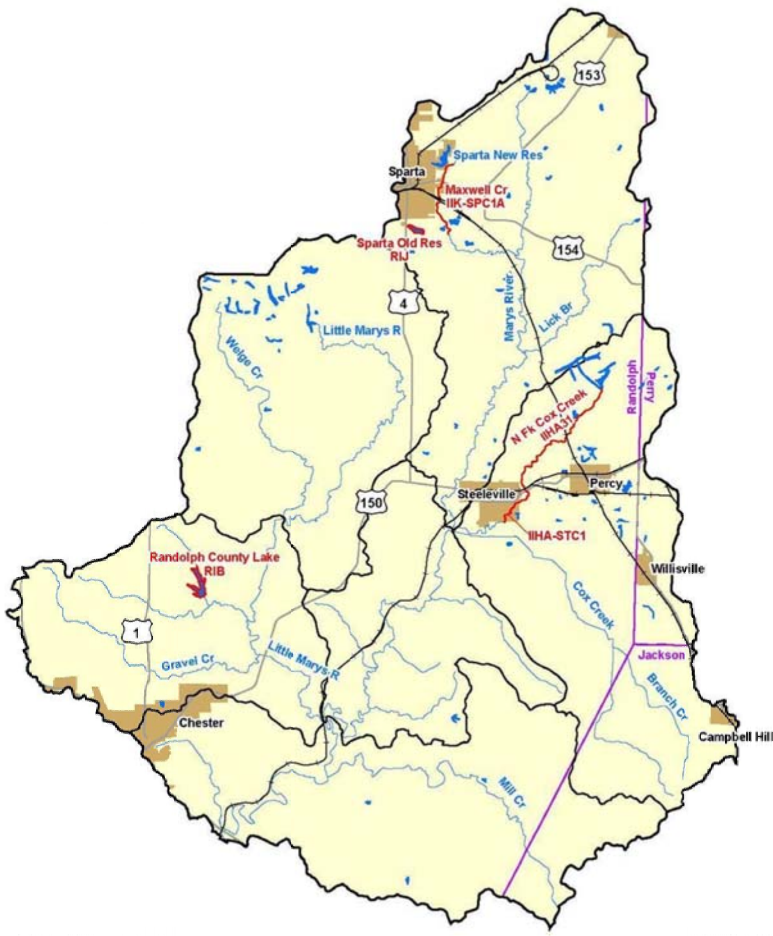
Illinois
Environmental
Protection Agency

Bureau of Water
P.O. Box 19276
Springfield, IL 62794-9276

June 2008

IEPA/BOW/07-024

Mary's River / North Fork Cox Creek Watershed TMDL Report



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TMDL Development for the Mary's River/ North Fork Cox Creek Watershed, Illinois

This file contains the following documents:

1) U.S. EPA Approval letter for Stage Three TMDL Report

2) Stage One Report: Third Quarter Draft

3) Stage Two Report: Data Report

4) Stage Three Report: TMDL Development

5) Implementation Plan Report

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

RECEIVED
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Watershed Management Section
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REPLY TO THE ATTENTION OF:

WW-16J

Marcia Willhite, Chief
Bureau of Water
Illinois Environmental Protection Agency
P.O. Box 19276
Springfield, IL 62794-9276

Dear Ms. Willhite:

The United States Environmental Protection Agency (U.S. EPA) has reviewed the final Total Maximum Daily Loads (TMDL) from the Illinois Environmental Protection Agency (IEPA) for Mary's River-North Fork Cox Creek Watershed in Illinois. The TMDLs are for phosphorus, total dissolved solids and sulphates, and address several impairments in these waterbodies.

Based on this review, U.S. EPA has determined that Illinois' TMDLs for sulphate, total dissolved solids, and phosphorus meet the requirements of Section 303(d) of the Clean Water Act and U.S. EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, U.S. EPA hereby approves five TMDLs for six impairments for North Fork Cox Creek (IL_IIHA-31 and IL_IIHA-STC1), Randolph County Lake (RIB), and Sparta Old Reservoir (RIJ) in Illinois. The statutory and regulatory requirements, and U.S. EPA's review of Illinois' compliance with each requirement, are described in the enclosed decision document.

We wish to acknowledge Illinois' effort in submitting this TMDL and look forward to future TMDL submissions by the State of Illinois. If you have any questions, please contact Dean Maraldo, TMDL Program Manager, at 312-353-2098.

Sincerely yours,

Kevin M. Pierard
Acting Director, Water Division

Enclosure

cc: Mike Eppley, IEPA

CDM

Illinois Environmental
Protection Agency

Mary's River/North Fork Cox Creek Watershed TMDL
Stage One
Third Quarter Draft Report

June 2006

Draft Report

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Contents

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Acronyms

°F	degrees Fahrenheit
BMP	best management practice
CWA	Clean Water Act
DMR	Discharge Monitoring Reports
DO	dissolved oxygen
ft	Foot or feet
GIS	geographic information system
HUC	Hydrologic Unit Code
IDA	Illinois Department of Agriculture
IDNR	Illinois Department of Natural Resources
IL-GAP	Illinois Gap Analysis Project
ILLCP	Illinois Interagency Landscape Classification Project
Illinois EPA	Illinois Environmental Protection Agency
INHS	Illinois Natural History Survey
IPCB	Illinois Pollution Control Board
LA	load allocation
LC	loading capacity
lb/d	pounds per day
mgd	Million gallons per day
mg/L	milligrams per liter
MOS	margin of safety
MUID	Map Unit Identification
NA	Not applicable
NASS	National Agricultural Statistics Service
NCDC	National Climatic Data Center
NED	National Elevation Dataset
NPDES	National Pollution Discharge Elimination System
NRCS	National Resource Conservation Service
PCS	Permit Compliance System
SSURGO	Soil Survey Geographic Database
STATSGO	State Soil Geographic
STORET	Storage and Retrieval
STP	Sanitary Treatment Plant
TMDL	total maximum daily load

ug/L	Micrograms per liter
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WLA	waste load allocation
WTP	Water Treatment Plant

Section 1
Goals and Objectives for Mary's River/North Fork Cox Creek Watershed (0714010502)

1.1 Total Maximum Daily Load (TMDL) Overview

A Total Maximum Daily Load, or TMDL, is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards. TMDLs are a requirement of Section 303(d) of the Clean Water Act (CWA). To meet this requirement, the Illinois Environmental Protection Agency (Illinois EPA) must identify water bodies not meeting water quality standards and then establish TMDLs for restoration of water quality. Illinois EPA lists water bodies not meeting water quality standards every two years. This list is called the 303(d) list and water bodies on the list are then targeted for TMDL development.

In general, a TMDL is a quantitative assessment of water quality problems, contributing sources, and pollution reductions needed to attain water quality standards. The TMDL specifies the amount of pollution or other stressor that needs to be reduced to meet water quality standards, allocates pollution control or management responsibilities among sources in a watershed, and provides a scientific and policy basis for taking actions needed to restore a water body.

Water quality standards are laws or regulations that states authorize to enhance water quality and protect public health and welfare. Water quality standards provide the foundation for accomplishing two of the principal goals of the CWA. These goals are:

- Restore and maintain the chemical, physical, and biological integrity of the nation's waters
- Where attainable, to achieve water quality that promotes protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water

Water quality standards consist of three elements:

- The designated beneficial use or uses of a water body or segment of a water body
- The water quality criteria necessary to protect the use or uses of that particular water body
- An antidegradation policy

Examples of designated uses are recreation and protection of aquatic life. Water quality criteria describe the quality of water that will support a designated use. Water quality criteria can be expressed as numeric limits or as a narrative statement. Antidegradation policies are adopted so that water quality improvements are conserved, maintained, and protected.

1.2 TMDL Goals and Objectives for Mary's River/North Fork Cox Creek Watershed

The Illinois EPA has a three-stage approach to TMDL development. The stages are:

- Stage 1 – Watershed Characterization, Data Analysis, Methodology Selection
- Stage 2 – Data Collection (optional)
- Stage 3 – Model Calibration, TMDL Scenarios, Implementation Plan

This report addresses Stage 1 TMDL development for the Mary's River/North Fork Cox Creek watershed. Stage 2 and 3 will be conducted upon completion of Stage 1. Stage 2 is optional as data collection may not be necessary if additional data are not required to establish the TMDL.

Following this process, the TMDL goals and objectives for the Mary's River/North Fork Cox Creek watershed will include developing TMDLs for all impaired water bodies within the watershed, describing all of the necessary elements of the TMDL, developing an implementation plan for each TMDL, and gaining public acceptance of the process. Following are the impaired water body segments in the Mary's River/ North Fork Cox Creek watershed for which a TMDL will be developed:

- North Fork Cox Creek (IIHA31)
- North Fork Cox Creek (IIHA-STC1)
- Maxwell Creek (IIK-SPC1A)
- Randolph County Lake (RIB)
- Sparta Old Reservoir (RIJ)

These impaired water body segments are shown on Figure 1-1. There are five impaired segments within the Mary's River/North Fork Cox Creek watershed. Table 1-1 lists the water body segment, water body size, and potential causes of impairment for the water body.

Table 1-1 Impaired Water Bodies in Mary's River/North Fork Cox Creek Watershed

Water Body Segment ID	Water Body Name	Size	Causes of Impairment with Numeric Water Quality Standards	Causes of Impairment with Assessment Guidelines
IIHA31	North Fork Cox Creek	4.76 miles	Sulfates, total dissolved solids (TDS)	Sedimentation/siltation, habitat alterations (streams), endrin
IIHA-STC1	North Fork Cox Creek	0.51 miles	TDS	Sedimentation/siltation
IIK-SPC1A	Maxwell Creek	2.25 miles	Dissolved oxygen	Total nitrogen, habitat alterations (streams), total phosphorus
RIB	Randolph County Lake	65 acres	Total phosphorus	Total suspended solids (TSS), excess algal growth, habitat alterations (lake)
RIJ	Sparta Old Reservoir	26.3 acres	Manganese, total phosphorus	Excess algal growth

Illinois EPA is currently only developing TMDLs for parameters that have numeric water quality standards, and therefore the remaining sections of this report will focus on the sulfates, TDS, dissolved oxygen, total phosphorus (numeric standard), and manganese impairments in the Mary's River/North Fork Cox Creek watershed. For potential causes that do not have numeric water quality standards as noted in Table 1-1, TMDLs will not be developed at this time. However, in the implementation plans completed during Stage 3 of the TMDL, many of these potential causes may be addressed by implementation of controls for the pollutants with water quality standards.

