL_DK-13

Sample Site	No. of samples	Minimum (cfu/100 mL)	Geometric Mean (cfu/100 mL)	Maximum (cfu/100 mL)	Number of exceedances of single sample maximum standard (400 cfu/100 mL)
Fecal Coliform					
DK-06	5	205	426	980	8

Table 17. Data summary, Mackinaw River IL_DK-17

Sample Site	Date	Result (mg/L)	Quarterly Average (mg/L)
Nitrate/Nitrite (nitrate + nitrite as N)			
DK-17	6/4/2015	10.5	10.5
	7/2/2015	10.6	6.2
	8/12/2015	4.57	
	8/13/2015	4.33	
	9/29/2015	5.24	

Red values indicate samples above the MCL

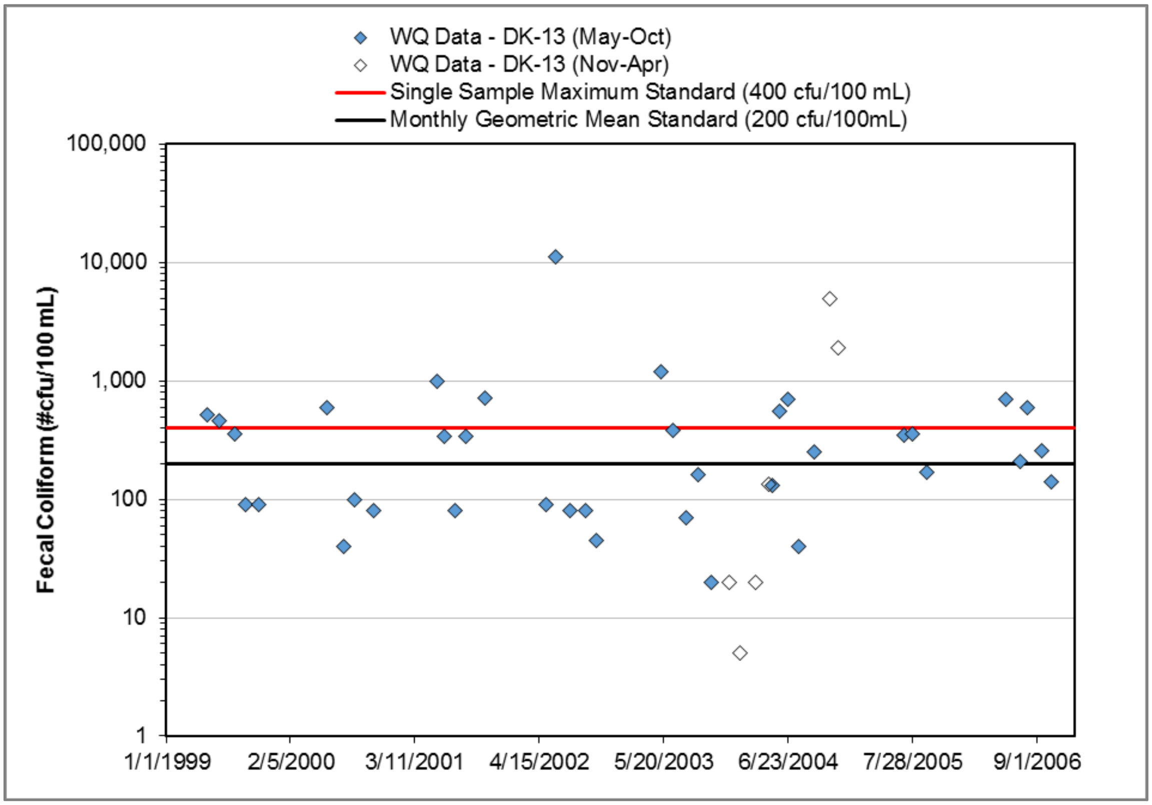

Figure 11. Fecal coliform water quality time series, 1999–2006, Mackinaw River DK-13 segment.