The TMDL for the segments listed above will specify the following elements:

- Loading Capacity (LC) or the maximum amount of pollutant loading a water body can receive without violating water quality standards
- Waste Load Allocation (WLA) or the portion of the TMDL allocated to existing or future point sources
- Load Allocation (LA) or the portion of the TMDL allocated to existing or future nonpoint sources and natural background
- Margin of Safety (MOS) or an accounting of uncertainty about the relationship between pollutant loads and receiving water quality

These elements are combined into the following equation:

$$\mathbf{TMDL = LC = \Sigma WLA + \Sigma LA + MOS}$$

The TMDL developed must also take into account the seasonal variability of pollutant loads so that water quality standards are met during all seasons of the year. Also, reasonable assurance that the TMDL will be achieved will be described in the implementation plan. The implementation plan for the Mary's River/North Fork Cox

Creek watershed will describe how water quality standards will be attained. This implementation plan will include recommendations for implementing best management practices (BMPs), cost estimates, institutional needs to implement BMPs and controls throughout the watershed, and timeframe for completion of implementation activities.

1.3 Report Overview

The remaining sections of this report contain:

- **Section 2 Mary's River/North Fork Cox Creek Watershed Characteristics** provides a description of the watershed's location, topography, geology, land use, soils, population, and hydrology
- **Section 3 Public Participation and Involvement** discusses public participation activities that occurred throughout the TMDL development
- **Section 4 Mary's River/North Fork Cox Creek Watershed Water Quality Standards** defines the water quality standards for the impaired water body
- **Section 5 Mary's River/North Fork Cox Creek Watershed Characterization** presents the available water quality data needed to develop TMDLs, discusses the characteristics of the impaired reservoirs in the watershed, and also describes the point and non-point sources with potential to contribute to the watershed load.
- **Section 6 Approach to Developing TMDL and Identification of Data Needs** makes recommendations for the models and analysis that will be needed for TMDL development and also suggests segments for Stage 2 data collection.

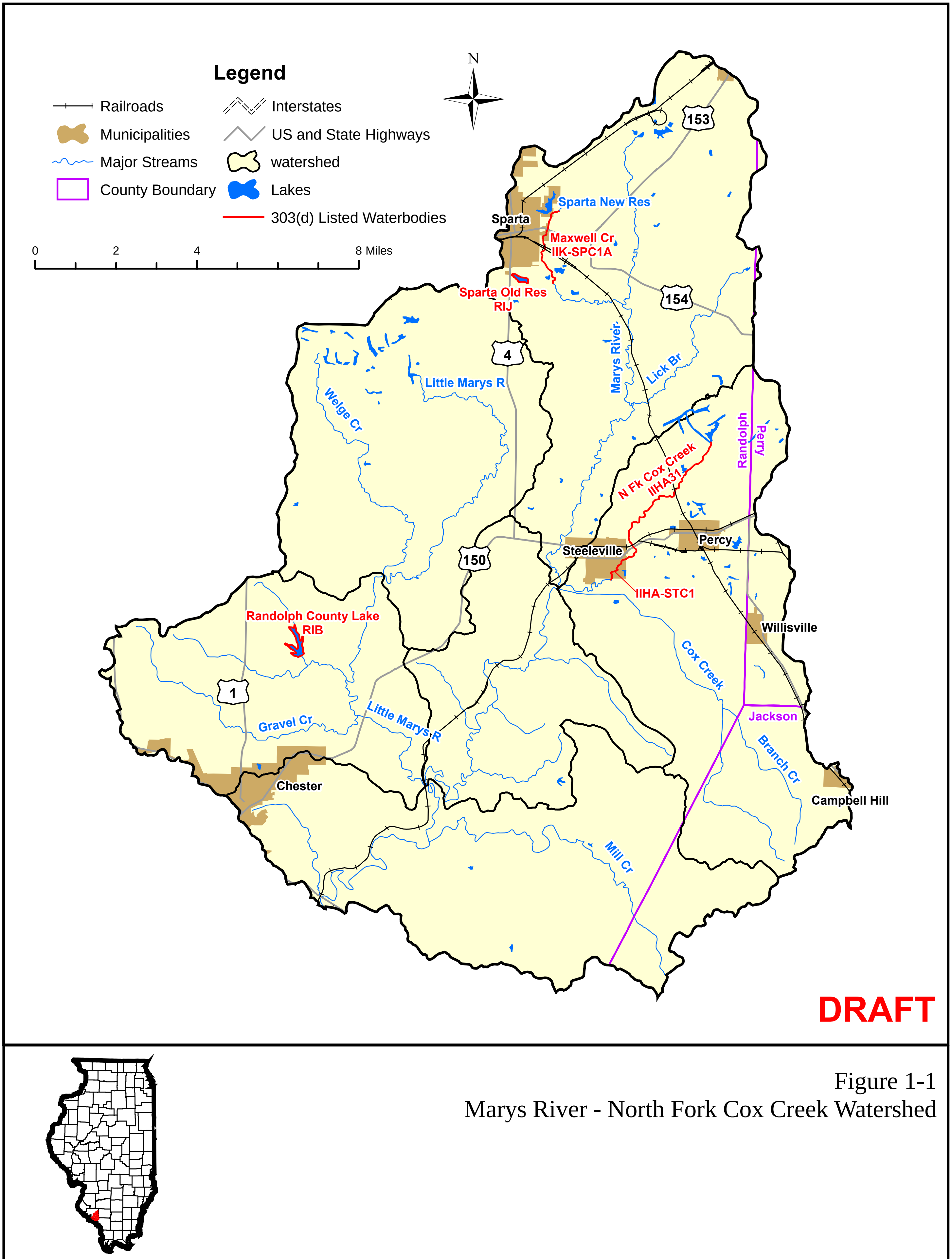

Figure 1-1
Marys River - North Fork Cox Creek Watershed

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Section 2
Mary's River/North Fork Cox Creek Watershed Description

2.1 Mary's River/North Fork Cox Creek Watershed Location

The Mary's River/North Fork Cox Creek watershed (Figure 1-1) is located in southern Illinois, flows in a south-southwesterly direction, and drains approximately 156,000 acres within the State of Illinois. The watershed covers land within Randolph, Jackson, and Perry Counties near the Missouri state line.

2.2 Topography

Topography is an important factor in watershed management because stream types, precipitation, and soil types can vary dramatically by elevation. National Elevation Dataset (NED) coverages containing 30-meter grid resolution elevation data are available from the USGS for each 1:24,000-topographic quadrangle in the United States. Elevation data for the Mary's River/North Fork Cox Creek watershed were obtained by overlaying the NED grid onto the GIS-delineated watershed. Figure 2-1 shows the elevations found within the watershed.

Elevation in the Mary's River/North Fork Cox Creek watershed ranges from 758 feet above sea level in the headwaters of Mary's River to 348 feet at its most downstream point in the northwest corner of the watershed. The absolute elevation change is 128 feet over the approximately 34-mile stream length of Mary's River, which yields a stream gradient of approximately 3.8 feet per mile.

2.3 Land Use

Land use data for the Mary's River/North Fork Cox Creek watershed were extracted from the Illinois Gap Analysis Project (IL-GAP) Land Cover data layer. IL-GAP was started at the Illinois Natural History Survey (INHS) in 1996, and the land cover layer was the first component of the project. The IL-GAP Land Cover data layer is a product of the Illinois Interagency Landscape Classification Project (IILCP), an initiative to produce statewide land cover information on a recurring basis cooperatively managed by the United States Department of Agriculture National Agricultural Statistics Service (NASS), the Illinois Department of Agriculture (IDA), and the Illinois Department of Natural Resources (IDNR). The land cover data was generated using 30-meter grid resolution satellite imagery taken during 1999 and 2000. The IL-GAP Land Cover data layer contains 23 land cover categories, including detailed classification in the vegetated areas of Illinois. Appendix A contains a complete listing of land cover categories. (Source: IDNR, INHS, IDA, USDA NASS's 1:100,000 Scale Land Cover of Illinois 1999-2000, Raster Digital Data, Version 2.0, September 2003.)

The land use of the Mary's River/North Fork Cox Creek watershed was determined by overlaying the IL-GAP Land Cover data layer onto the GIS-delineated watershed.

Table 2-1 contains the land uses contributing to the Mary's River/North Fork Cox Creek watershed, based on the IL-GAP land cover categories and also includes the area of each land cover category and percentage of the watershed area. Figure 2-2 illustrates the land uses of the watershed.

The land cover data reveal that approximately 117,360 acres, representing nearly 75 percent of the total watershed area, are devoted to agricultural activities. Corn and soybean farming account for nearly 14 percent and 21 percent of the watershed area, respectively; winter wheat and winter wheat/soybeans farming account for about 6 percent and 7 percent, respectively; and rural grassland accounts for approximately 27 percent. Upland forests occupy 14 percent of the watershed. Other land cover categories represent less that 5 percent of the watershed area.

Table 2-1. Land Use in Mary's River/North Fork Cox Creek Watershed

Land Cover Category	Area (Acres)	Percentage
Corn	21,738	14.0%
Soybeans	31,908	20.5%
Winter Wheat	8,806	5.7%
Other Small Grains & Hay	2,220	1.4%
Winter Wheat/Soybeans	11,221	7.2%
Other Agriculture	21	0.0%
Rural Grassland	41,446	26.6%
Upland	21,995	14.1%
Forested Area	2,404	1.5%
High Density	797	0.5%
Low/Medium Density	1,333	0.9%
Urban Open Space	2,356	1.5%
Wetlands	6,911	4.4%
Surface Water	2,477	1.6%
Barren & Exposed Land	87	0.1%
Total	**155,720**	**100%**

1. Forested areas includes partial canopy/savannah upland and coniferous.
2. Wetlands includes shallow marsh/wet meadow, deep marsh, seasonally/temporally flooded, floodplain forest, swamp, and shallow water.

2.4 Soils

Two types of soil data are available for use within the state of Illinois through the National Resource Conservation Service (NRCS). General soils data and map unit delineations for the entire state are provided as part of the State Soil Geographic (STATSGO) database. Soil maps for the database are produced by generalizing detailed soil survey data. The mapping scale for STATSGO is 1:250,000. More detailed soils data and spatial coverages are available through the Soil Survey Geographic (SSURGO) database for a limited number of counties. For SSURGO data, field mapping methods using national standards are used to construct the soil maps. Mapping scales generally range from 1:12,000 to 1:63,360 making SSURGO the most detailed level of soil mapping done by the NRCS.

The Mary's River/North Fork Cox Creek watershed falls within Randolph, Jackson, and Perry Counties. At this time, SSURGO data is only available for Randolph County. STATSGO data has been used in lieu of SSURGO data for the portion of the watershed that lies within Jackson and Perry Counties. Figure 2-3 displays the STATSGO soil map units as well as the SSURGO soil series in the Mary's River/North Fork Cox Creek watershed. Attributes of the spatial coverage can be linked to the STATSGO and SSURGO databases which provide information on various chemical and physical soil characteristics for each map unit and soil series. Of particular interest for TMDL development are the hydrologic soil groups as well as the K-factor of the Universal Soil Loss Equation. The following sections describe and summarize the specified soil characteristics for the Mary's River/North Fork Cox Creek watershed.