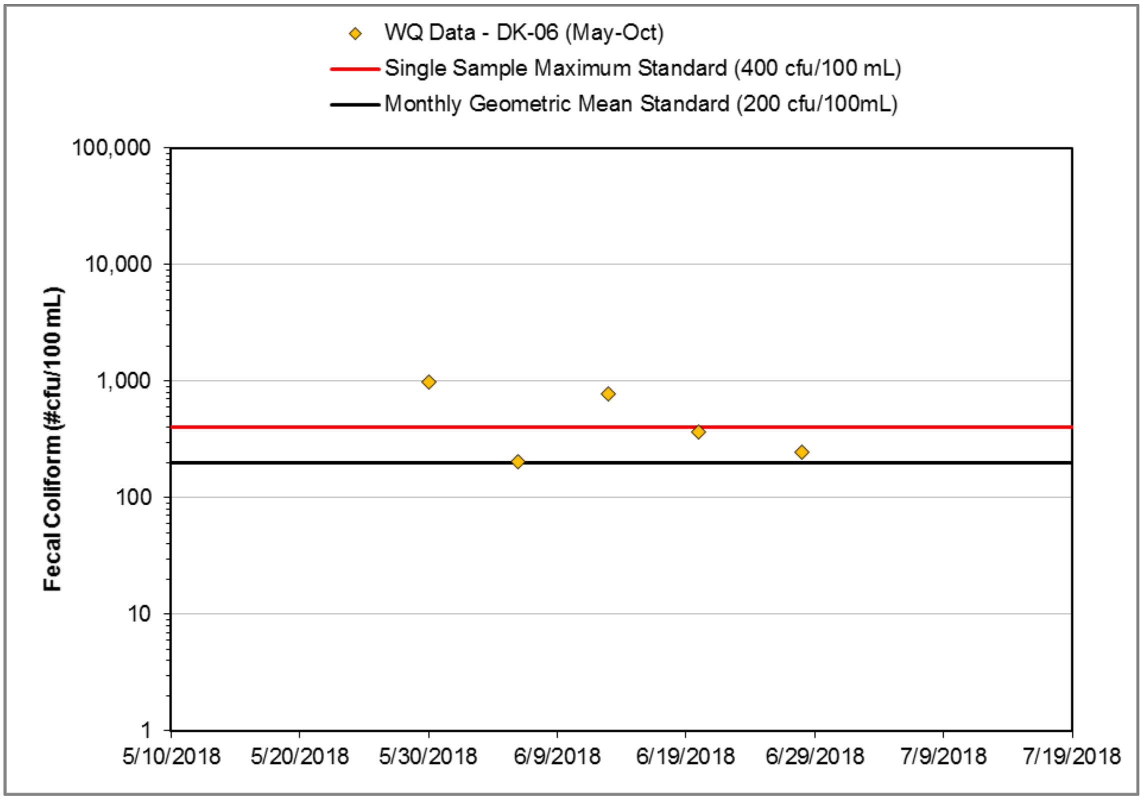

Figure 12. Fecal coliform water quality time series, 2018, Mackinaw River DK-13 segment.

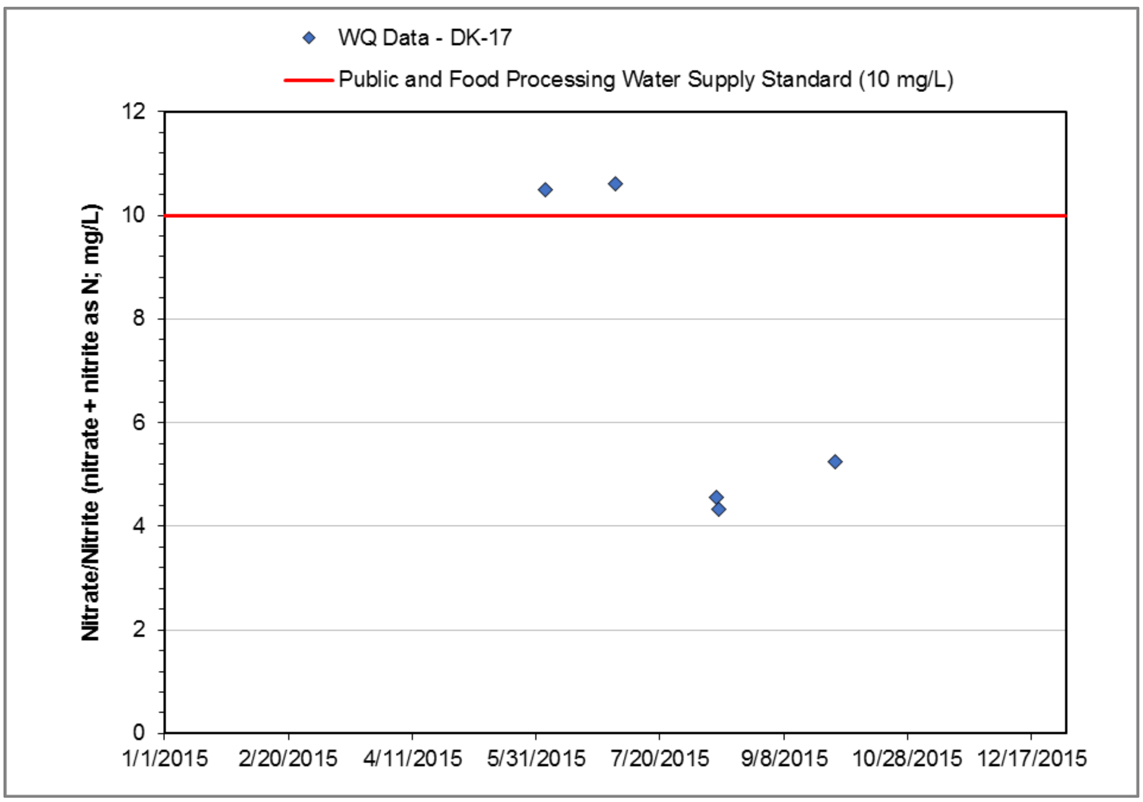

Figure 13. Nitrate water quality time series, Mackinaw River DK-17 segment.

4.1.2 Hickory Grove Ditch (DKB-01)

Hickory Grove Ditch DKB-01 is listed as impaired for aquatic life use due low dissolved oxygen. One IEPA sampling site was identified on the stream, DKB-01. Continuous dissolved oxygen data were collected at site DKB-01 in 2010 and 2015. Multiple violations of the standard were observed in June 2010 and 2015 (Figure 14). Aquatic life use impairment is verified on this segment.

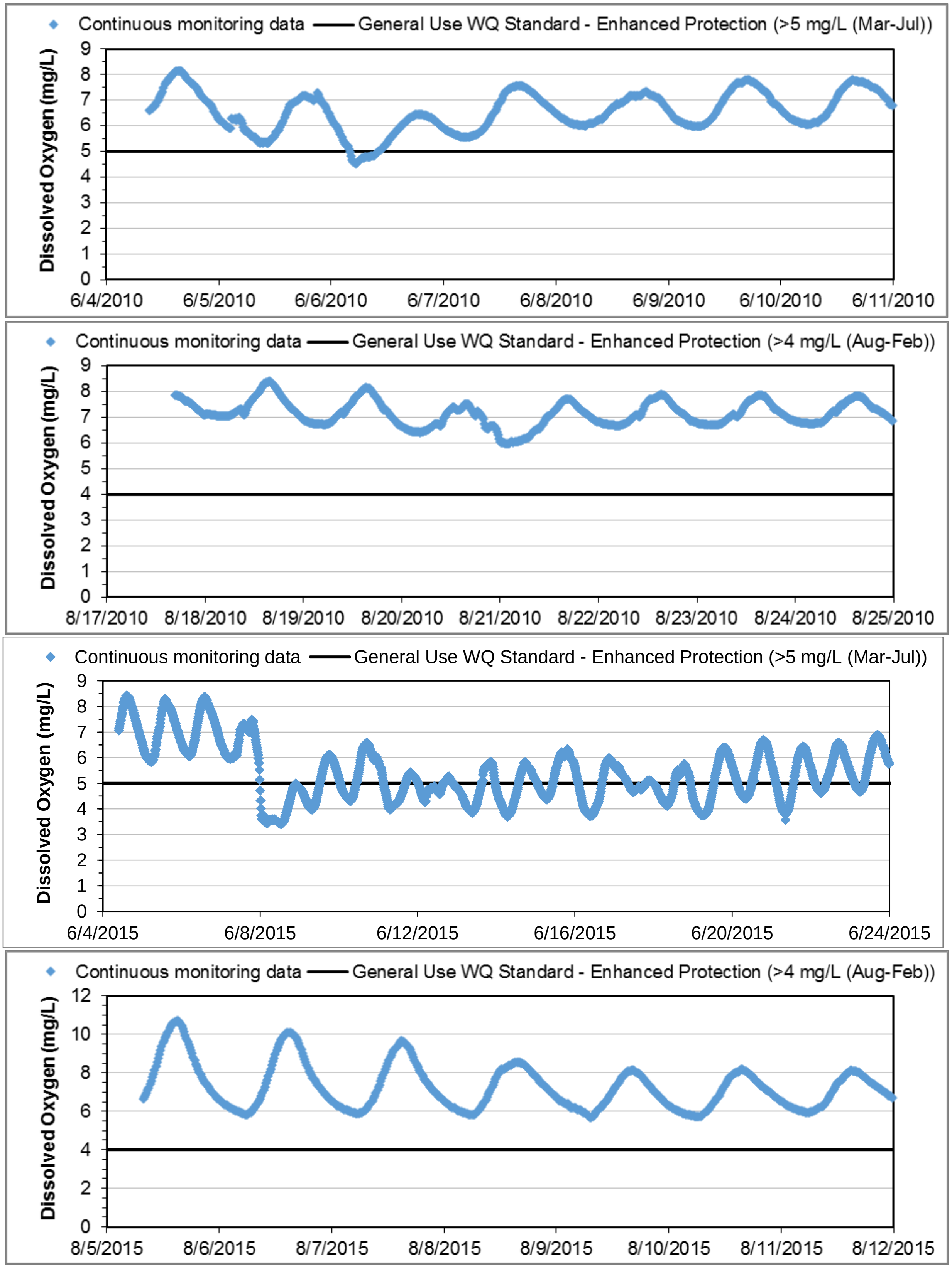

Figure 14. Continuous dissolved oxygen water quality time series, Hickory Grove Ditch DKB-01.