2.4.1 Mary's River/North Fork Cox Creek Watershed Soil Characteristics

Appendix B contains the STATSGO Map Unit IDs (MUIDs) for the Mary's River/North Fork Cox Creek watershed as well as the SSURGO soil series. The table also contains the area, dominant hydrologic soil group, and k-factor range. Each of these characteristics is described in more detail in the following paragraphs. The soil type that covers the largest percent of watershed area is Marine silt loam on zero to five percent slope. Marine silt loam covers approximately ten percent of the area.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils are assigned to one of four groups. They are grouped according to the infiltration of water when the soils are thoroughly wet and receive precipitation from long-duration storms. Hydrologic soil groups B, C, and D are found within the Mary's River/North Fork Cox Creek watershed with the majority of the watershed falling into category B. Category B soils are defined as "soils having a moderate infiltration rate when thoroughly wet." Category B soils "consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture." These soils have a moderate rate of water transmission. (NRCS, 2005).

A commonly used soil attribute is the K-factor. The K-factor:

> *Indicates the susceptibility of a soil to sheet and rill erosion by water.* (The K-factor) *is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion. Losses are expressed in tons per acre per year. These estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.02 to 0.69. The higher the value, the more susceptible the soil is to sheet and rill erosion by water (NRCS 2005).*

The distribution of K-factor values in the Mary's River/North Fork Cox Creek watershed range from 0.2 to 0.64.

2.5 Population

Population data were retrieved from Census 2000 TIGER/Line Data from the US Bureau of the Census. Geographic shape files of census blocks were downloaded for every county containing any portion of the watersheds. The block files were clipped to each watershed so that only block populations associated with the watershed would be counted. The census block demographic text file (PL94) containing population data was downloaded and linked to each watershed and summed. City populations were taken from the US Bureau of the Census. For municipalities that are located across watershed borders, the population was estimated based on the percentage of area of municipality within the watershed boundary.

Approximately 19,000 people reside in the watershed. The municipalities in the Mary's River/North Fork Cox Creek watershed are shown in Figure 1-1. The Chester and Steeleville are the largest population centers in the watershed and contribute an estimated 2,600 and 2,100 people to total watershed population, respectively.

2.6 Climate and Streamflow

2.6.1 Climate

Southern Illinois has a temperate climate with hot summers and cold, snowy winters. Monthly precipitation and temperature data were available for the Sparta 1W station (id. 8147) in Randolph County and were extracted from the NCDC database. Data were available from 1901-2004. Sparta, Illinois is located within the basin and was chosen to be representative of meteorological conditions throughout the Mary's River/North Fork Cox Creek watershed.

Table 2-2 contains the average monthly precipitation along with average high and low temperatures for the period of record. The average annual precipitation is approximately 41 inches.

Table 2-2 Average Monthly Climate Data in Sparta, Illinois

Month	Total Precipitation (inches)	Maximum Temperature (degrees F)	Minimum Temperature (degrees F)
January	2.6	41	23
February	2.3	46	27
March	3.7	57	35
April	4.2	68	45
May	4.5	77	54
June	3.7	86	63
July	3.6	91	67
August	3.6	89	65
September	3.3	83	58
October	3.2	71	47
November	3.3	57	36
December	2.9	44	27
Total	**40.9**		

2.6.2 Streamflow

Analysis of the Mary's River/North Fork Cox Creek watershed requires an understanding of flow throughout the drainage area. Unfortunately, there are no USGS gages within the watershed that have current, or even recent, streamflow data. Streamflow values can be collected in the watershed if any Stage 2 data collection occurs or values can be estimated through the drainage area ratio method which assumes that the flow per unit area is equivalent in watersheds with similar characteristics. For Stage 3 of TMDL development, site-specific data collected during Stage 2 or data from a neighboring gage will be used to estimate flows in the Mary's River/North Fork Cox Creek watershed.

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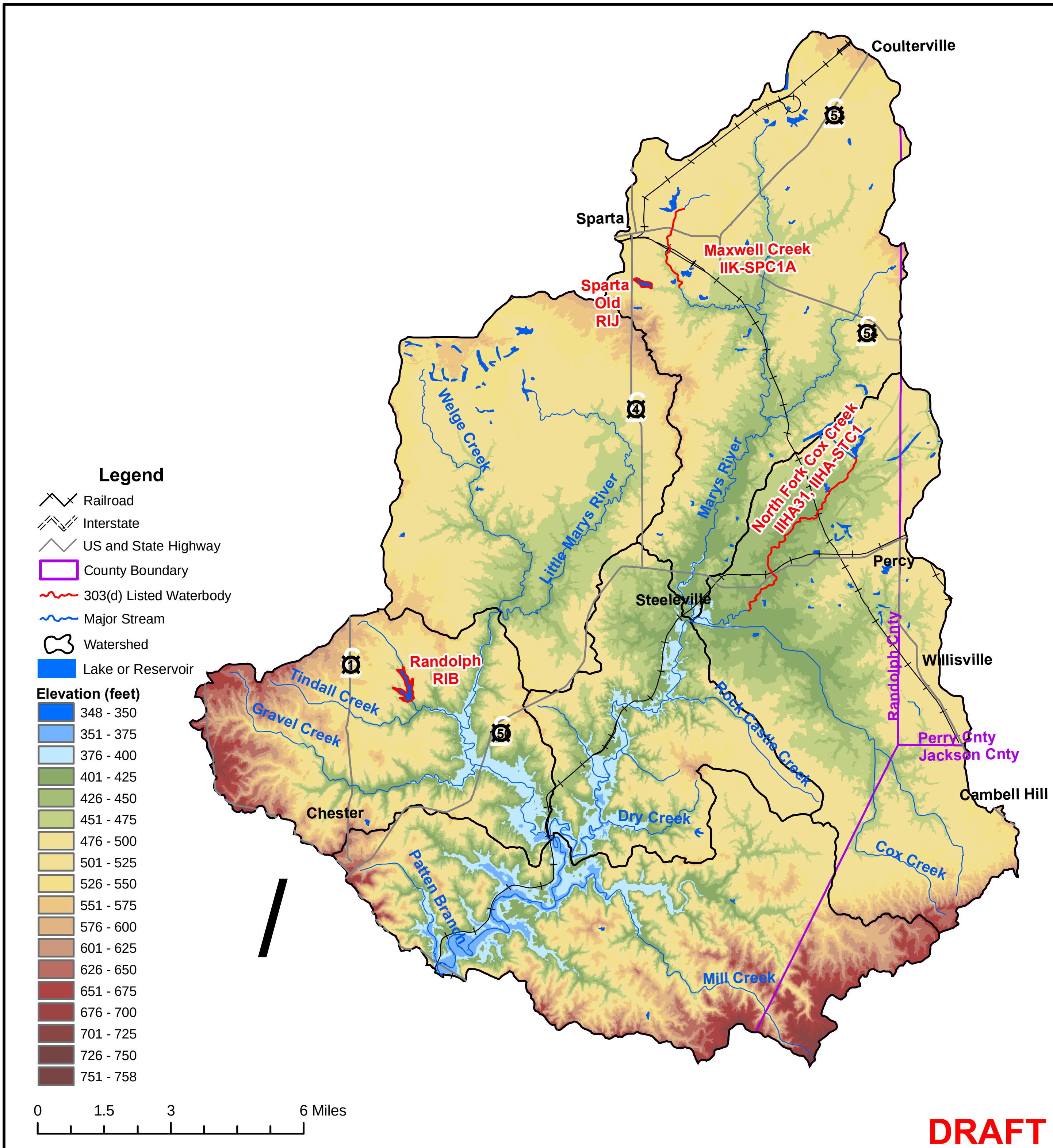

Figure 2-1
Mary's River/N. Fork Cox Creek Watershed
Elevation

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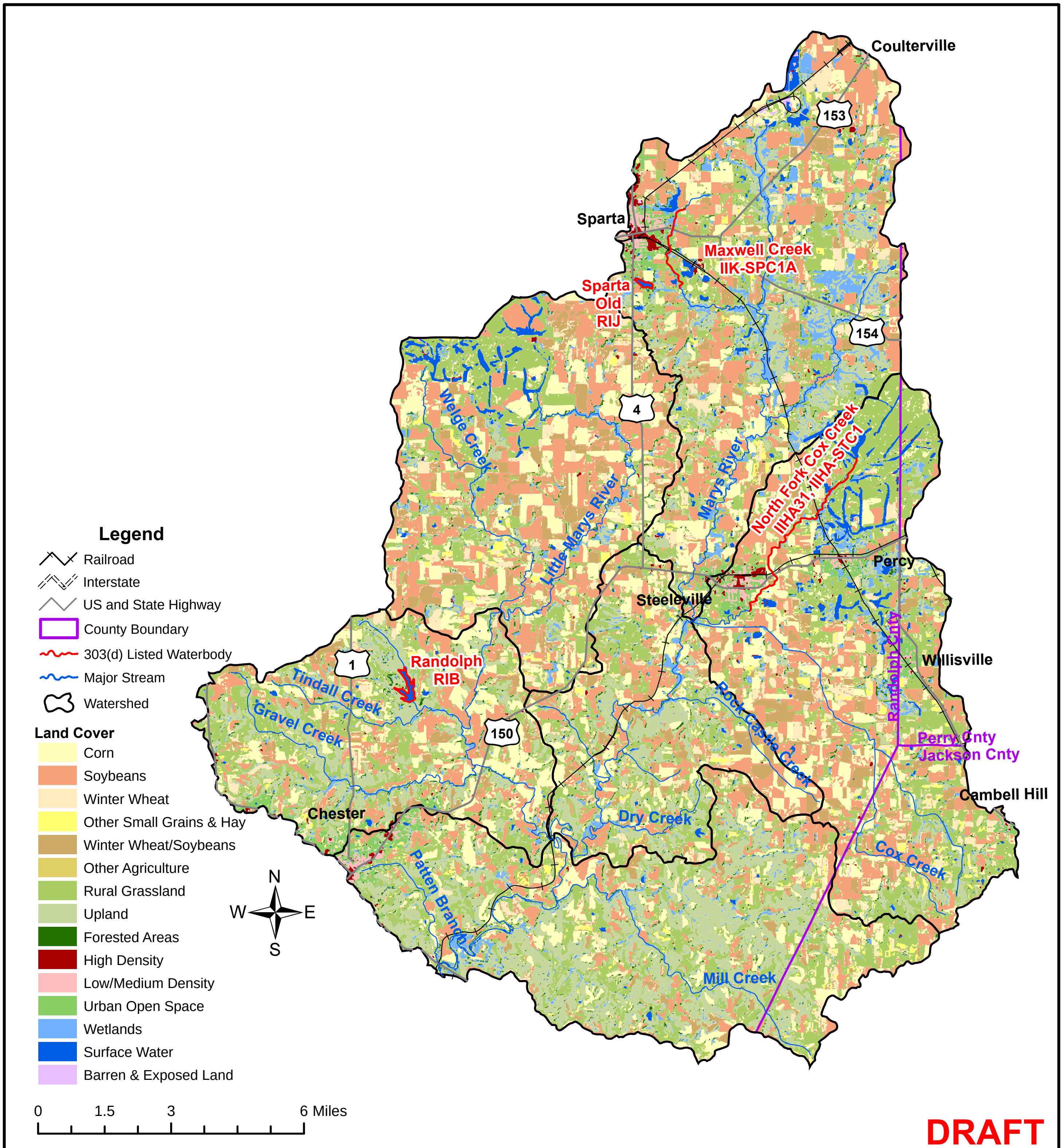