4.1.3 Sixmile Creek (DKN-01)

Sixmile Creek (DKN-01) is listed as impaired for aquatic life due to low levels of dissolved oxygen. One Illinois EPA sampling site with relevant data was identified on Sixmile Creek at DKN-02. This station is located in the upper part of the stream segment, well above Lake Evergreen. Eight dissolved oxygen samples were collected at the site between 2010 and 2015 (Table 18 and Figure 15). Two samples violated the general use water quality standard in 2010. Continuous dissolved oxygen was monitored in June and August of 2010; dissolved oxygen regularly violated the standard in August 2010 (Figure 17). Available phosphorus data were evaluated to determine if eutrophication was contributing to low dissolved oxygen conditions; however, no correlation was found between phosphorus and dissolved oxygen (Figure 16). Aquatic life use impairment is verified on this creek.

Table 18. Data summary, Sixmile Creek IL_DKN-01

Sample Site	No. of samples	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	CV (standard deviation/ average)	Number of exceedances of general use water quality standard (>5 mg/L (Mar-Jul) and >3.5 mg/L (Aug-Feb))
Dissolved Oxygen						
DKN-02	8	1.3	7.2	10.2	0.45	2

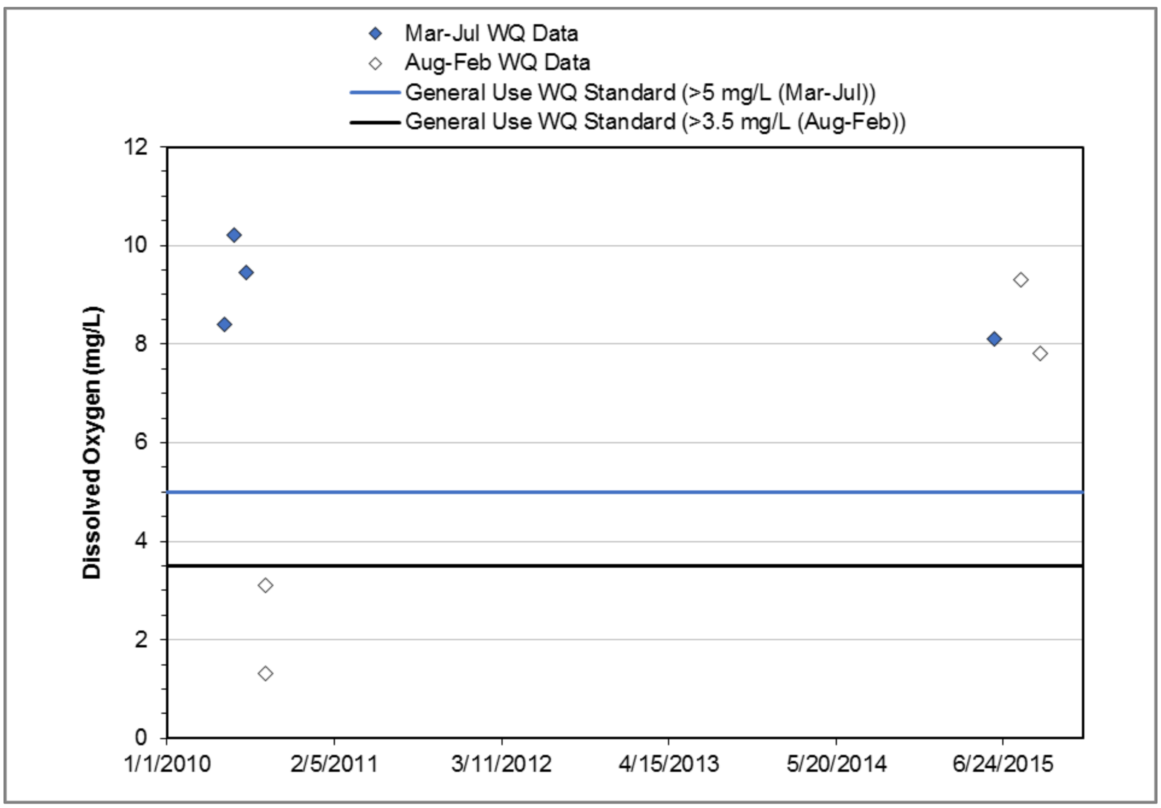

Figure 15. Dissolved oxygen water quality time series, Sixmile Creek DKN-01.