Figure 2-2
Mary's River/N. Fork Cox Creek Watershed
Land Use

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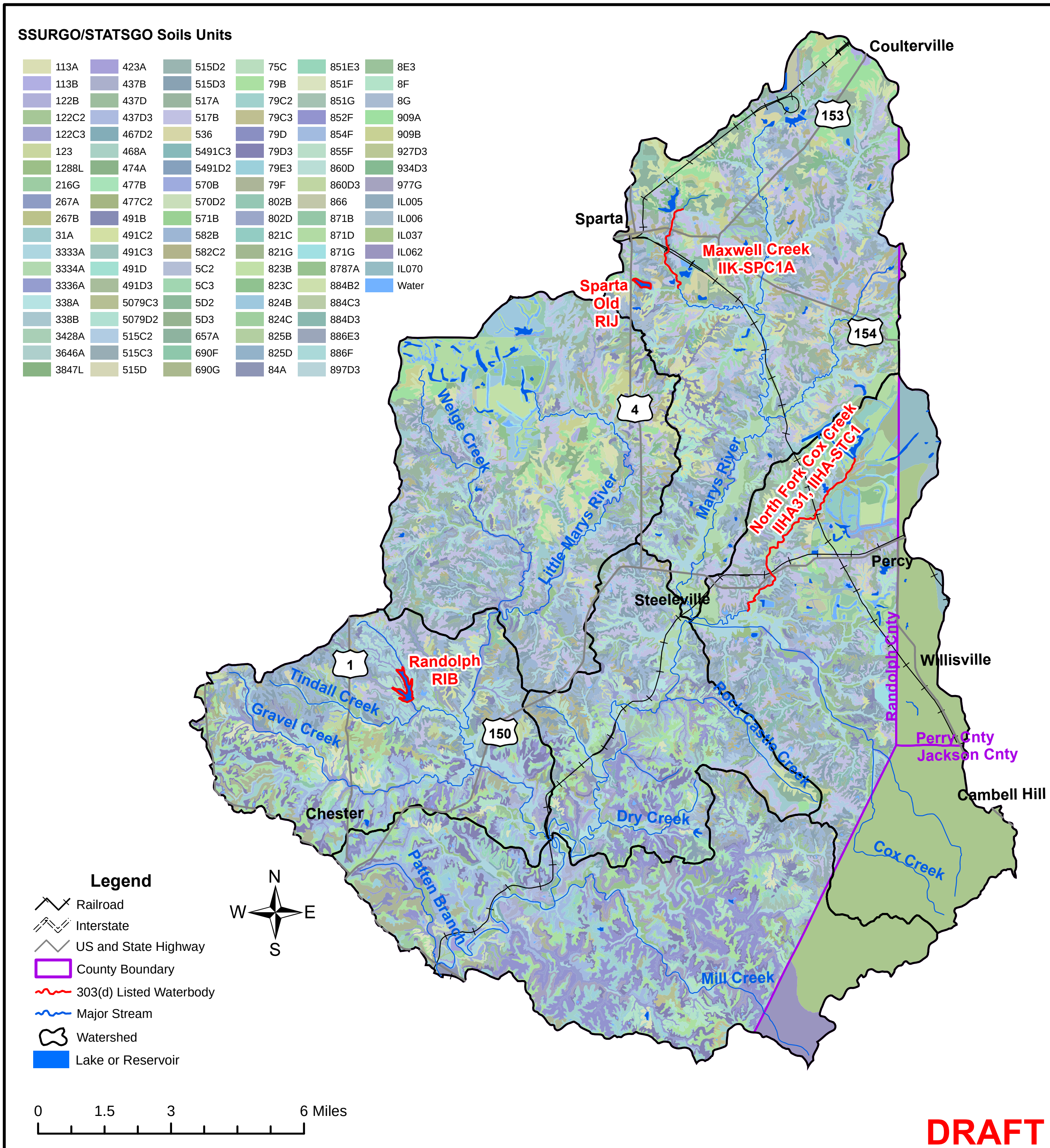

Figure 2-3
Mary's River/N. Fork Cox Creek Watershed
Soils

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Section 3
Public Participation and Involvement

3.1 Mary's River/North Fork Cox Creek Watershed Public Participation and Involvement

Public knowledge, acceptance, and follow through are necessary to implement a plan to meet recommended TMDLs. It is important to involve the public as early in the process as possible to achieve maximum cooperation and counter concerns as to the purpose of the process and the regulatory authority to implement any recommendations.

Illinois EPA, along with CDM, will hold up to four public meetings within the watershed throughout the course of the TMDL development. This section will be updated once public meetings have occurred.

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Section 4
Mary's River/North Fork Cox Creek Watershed Water Quality Standards

4.1 Illinois Water Quality Standards

Water quality standards are developed and enforced by the state to protect the "designated uses" of the state's waterways. In the state of Illinois, setting the water quality standards is the responsibility of the Illinois Pollution Control Board (IPCB). Illinois is required to update water quality standards every three years in accordance with the CWA. The standards requiring modifications are identified and prioritized by Illinois EPA, in conjunction with USEPA. New standards are then developed or revised during the three-year period.

Illinois EPA is also responsible for developing scientifically based water quality criteria and proposing them to the IPCB for adoption into state rules and regulations. The Illinois water quality standards are established in the Illinois Administrative Rules Title 35, Environmental Protection; Subtitle C, Water Pollution; Chapter I, Pollution Control Board; Part 302, Water Quality Standards.

4.2 Designated Uses

The waters of Illinois are classified by designated uses, which include: General Use, Public and Food Processing Water Supplies, Lake Michigan, and Secondary Contact and Indigenous Aquatic Life Use (Illinois EPA 2005). The designated uses applicable to the Mary's River/North Fork Cox Creek watershed are the General Use and Public and Food Processing Water Supplies Use.

4.2.1 General Use

The General Use classification is defined by IPCB as: The General Use standards will protect the state's water for aquatic life, wildlife, agricultural use, secondary contact use and most industrial uses and ensure the aesthetic quality of the state's aquatic environment. Primary contact uses are protected for all General Use waters whose physical configuration permits such use.

4.2.2 Public and Food Processing Water Supplies

The Public and Food Processing Water Supplies Use is defined by IPCB as: These are cumulative with the general use standards of Subpart B and must be met in all waters designated in Part 303 at any point at which water is withdrawn for treatment and distribution as a potable supply or for food processing.

4.3 Illinois Water Quality Standards

To make 303(d) listing determinations for aquatic life uses, Illinois EPA first collects biological data and if this data suggests that impairment to aquatic life is occurring, then a comparison of available water quality data with water quality standards occurs. For public and food processing water supply waters, Illinois EPA compares available data with water quality standards to make impairment determinations. Tables 4-1 and 4-2 present the water quality standards of the potential causes of impairment for both lakes and streams in the Mary's River/North Fork Cox Creek watershed. Only constituents with numeric water quality standards will have TMDLs developed at this time.

Table 4-1 Summary of Water Quality Standards for Potential Mary's River/North Fork Cox Creek Watershed Lake Impairments

Parameter	Units	General Use Water Quality Standard	Public and Food Processing Water Supplies
Excess Algal Growth	NA	No numeric standard	No numeric standard
Habitat Alterations (Lake)	NA	No numeric standard	No numeric standard
Manganese	µg/L	1000	150
Total Phosphorus	mg/L	0.05[1]	No numeric standard
Total Suspended Solids	NA	No numeric standard	No numeric standard

µg/L = micrograms per liter mg/L = milligrams per liter

NA = Not Applicable

(1) Standard applies in particular inland lakes and reservoirs (greater than 20 acres) and in any stream at the point where it enters any such lake or reservoir.

Table 4-2 Summary of Water Quality Standards for Potential Mary's River/North Fork Cox Creek Watershed Stream Impairments

Parameter	Units	General Use Water Quality Standard	Public and Food Processing Water Supplies
Endrin - Statistical Guideline	NA	No numeric standard	No numeric standard
Habitat Alterations (Streams)	NA	No numeric standard	No numeric standard
Oxygen, Dissolved	mg/L	5.0 instantaneous minimum; 6.0 minimum during at least 16 hours of any 24 hour period	No numeric standard
Sedimentation/Siltation	NA	No numeric standard	No numeric standard
Sulfates	mg/L	500	250
Total Dissolved Solids	µg/L	1000	500
Total Nitrogen as N	NA	No numeric standard	No numeric standard
Total Phosphorus - Statistical Guideline	NA	No numeric standard	No numeric standard

µg/L = micrograms per liter mg/L = milligrams per liter NA = Not Applicable

4.4 Potential Pollutant Sources

In order to properly address the conditions within the Mary's River/North Fork Cox Creek watershed, potential pollution sources must be investigated for the pollutants where TMDLs will be developed. The following is a summary of the potential sources associated with the listed causes for the 303(d) listed segments in this watershed. They are summarized in Table 4-3.

Table 4-3 Summary of Potential Sources for Mary's River/North Fork Cox Creek Watershed

Segment ID	Segment Name	Potential Causes	Potential Sources
IIHA31	North Fork Cox Creek	Sulfates, sedimentation/siltation, total dissolved solids, habitat alterations (streams), endrin	Agriculture, crop-related sources, nonirrigated crop production, urban runoff/storm sewers, resource extraction/surface mining, habitat modification (other than hydromodificaiton), removal of riparian vegetation, bank or shoreline modification/destabilization
IIHA-STC1	North Fork Cox Creek	Sedimentation/siltation, total dissolved solids	Municipal point sources, agriculture, crop-related sources, nonirrigated crop production, urban runoff/storm sewers, resource extraction, surface mining
IIK-SPC1A	Maxwell Creek	Total nitrogen as N, dissolved oxygen, habitat alterations (streams), total phosphorus	Municipal point sources, urban runoff/storm sewers, habitat modification (other than hydromodificaiton), bank or shoreline modification/destabilization
RIB	Randolph County Lake	Total phosphorus, total suspended solids, excess algal growth, habitat alterations (lake)	Agriculture, crop-related sources, nonirrigated crop production, grazing related sources, pasture grazing – riparian and/or upland, habitat modification (other than hydromodification), bank or shoreline modification/destabilization, natural sources, lake fertilization, forest/grassland/parkland
RIJ	Sparta Old Reservoir	Manganese, total phosphorus, excess algal growth	Agriculture, crop-related sources, nonirrigated, source unknown

Section 5
Mary's River/North Fork Cox Creek Watershed Characteristics

Data were collected and reviewed from many sources in order to further characterize the Mary's River/North Fork Cox Creek watershed. Data have been collected in regards to water quality, reservoirs, and both point and nonpoint sources. This information is presented and discussed in further detail in the remainder of this section.