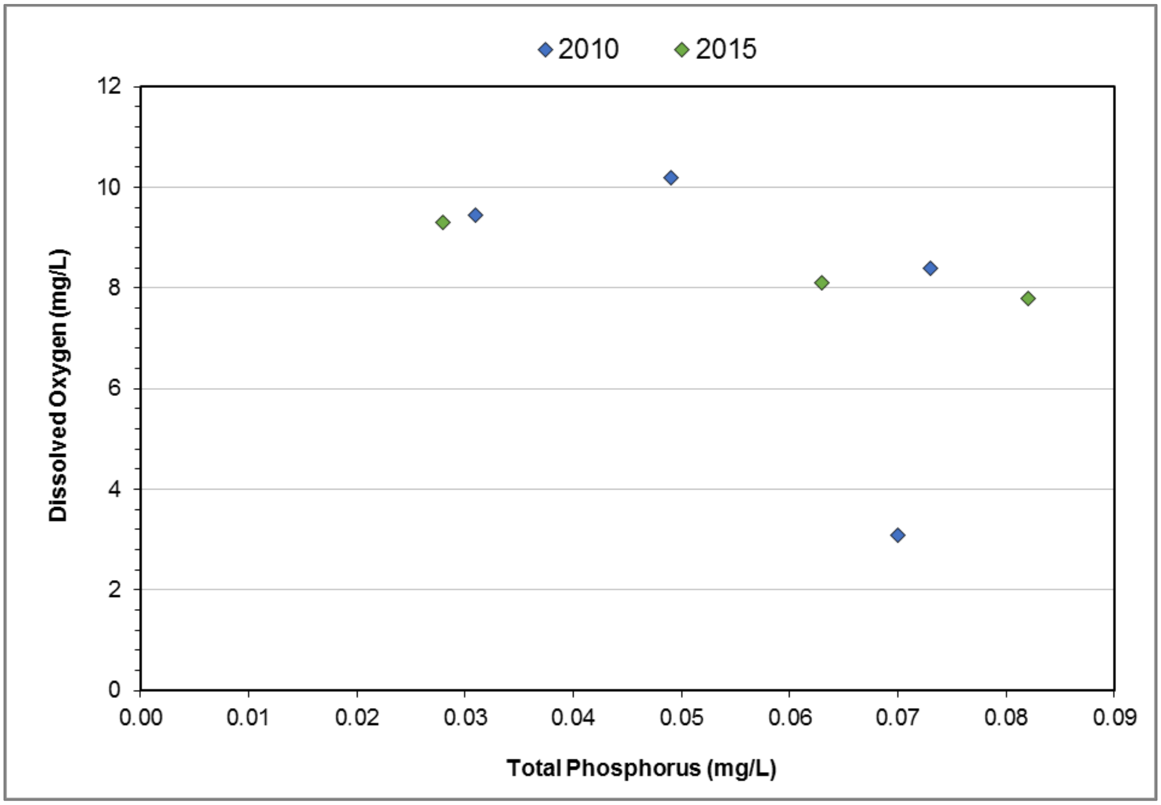

Figure 16. Total phosphorus versus dissolved oxygen, Sixmile Creek DKN-01.

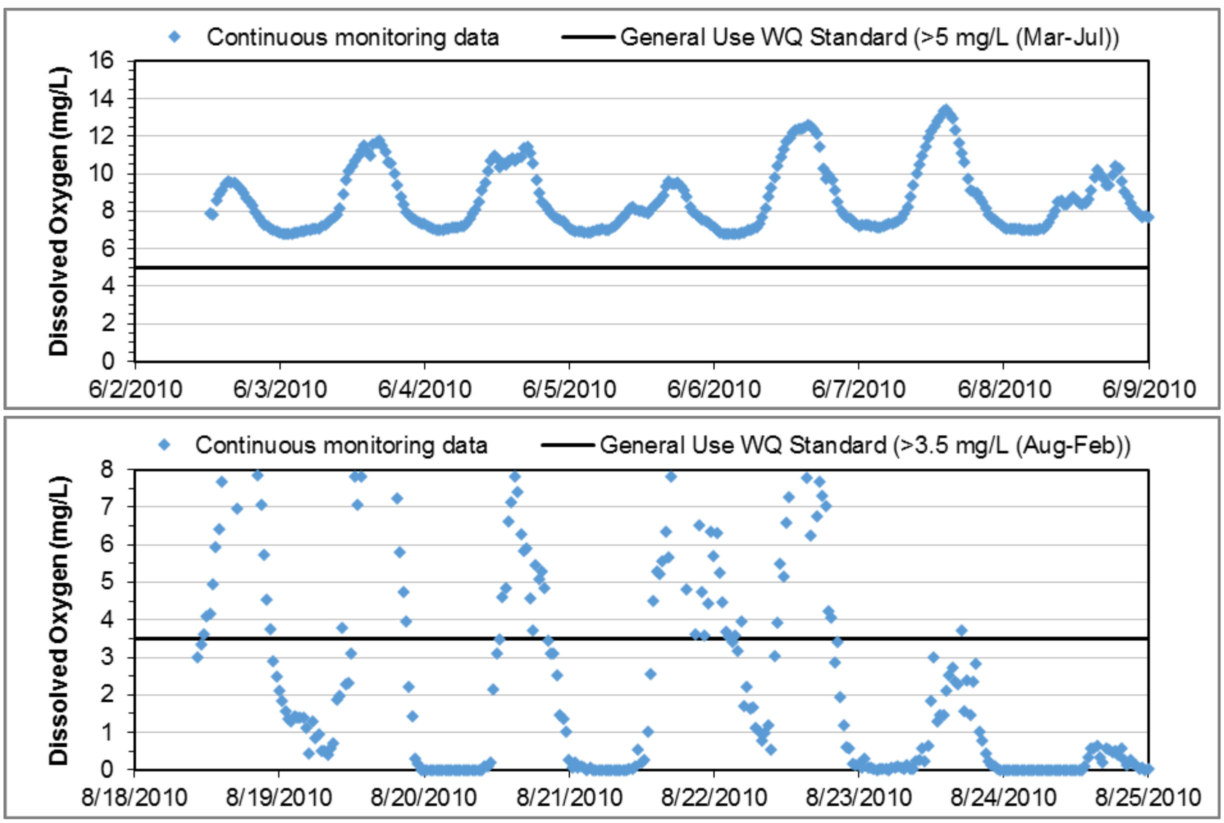

Figure 17. Continuous water quality time series for dissolved oxygen, Sixmile Creek (DKN-01).

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

5.1 Stream 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 and nitrate impairments.

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

Table 19. Proposed Model Summary

Name	Segment ID	Designated Uses	TMDL Parameter(s)	Proposed Model	Proposed Pollutant
Mackinaw River	IL_DK-13	Primary contact recreation	Fecal coliform	Load duration curve	Fecal coliform
	IL_DK-17	Public and food processing water supply	Nitrogen, Nitrate	Load duration curve	Nitrogen, Nitrate
Hickory Grove Ditch	IL_DKB-01	Aquatic life	Dissolved Oxygen	Qual2K	Biochemical oxygen demand, ammonia, phosphorus
Sixmile Creek	IL_DKN-01	Aquatic life	Dissolved Oxygen	Qual2K or load duration curve or 4C impairment, pending data collection	Biochemical oxygen demand, ammonia, phosphorus; or phosphorus; or non-pollutant, pending data collection

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		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	

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

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

5.1.2 Qual2K

Qual2K is a steady-state water quality model that simulates eutrophication kinetics and conventional water quality parameters and is maintained by U.S. EPA. Qual2K simulates up to 15 water quality constituents in branching stream systems. A stream reach is divided into a number of computational elements, and for each computational element, a hydrologic balance in terms of stream flow (e.g., m3/s), a heat balance in terms of temperature (e.g., degrees C), and a material balance in terms of concentration (e.g., mg/l) are written. Both advective and dispersive transport processes are considered in the material balance. Mass is gained or lost from the computational element by transport processes, wastewater discharges, and withdrawals. Mass can also be gained or lost by internal processes such as release of mass from benthic sources or biological transformations.

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

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

Hydraulically, Qual2K is limited to the simulation of time periods during which both the stream flow in river basins and input waste loads are essentially constant. Qual2K can operate as either a steady-state or a quasi-dynamic model, making it a very helpful water quality planning tool. When operated as a steady-state model, it can be used to study the impact of waste loads (magnitude, quality, and location) on instream water quality. By operating the model dynamically, the user can study the effects of diurnal variations in meteorological data on water quality (primarily dissolved oxygen and temperature) and also can study diurnal dissolved oxygen variations due to algal growth and respiration. However, the effects of dynamic forcing functions, such as headwater flows or point loads, cannot be modeled in Qual2K. A steady-state model is proposed for Sixmile Creek (DKN-01), if needed.

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

5.2 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); and
- 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
Mackinaw River	IL_DK-13	Primary contact recreation	Fecal coliform	None
	IL_DK-17	Public and food processing water supply	Nitrogen, Nitrate	None
Hickory Grove Ditch	IL_DKB-01	Aquatic life	Dissolved Oxygen	To support Qual2K model
Sixmile Creek	IL_DKN-01	Aquatic life	Dissolved Oxygen	To determine effect of point source and to support Qual2K model if needed
All	All	All	All	Implementation monitoring

Specific data needs include:

Support Qual2K Model Development (DKB-01)—Four monitoring stations are needed. Ideally, there would be two separate data collection periods, each time period lasting roughly one week during critical conditions (low flow, warm conditions). Although these monitoring locations are a minimum, adding more locations along the reach of interest will help determine how heterogeneous the system is and what dynamics are occurring along the reach. Monitoring stations can be located downstream of key tributaries, at road crossings, etc. as deemed necessary.