5.1 Water Quality Data

There are 10 historic water quality stations within the Mary's River/North Fork Cox Creek watershed that were used for this report. Figure 5-1 shows the water quality data stations within the watershed that contain data relevant to the impaired segments.

The impaired water body segments in the Mary's River/North Fork Cox Creek watershed were presented in Section 1. Refer to Table 1-1 for impairment information specific to each segment. The following sections address both stream and lake impairments. Data are summarized by impairment and discussed in relation to the relevant Illinois numeric water quality standard. Data analysis is focused on all available data collected since 1990. The information presented in this section is a combination of EPA Storage and Retrieval (STORET) database and Illinois EPA database data. STORET data are available for stations sampled prior to January 1, 1999 while Illinois EPA data (electronic and hard copy) are available for stations sampled after that date. The following sections will first discuss Mary's River/North Fork Cox Creek watershed stream data followed by Mary's River/North Fork Cox Creek watershed lake data.

5.1.1 Stream Water Quality Data

The Mary's River/North Fork Cox Creek watershed has two impaired streams within its drainage area that are addressed in this report. There are four active water quality stations on impaired segments (see Figure 5-1). The data summarized in this section include water quality data for impaired constituents as well as parameters that could be useful in future modeling and analysis efforts. All historic data are available in Appendix C.

5.1.1.1 Dissolved Oxygen

Segment IIK-SP-C1A of Maxwell Creek in the Mary's River/North Fork Cox Creek watershed is listed for an impairment potentially caused by dissolved oxygen (DO). Table 5-1 summarizes the available historic DO data since 1990 for the impaired stream segments (raw data contained in Appendix C). The table also shows the number of violations for the segment. A sample was considered a violation if the concentration was below 5.0 mg/L. Both of the available DO samples violated the standard.

Table 5-1 Existing DO Data for Mary's River Watershed Impaired Stream Segments

Sample Location and Parameter	Illinois WQ Standard (mg/L)	Period of Record and Number of Data Points	Mean	Maximum	Minimum	Number of Violations
Maxwell Creek Segment IIK-SPC1A; Sample Locations IIK-SPC1 and IIK-SPC3						
DO	5.0[(1)]	1999; 2	2.6	2.6	2.5	2

(1) Instantaneous Minimum

Table 5-2 contains information on data availability for other parameters that may be useful in data needs analysis and future modeling efforts for DO. Where available, all nutrient, biological oxygen demand (BOD), and total organic carbon data has been collected for possible use in future analysis.

Table 5-2 Data Availability for DO Data Needs Analysis and Future Modeling Efforts

Sample Location and Parameter	Available Period of Record post-1990	Number of Samples
Maxwell Creek Segment IIK-SPC1A; Sample Locations IIK-SPC1 and IIK-SPC3		
BOD	1999	2
BOD, Carbonaceous	1999	2
Carbon, Total Organic (mg/L)	1999	2
Nitrogen, Ammonia (NH3), Total mg/L	1999	2
Nitrogen, Nitrite (NO2) + Nitrate (NO3) (mg/L)	1999	2
Phosphorus as P, Total mg/L	1999	2

5.1.1.2 Chemical Constituents: Sulfates and Total Dissolved Solids

North Fork Cox Creek segment IIHA-31 is listed for an exceedance of the sulfates criterion. The applicable water quality criterion for sulfates is a maximum total sulfate concentration of 500 mg/L. North Fork Cox Creek segments IIHA-31 and IIHA-STC1 are listed for exceedances of the total dissolved solids (TDS) criterion. The applicable water quality criterion for TDS is a maximum TDS concentration of 1,000 mg/L. Standards for general use cannot be exceeded except where mixing is allowed as provided in 35 Ill. Adm. Code 302.102.

Table 5-3 summarizes the available historic sulfate and TDS data since 1990 for the impaired stream segments. The table also shows the number of violations for each segment.

Table 5-3 Existing Chemical Constituents Data (Sulfates and Total Dissolved Solids)

Sample Location and Parameter	Illinois WQ Standard (mg/L)	Period of Record and Number of Data Points	Mean	Maximum	Minimum	Number of Violations
North Fork Cox Creek Segment IIHA-STC1; Sample Location IIHA-STC1						
TDS (mg/L)	1,000	1995; 1	1,974	1,974	1,974	1
North Fork Cox Creek Segment IIHA31; Sample Location IIHA31						
Sulfates (mg/L)	500	1995-1996; 2	1,025	1,370	680	2
TDS (mg/L)	1,000	1995-1996; 2	2,428	3,215	1,640	2

5.1.2 Lake Water Quality Data

The Mary's River/North Fork Cox Creek watershed has two impaired lakes within its drainage area that are addressed in this report. The data summarized in this section include water quality data for impaired constituents as well as parameters that could be useful in future modeling and analysis efforts. All historic data are available in Appendix C.

5.1.2.1 Randolph County Lake

There are three active stations in Randolph County Lake. The lake has been listed for impairment caused by total phosphorus. An inventory of all available impairment data at all depths is presented in Table 5-4.

Table 5-4 Randolph County Lake Data Inventory for Impairments

Randolph County Lake Segment RIB; Sample Locations RIB-1, RIB-2, and RIB-3		
RIB-1	**Period of Record**	**Number of Samples**
Total Phosphorus	1992-1994	12
Dissolved Phosphorus	1992-1993	10
Total Phosphorus in Bottom Deposits	1992-1995	3
RIB-2		
Total Phosphorus	1993	5
Dissolved Phosphorus	1993	5
RIB-3		
Total Phosphorus	1993	5
Dissolved Phosphorus	1993	5
Total Phosphorus in Bottom Deposits	1993	2

Table 5-5 contains information on data availability for other parameters that may be useful in data needs analysis and future modeling efforts for total phosphorus. DO at varying depths as well as chlorophyll-a data has been collected where available.

Table 5-5 Randolph County Lake Data Availability for Data Needs Analysis and Future Modeling Efforts

Randolph County Lake Segment RIB; Sample Locations RIB-1, RIB-2, and RIB-3		
RIB-1	**Period of Record**	**Number of Samples**
Chlorophyll-a Corrected	1992-1993	6
Chlorophyll-a Uncorrected	1992-1993	6
Total Depth	1992-1993	16
DO	1992-1993	105
Temperature	1992-1996	106
RIB-2		
Chlorophyll-a Corrected	1993	5
Chlorophyll-a Uncorrected	1993	5
Total Depth	1993	10
DO	1993	49
Temperature	1993	49
RIB-3		
Chlorophyll-a Corrected	1993	5
Chlorophyll-a Uncorrected	1993	5
Total Depth	1993	10
DO	1993	45
Temperature	1991-1993	45

5.1.2.1.1 Total Phosphorus

Compliance with the total phosphorus standard is assessed using samples collected at one-foot depth from the lake surface. The average total phosphorus concentrations at one-foot depth for each year of available data at each monitoring site in Randolph County Lake are presented in Table 5-6. The water quality standard for total phosphorus is 0.05 mg/L.

Table 5-6 Average Total Phosphorus Concentrations (mg/L) in Randolph County Lake at one-foot depth

	RIB-1		RIB-2		RIB-3		Lake Average	
Year	Data Count; Number of Violations	Average	Data Count; Number of Violations	Average	Data Count; Number of Violations	Average	Data Count; Number of Violations	Average
1992	1; 0	0.022	NA	NA	NA	NA	1; 0	0.022
1993	5; 1	0.033	5; 1	0.041	5; 1	0.035	10; 3	0.036

There were no violations in 1992 and three violations in 1993. The three violations were all sampled on April 15, 1993. Because phosphorus samples are limited on Randolph County Lake, Figure 5-2 shows all total phosphorus samples collected at one-foot depth.

5.1.2.2 Sparta Old Reservoir

There are three active stations on Sparta Old Reservoir. The lake is listed for impairment caused by manganese and total phosphorus. An inventory of all available manganese and phosphorus data at all depths is presented in Table 5-7.

Table 5-7 Sparta Old Reservoir Data Inventory for Impairments

Sparta Old Reservoir Segment RIJ; Sample Locations RIJ-1, RIJ-2, RIJ-3		
RIJ-1	**Period of Record**	**Number of Samples**
Total Phosphorus	1991-1999	24
Dissolved Phosphorus	1999	2
Total Phosphorus in Bottom Deposits	1999	1
Total Manganese	1999	5
Manganese Bottom Deposits	1999	1
RIJ-2		
Total Phosphorus	1999	5
Dissolved Phosphorus	1999	5
RIJ-3		
Total Phosphorus	1991-1999	17
Dissolved Phosphorus	1999	5
Total Phosphorus in Bottom Deposits	1999	1
Manganese Bottom Deposits	1999	1

Table 5-8 contains information on data availability for other parameters that may be useful in data needs analysis and future modeling efforts for total phosphorus and manganese. DO and chlorophyll-a data has been collected where available.

Table 5-8 Sparta Old Reservoir Data Availability for Data Needs Analysis and Future Modeling Efforts

Sparta Old Reservoir Segment RIJ; Sample Locations RIJ-1, RIJ-2, RIJ-3		
RIJ-1	**Period of Record**	**Number of Samples**
Chlorophyll-a Corrected	1999	6
Chlorophyll-a Uncorrected	1999	6
Total Depth	1990-1999	20
DO	1999	43
Dissolved Phosphorus	1999	10
Temperature	1999	43
RIJ-2		
Chlorophyll-a Corrected	1999	4
Chlorophyll-a Uncorrected	1999	4
Total Depth	1990-1999	20
DO	1999	27
Temperature	1999	27
RIJ-3		
Chlorophyll-a Corrected	1999	5
Chlorophyll-a Uncorrected	1999	5
Total Depth	1990-1999	20
DO	1999	12
Temperature	1999	12

5.1.2.2.1 Total Phosphorus

The water quality standard for total phosphorus is 0.05 mg/L. Compliance is assessed using samples collected at one-foot depth from the lake surface. The average total phosphorus concentrations at a one-foot depth for each year of available data at each monitoring site in Sparta Old Reservoir are presented in Table 5-9.

Table 5-9 Average Total Phosphorus Concentrations (mg/L) in Sparta Old Lake at one-foot depth

	RIJ-1		RIJ-2		RIJ-3		Lake Average	
Year	Data Count; Number of Violations	Average	Data Count; Number of Violations	Average	Data Count; Number of Violations	Average	Data Count; Number of Violations	Average
1991	6; 6	0.230	NA	NA	6; 6	0.233	6; 6	0.232
1992	6; 6	0.344	NA	NA	6; 6	0.319	6; 6	0.332
1999	5; 5	0.195	5; 5	0.167	5; 5	0.181	15; 15	0.177

All samples have exceeded the 0.05 mg/L total phosphorus standard. Figure 5-3 shows all total phosphorus samples collected at each sampling location on the lake. Average lake values were found by averaging data from each sampling location. Average concentrations were highest at all sites in 1992.

5.1.2.2.2 Manganese

Sparta Old Reservoir is a source of public water. Therefore, the applicable water quality standard for manganese is 150 µg/L. Table 5-10 summarizes available manganese data for Sparta Old Reservoir. Samples were collected between April and July of 1999 at a 9 foot depth. Two of the three samples violated the public water supply standard.

Table 5-10 Average Total Manganese Concentrations in Sparta Old Lake

	RIJ-1			
Year	**Water Quality Standard (mg/L)**	**Data Count**	**Number of Violations**	**Average**
1999	150	3	2	287

5.2 Reservoir Characteristic

There are two impaired reservoirs in the Mary's River/North Fork Cox Creek watershed. Reservoir information that can be used for future modeling efforts was collected from GIS analysis, the US Army Corps of Engineers, the Illinois EPA, and USEPA water quality data. The following sections will discuss the available data for each reservoir.

5.2.1 Randolph County Lake

Located five miles north of Chester in Randolph County, Randolph Lake has a surface area of 65 acres and a shoreline length of approximately 3.8 miles. Table 5-11 contains dam information for the lake, while Table 5-12 contains depth information for each sampling location. The average maximum depth in Randolph County Lake is 32.6 feet.

Table 5-11 Randolph County Lake Dam Information (U.S. Army Corps of Engineers)

Dam Length	665 feet
Dam Height	47 feet
Maximum Discharge	NA
Maximum Storage	1,563 acre-feet
Normal Storage	946 acre-feet
Spillway Width	263 feet
Outlet Gate Type	U

Table 5-12 Average Depths (ft) for Randolph Lake Segment RIB (USEPA STORET)

Year	RIB-1	RIB-2	RIB-3
1992	33.0	–	–
1993	32.1	18.2	16.8
Average	**32.6**	**18.2**	**16.8**

5.2.2 Sparta Old Reservoir

Sparta Old Reservoir is located in Randolph County south of the City of Sparta. In conjunction with Sparta North, Sparta Northwestern Reservoirs, and the Kaskaskia River, the Sparta Old Reservoir provides drinking water to the City of Sparta (Source Water Assessment Program, Illinois EPA 2002). The Sparta Old Reservoir was constructed in 1915 by damming a tributary to Mary's River. Table 5-13 shows dam information for the lake, while Table 5-14 contains depth information for each sampling location. The maximum average water depth is 15.3 feet.

Table 5-13 Sparta Old City Reservoir Lake Dam Information (U.S. Army Corps of Engineers)

Dam Length	650 feet
Dam Height	21 feet
Maximum Discharge	NA
Maximum Storage	289 acre-feet
Normal Storage	198 acre-feet
Spillway Width	101 feet
Outlet Gate Type	U

Table 5-14 Average Depths (ft) for Sparta Old Reservoir Segment RIJ (USEPA STORET)

Year	RIJ-1	RIJ-2	RIJ-3
1990	14.7	9.5	3.1
1991	14.8	8.4	2.6
1992	15.3	8.9	3.2
1993	16.0	10.5	3.5
1999	15.8	8.8	2.9
Average	**15.3**	**9.2**	**3.1**

5.3 Point Sources

Point sources for the Mary's River/North Fork Cox Creek watershed have been separated into municipal/industrial sources and mining discharges. Available data have been summarized and are presented in the following sections.

5.3.1 Municipal and Industrial Point Sources

Permitted facilities must provide Discharge Monitoring Reports (DMRs) to Illinois EPA as part of their NPDES permit compliance. DMRs contain effluent discharge sampling results that are then maintained in a database by the state. There are four point sources located within the Mary's River/North Fork Cox Creek watershed. Point source locations are shown on Figure 5-4. In order to assess point source contributions to the watershed, the data have been examined by receiving water and then by the downstream impaired segment that has the potential to receive the discharge. Receiving waters were determined through information contained in the USEPA Permit Compliance System (PCS) database. Maps were used to determine downstream impaired receiving water information when PCS data was not available. The impairments for each segment or downstream segment were considered when reviewing DMR data. Data have been summarized for any sampled parameter that is associated with a downstream impairment (i.e., all available nutrient and biological oxygen demand data was reviewed for segments that are impaired for DO). This will help in future model selection as well as source assessment and load allocation.

5.3.1.1 North Fork Cox Creek Segments IIHA31 and IIHA-STC1

There are three point sources that discharge directly to or upstream of North Fork Cox Creek segments IIHA31 and IIHA-STC1. Segments IIHA31 and IIHA-STC1 are listed for total dissolved solids (TDS). Segment IIHA31 is also listed for sulfates. Table 5-15 contains a summary of available DMR data for these point sources. No discharge data was available for sulfates or TDS because sampling for these parameters is not required by the discharge permits for these facilities.

Table 5-15 Effluent Data from Point Sources Discharging Directly to or Upstream of North Fork Cox Creek Segments IIHA31 and IIHA-STC1 (Illinois EPA 2005)

Facility Name Period of Record Permit Number	Receiving Water/ Downstream Impaired Waterbody	Constituent	Average Value	Average Loading (lb/d)
Steeleville STP 1993-2005 IL0031241	North Fork Cox Creek/ North Fork Cox Creek Segment IIHA-SCT1	Average Daily Flow	0.5 mgd	NA
Steeleville WTP 1993-2004 IL0051861	NA/North Fork Cox Creek Segment IIHA- SCT1	Average Daily Flow	0.001 mgd	NA
Percy STP 1994-2005 ILG580109	North Fork Cox Creek/ North Fork Cox Creek Segment IIHA31	Average Daily Flow	0.108 mgd	NA

5.3.1.2 Maxwell Creek Segment IIK-SPC1A

There is one permitted facility that discharges to Maxwell Creek Segment IIK-SPC1A. Segment IIK-SPC1A is listed for DO. Table 5-16 contains a summary of available DMR data for this point source.

Table 5-16 Effluent Data from Point Sources Discharging to Maxwell Creek Segment IIK-SPC1A (Illinois EPA 2005)

Facility Name Period of Record Permit Number	Receiving Water/ Downstream Impaired Waterbody	Constituent	Average Value	Average Loading (lb/d)
Sparta Southeast STP 1989-2005 IL0031160	Maxwell Creek/Maxwell Creek Segment IIK- SPC1A	Average Daily Flow	0.65 mgd	NA
		BOD, 5-Day	173.8 mg/L	–
		CBOD, 5-Day	3.53 mg/L	18.0
		Nitrogen, Ammonia	1.71 mg/L	

5.3.1.3 Other Impaired Segments

There are no permitted facilities that discharge directly or through tributaries to Randolph County Lake or Sparta Old Reservoir.

5.3.2 Mining Discharges

There are three NPDES permits for mining within the Mary's River/North Fork Cox Creek watershed. The permits are held by Alpena Vision Resources (previously Old Ben Coal Company), Consolidated Coal Company, and Knight Hawk Coal. Figure 5-5 shows the locations of the mines within the watershed.

Data provided from the State of Illinois include DMRs for each permit. Outfall 296 under permit IL00451 is the discharge from a permanent impoundment left as part of the reclamation plan for a large surface mining area. This outfall discharges on a fairly consistent basis due to the permanent impoundment being fed by shallow groundwater in the area. Under NPDES permit number IL0055824, outfalls 001 and 002 discharge only in response to precipitation events and therefore discharge quite infrequently. The other permitted outfall (Outfall 002 under permit number IL0072575) is associated with a relatively new facility with construction of the basin and outfall occurring in 2003. Until recently, Outfall 002 received drainage from active mining areas. However, the mining activities have been completed and the site is now in reclamation. Because of this, the discharge quality from this basin is expected to improve significantly with time. Table 5-17 contains a summary of available relevant data from each outfall with DMRs.

Table 5-17 Sulfate, Manganese, and pH Pipe Outfall Concentrations

Permit ID and Sample Dates	Pipe Outfall	Flow (cfs)				pH				Manganese (mg/L)				Sulfate (mg/L)			
		# of Samples	Minimum	Maximum	Average	# of Samples	Minimum	Maximum	Average	# of Samples	Minimum	Maximum	Average	# of Samples	Minimum	Maximum	Average
IL0000451 1/02 - 6/05	296	42	0.03	1.61	0.28	42	7.2	8.6	8.0	0				15	162	602	404
IL0055824 1/01 - 5/05	001	15	0.00	0.89	0.12	16	6.8	8.7	7.8	15	0.02	0.65	0.44	14	287	1424	777
	002	17	0.00	0.11	0.03	17	6.5	8.6	7.9	17	0.05	1.93	0.26	17	5	115	15
IL0072575 9/03 - 7/05	002	17	0.00	1.08	0.12	17	7.5	9.0	8.2	0				17	804	2242	1804

5.4 Nonpoint Sources

There are many potential nonpoint sources of pollutant loading to the impaired segments in the Mary's River/North Fork Cox Creek watershed. This section will discuss site-specific cropping practices, animal operations, and area septic systems. Data were collected through communication with the local NRCS, Soil and Water Conservation District (SWCD), public health departments, and county tax department officials.

5.4.1 Crop Information

A portion of the land found within the Mary's River/North Fork Cox Creek watershed is devoted to crops. Corn and soybean farming account for approximately 14 percent and 21 percent of the watershed respectively. Tillage practices can be categorized as conventional till, reduced till, mulch-till, and no-till. The percentage of each tillage practice for corn, soybeans, and small grains by county are generated by the Illinois Department of Agriculture from County Transect Surveys. The most recent survey was conducted in 2004. Data specific to the Mary's River/North Fork Cox Creek watershed were not available; however, the Randolph, Jackson, and Perry County practices were available and are shown in the following tables.