Recommended monitoring includes:

- Site DKB-01 and a new station where Hickory Grove Ditch crosses East County Road 2550 N (just upstream of the upstream end of the impaired segment):
  - Continuous dissolved oxygen, stream temperature, conductivity, and pH monitoring during a warm, low flow period in July; monitoring should take place over approximately two weeks
  - Flow monitoring (depth and velocity) at least twice during dissolved oxygen monitoring; the number of measurements will be dependent on weather and stream conditions
  - Multiple samples of organic nitrogen, ammonia nitrogen, nitrate nitrogen, organic phosphorus, soluble reactive phosphorus, total inorganic carbon, carbonaceous biochemical oxygen demand (5-day and 20-day if possible), inorganic solids, chlorophyll-*a*, and alkalinity. Depending on the monitoring station, grab samples could be collected twice per day during the first and last days of sonde deployment or throughout the week.
  - Macrophyte and attached algae survey, survey of groundwater and tributary contributions, if any
  - Channel geometry, shade/vegetative survey, cloud cover, and channel substrate and bottom material, both upstream and downstream of the monitoring stations(s)
- New site on Manito Ditch where it crosses County Road 900 North (just upstream of where Manito Ditch outlets into Hickory Grove Ditch):
  - Continuous dissolved oxygen, stream temperature, conductivity, and pH monitoring during the same period as data collected on the main stem sites.
  - Multiple samples of organic nitrogen, ammonia nitrogen, nitrate nitrogen, TKN, organic phosphorus, soluble reactive phosphorus, total inorganic carbon, total organic carbon, carbonaceous biochemical oxygen demand (5-day and 20-day if possible), inorganic solids, chlorophyll-*a*, and alkalinity. Depending on the monitoring station, grab samples could be collected twice per day during the first and last days of sonde deployment or throughout the week.

  – Flow monitoring (depth and velocity) at least twice during the monitoring period.
- Monitoring downstream of the Manito STP discharge (relatively close to the discharge point):
  – One set of the following parameters, taken on the same day as grab sampling downstream: organic nitrogen, ammonia nitrogen, nitrate nitrogen, TKN, organic phosphorus, soluble reactive phosphorus, total inorganic carbon, total organic carbon, carbonaceous biochemical oxygen demand (5-day and 20-day if possible), inorganic solids, chlorophyll-*a*, and alkalinity.
  – Flow monitoring (depth and velocity) at least twice during the monitoring period.
- A longitudinal/synoptic survey of DO concentrations along the entire reach (hand-sampling by probe on foot or from a row-boat periodically along the entire reach extent)
- Funding permitted: *in-situ* measurements of stream reaeration (via diffusion dome technique) and *in-situ* measurements of sediment oxygen demand (via chambers deployed on the streambed). Sediment bed surveys can be conducted potentially in lieu of SOD sampling (sediment total organic carbon sampling for instance could be a rough proxy for SOD if needed).
- Photo documentation of the system

Support Qual2K Model Development (DKN-01)–Prairie View Homeowners Association STP (IL0074365) discharges to IL_DKN-01 downstream of monitoring station DKN-02, where the low dissolved oxygen impairment was observed. Additional monitoring downstream of the point source is needed to determine the extent of impairment and to support Qual2K model development if it is determined that the point source contributes to the impairment.

A minimum of two monitoring stations (DKN-01 and DKN-02) are needed on the impaired segment. Ideally, there will be two separate data collection periods, each time period lasting roughly 1 week during critical conditions (low flow, warm conditions). Although two monitoring locations are a minimum, adding more locations along the reach of interest will help determine how heterogeneous the system is and what dynamics are occurring along the reach. Monitoring stations can be located downstream of key tributaries, at road crossings, etc. as deemed necessary.

Recommended monitoring includes:

- Continuous dissolved oxygen, stream temperature, conductivity, and pH monitoring during a warm, low flow period in July; monitoring should take place over approximately two weeks at a minimum of two locations.
- Flow monitoring (depth and velocity) during dissolved oxygen monitoring at least twice at two locations, the number of measurements will be dependent on weather and stream conditions
- Multiple samples of organic nitrogen, ammonia nitrogen, nitrate nitrogen, TKN, organic phosphorus, soluble reactive phosphorus, total inorganic carbon, total organic carbon, carbonaceous biochemical oxygen demand (5-day and 20-day if possible), inorganic solids, chlorophyll-a, and alkalinity. Depending on the monitoring station, grab samples could be collected twice per day during the first and last days of sonde deployment or throughout the week.
- Macrophyte and attached algae survey, survey of groundwater and tributary contributions, if any
- Channel geometry, shade/vegetative survey, cloud cover, and channel substrate and bottom material, both upstream and downstream of the monitoring stations(s)
- A longitudinal/synoptic survey of DO concentrations along the entire reach (hand-sampling by probe on foot or from a row-boat periodically along the entire reach extent)
- Funding permitted: *in-situ* measurements of stream reaeration (via diffusion dome technique) and in-situ measurements of sediment oxygen demand (via chambers deployed on the streambed).

Sediment bed surveys can be conducted potentially in lieu of SOD sampling (sediment total organic carbon sampling for instance could be a rough proxy for SOD if needed).

- Photo documentation of the system

Implementation Monitoring - 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 includes:

- Wind shield surveys
- Streambank surveys and stream assessments for Mackinaw River IL_DK-13 fecal coliform impairment and dissolved oxygen impairments on Hickory Grove Ditch and Sixmile Creek
- Farmer/landowner surveys
- Word of mouth and in-person conversations with local stakeholders and landowners

6. Public Participation

<to be updated based on Stage 1 meetings>

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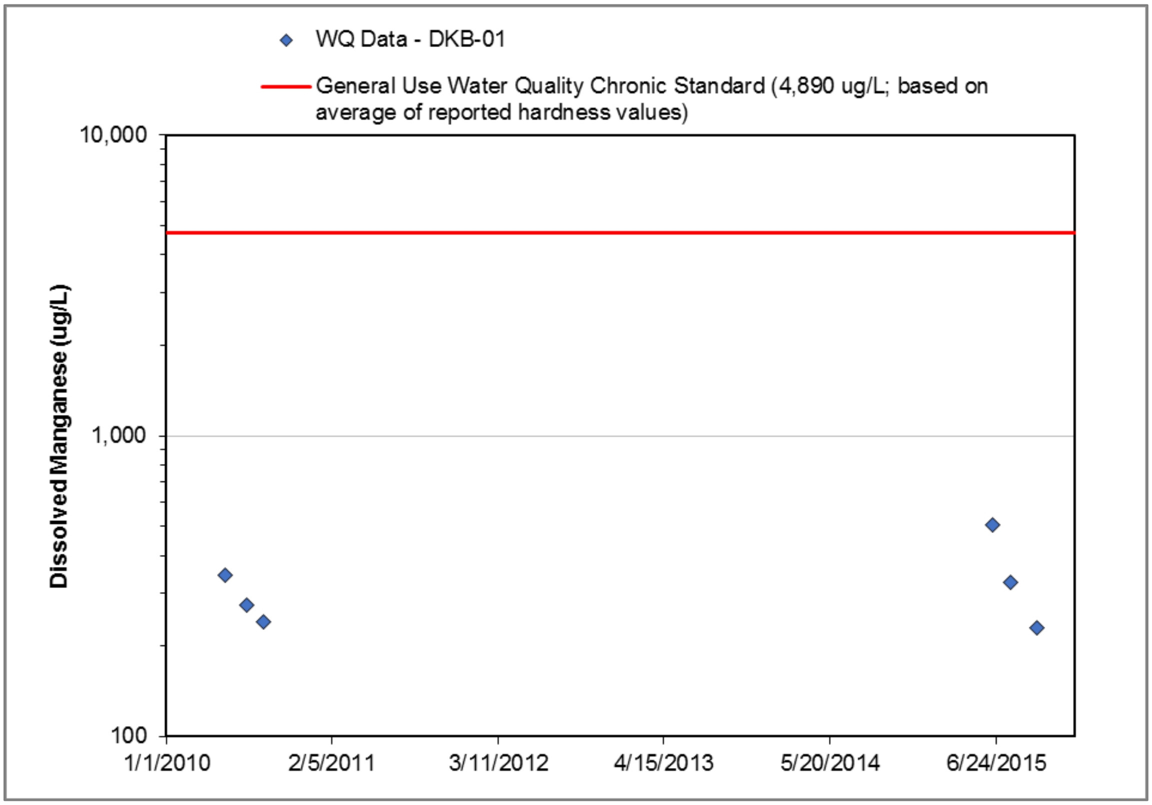
Appendix A – Unimpaired Stream Data Analysis

Hickory Grove Ditch (DKB-01)

Hickory Grove Ditch DKB-01 is listed as impaired for aquatic life use due to high manganese. One IEPA sampling site was identified on the stream, DKB-01. No samples during data collection in 2010 and 2015 were recorded above the general use chronic standard for manganese. It is therefore recommended that the segment be delisted for manganese and no TMDL be developed.



Manganese water quality time series, Hickory Grove Ditch DKB-01.