Table 5-18 Tillage Practices in Randolph County

Tillage System	Corn	Soybean	Small Grain
Conventional	76%	28%	46%
Reduced - Till	9%	11%	20%
Mulch – Till	8%	15%	22%
No – Till	7%	46%	11%

Table 5-19 Tillage Practices in Jackson County

Tillage System	Corn	Soybean	Small Grain
Conventional	57%	54%	59%
Reduced - Till	0%	0%	0%
Mulch – Till	17%	18%	41%
No – Till	26%	27%	0%

Table 5-20 Tillage Practices in Perry County

Tillage System	Corn	Soybean	Small Grain
Conventional	1%	3%	0%
Reduced - Till	12%	4%	0%
Mulch – Till	20%	6%	2%
No – Till	66%	88%	98%

No watershed-specific information has been available regarding tile drainage throughout the area. Site-specific data will be incorporated if it becomes available. Without local information, digital land cover data along with SSURGO soils data will be reviewed for information on agricultural lands and hydrologic soil group in order to provide a basis for tile drain estimates.

5.4.2 Animal Operations

Watershed specific animal numbers were not available for the Mary's River/North Fork Cox Creek watershed. Data from the National Agricultural Statistics Service were reviewed and are presented below to show countywide livestock numbers.

Table 5-21 Randolph County Animal Population (2002 Census of Agriculture)

	1997	2002	Percent Change
Cattle and Calves	21,920	17,967	-18%
Beef	8,246	6,540	-21%
Dairy	2,050	2,039	-1%
Hogs and Pigs	27,140	10,034	-63%
Poultry	1,299	182	-86%
Sheep and Lambs	866	660	-24%
Horses and Ponies	NA	708	NA

Table 5-22 Jackson County Animal Population (2002 Census of Agriculture)

	1997	2002	Percent Change
Cattle and Calves	16,066	16,566	3%
Beef	7,833	7,416	-5%
Dairy	542	1,183	118%
Hogs and Pigs	9,975	6,335	-36%
Poultry	510	715	40%
Sheep and Lambs	706	380	-46%
Horses and Ponies	NA	864	NA

Table 5-23 Perry County Animal Population (2002 Census of Agriculture)

	1997	2002	Percent Change
Cattle and Calves	11,968	12,384	3%
Beef	4,601	5,360	16%
Dairy	479	717	50%
Hogs and Pigs	10,253	4,909	-52%
Poultry	488	309	-37%
Sheep and Lambs	768	1,065	39%
Horses and Ponies	NA	232	NA

Illinois EPA provided a GIS shapefile illustrating the location of livestock facilities in the South Mississippi River basin, which includes the Mary's River/North Fork Cox Creek watershed. In 2000, Illinois EPA assessed the potential impact of each facility on water quality with regard to the size of the facility, the site condition and management, pollutant transport efficiency, and water resources vulnerability. The GIS data have been used as a reference since the surveys were conducted at the beginning of the decade. At the time of the survey, there were 32 facilities in existence within the watershed. Twelve of the facilities were classified as feedlots while the remaining facilities were listed as animal management areas. Nine of the animal management areas were dairies. Of the 32 sites, 18 were assessed to have no impact, 12 were assessed to have a slight impact, and 2 were assessed to have a moderate impact. Neither of the moderate impact sites are located on an impaired stream segment.

5.4.3 Septic Systems

Many households in rural areas of Illinois that are not connected to municipal sewers make use of onsite sewage disposal systems, or septic systems. There are a variety of types of septic systems, but the most common septic system is composed of a septic tank draining to a septic field, where nutrient removal occurs. However, the degree of nutrient removal is limited by soils and system upkeep and maintenance.

Information on septic systems in the Mary's River/North Fork Cox Creek watershed has not been available. However, from land use data (Section 2.1), it appears that there are no residences on Sparta Old or Randolph County lakes, which are both have phosphorus listed as causes of impairment.

5.5 Watershed Studies and Other Watershed Information

The extent of previous planning efforts within the Mary's River/North Fork Cox Creek watershed is not known. It is assumed that this information will become available through public meetings within the watershed community. In the event that other applicable watershed-specific information becomes available, it will be reviewed and all applicable data will be incorporated during Stages 2 and 3 of TMDL development.

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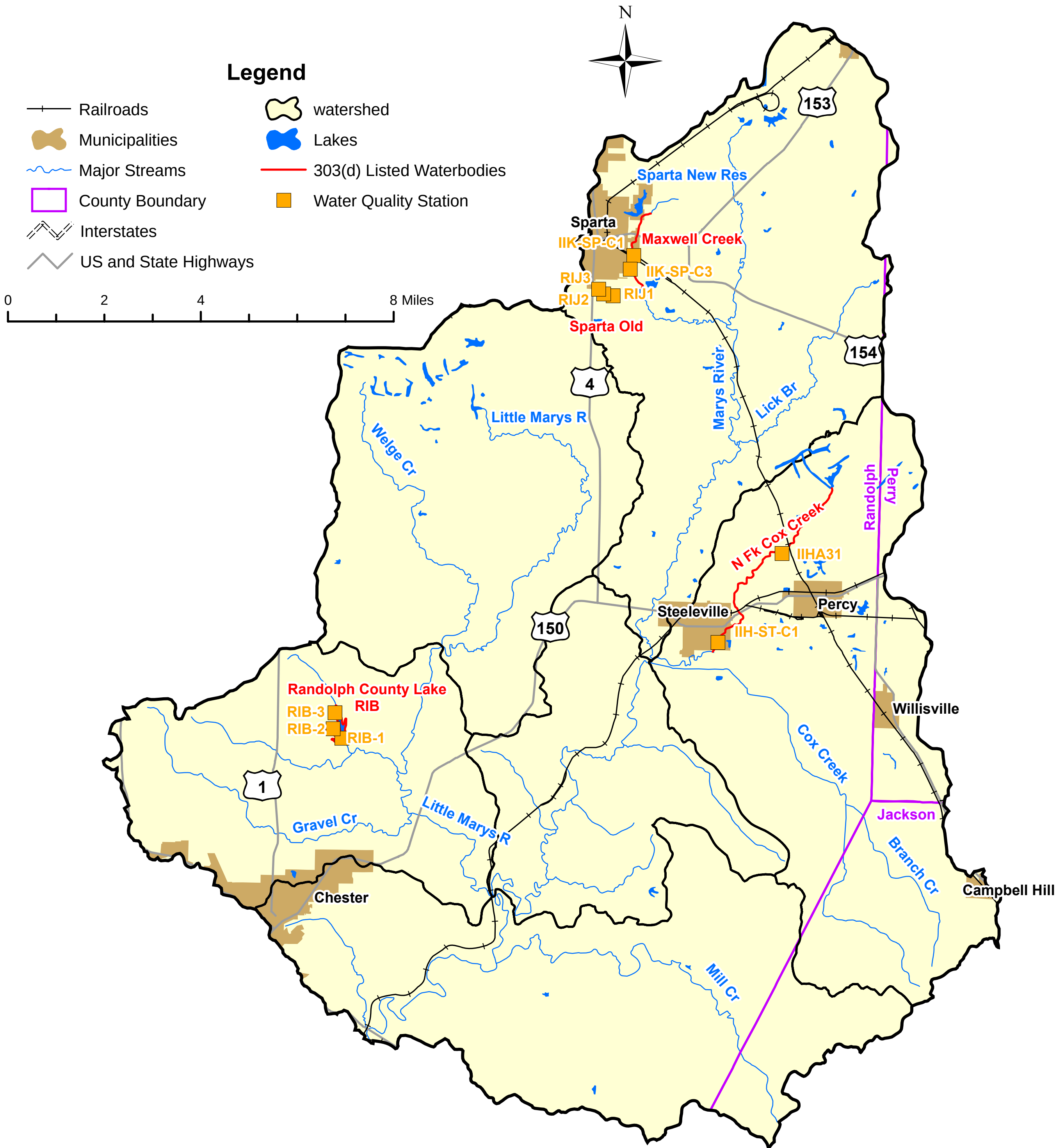

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Figure 5-1:
Water Quality Stations
Marys River - North Fork Cox Creek Watershed

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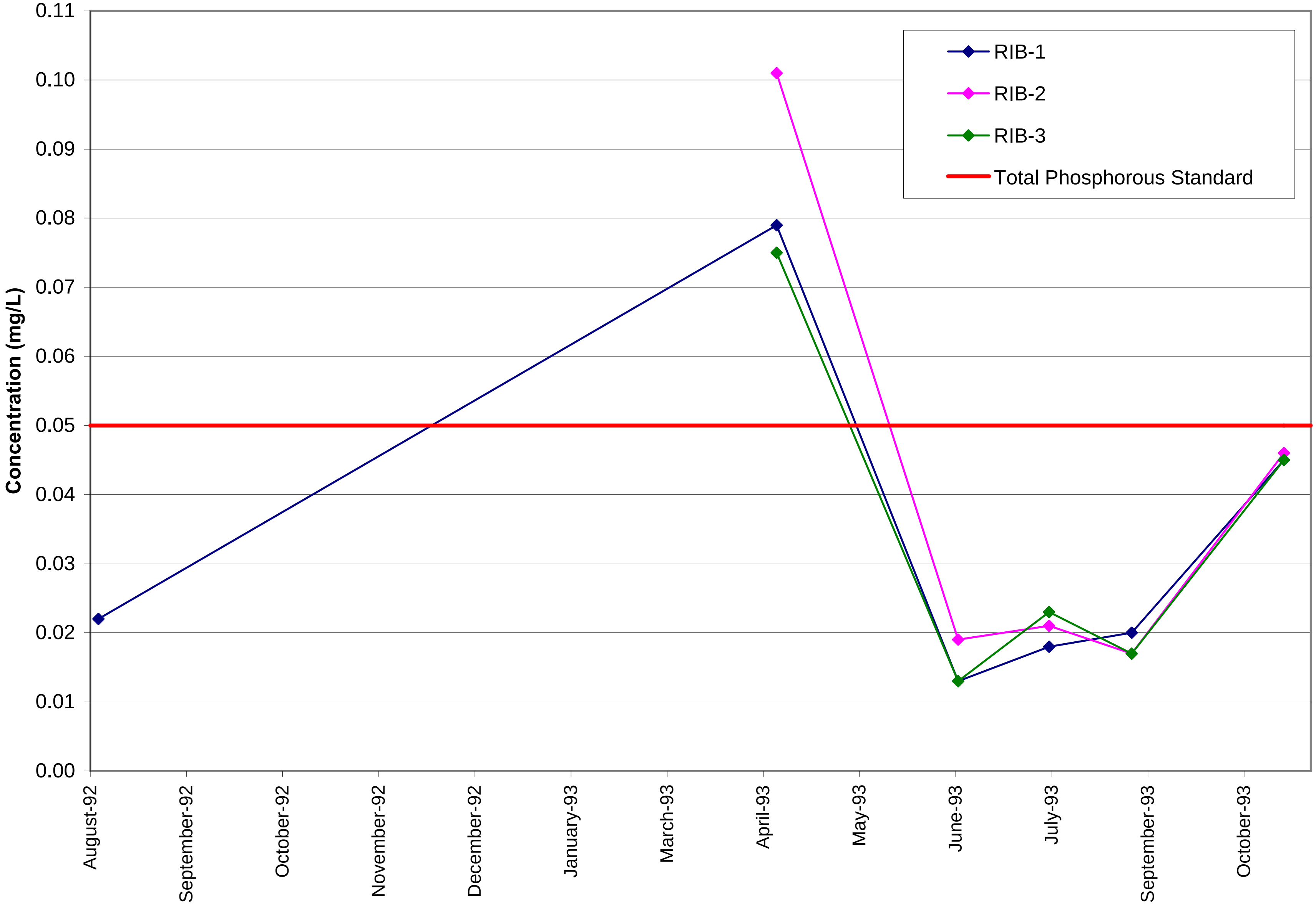

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Figure 5-2:
Randolph County Lake
Total Phosphorous Samples at One-Foot Depth

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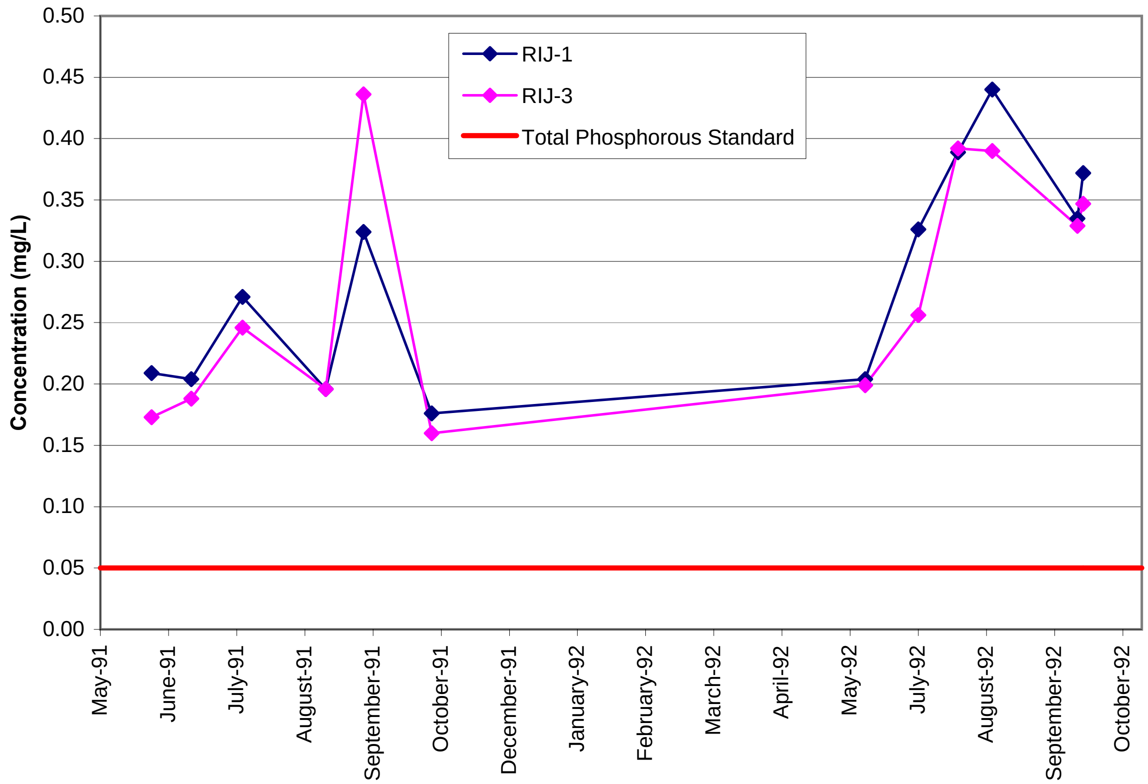

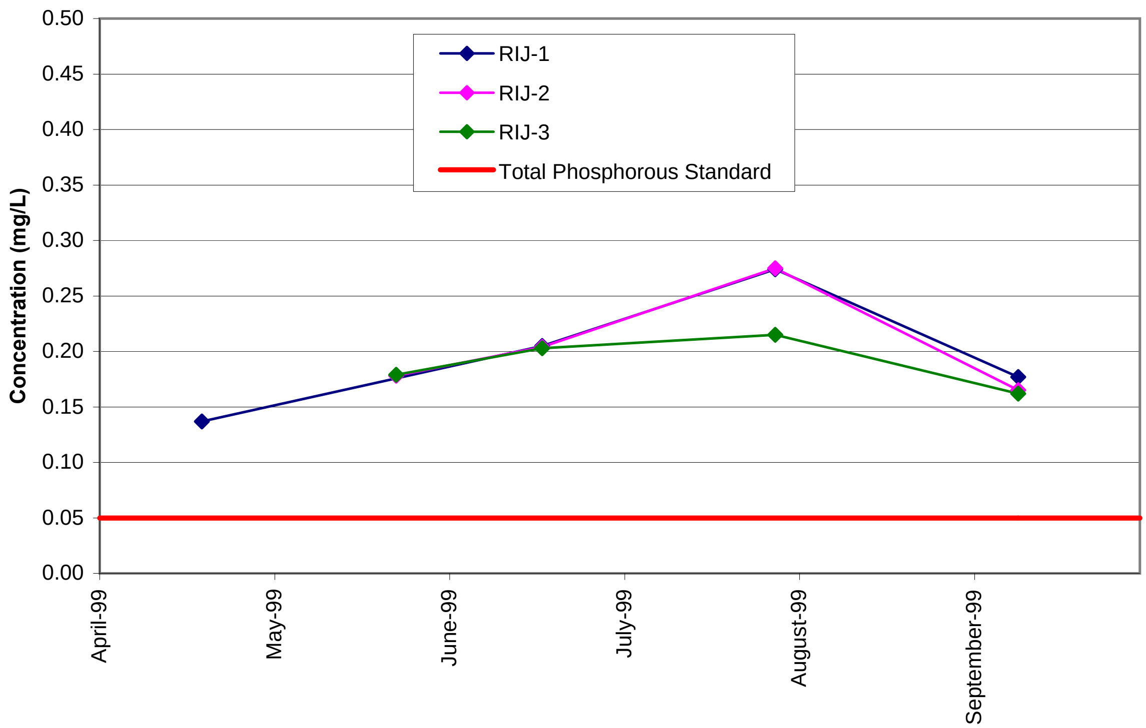

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Figure 5-3:
Sparta Old Lake
Total Phosphorous Samples at One-foot Depth

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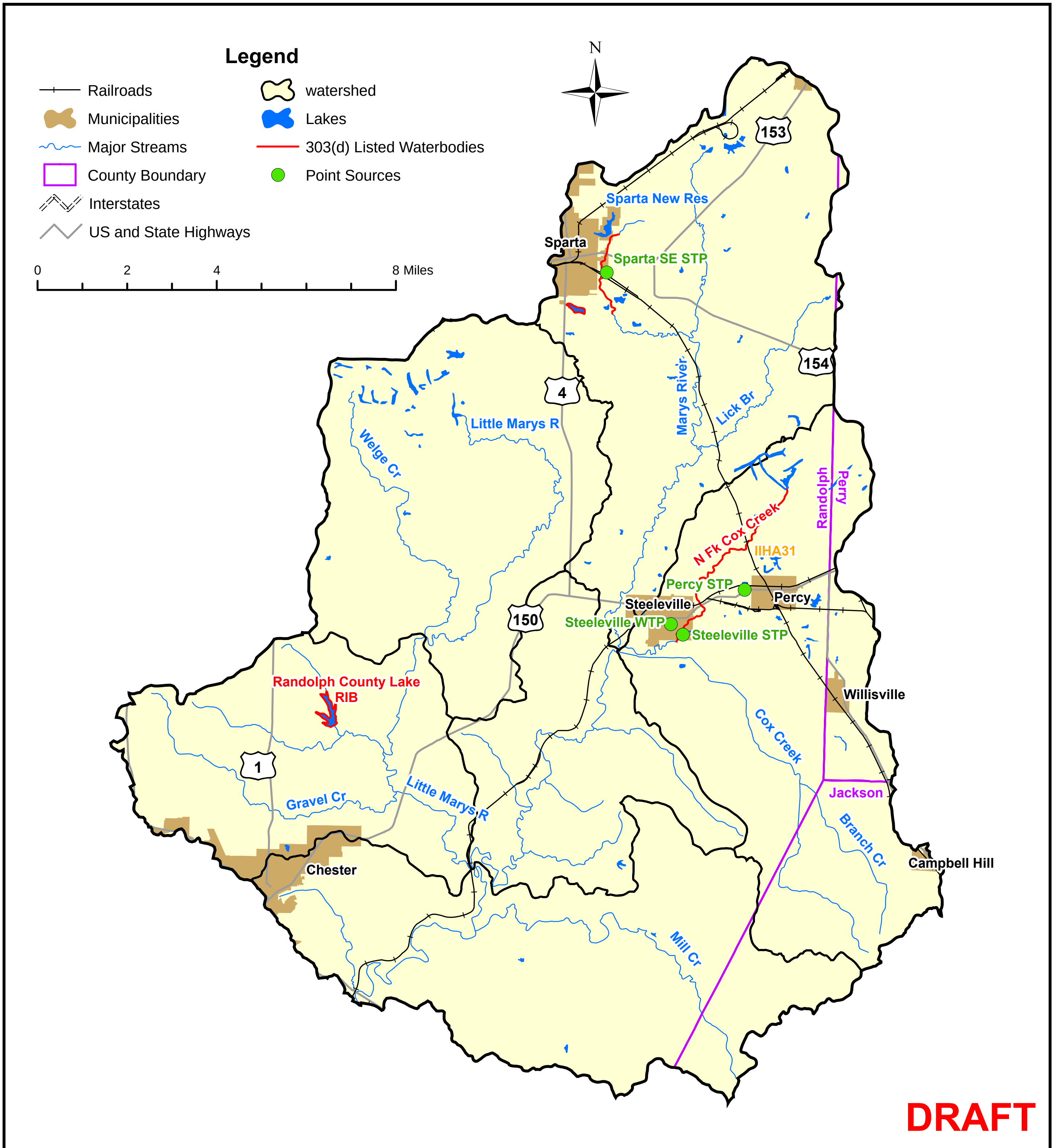

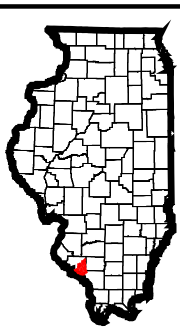

Figure 5-4:
NPDES Permits
Marys River - North Fork Cox Creek Watershed

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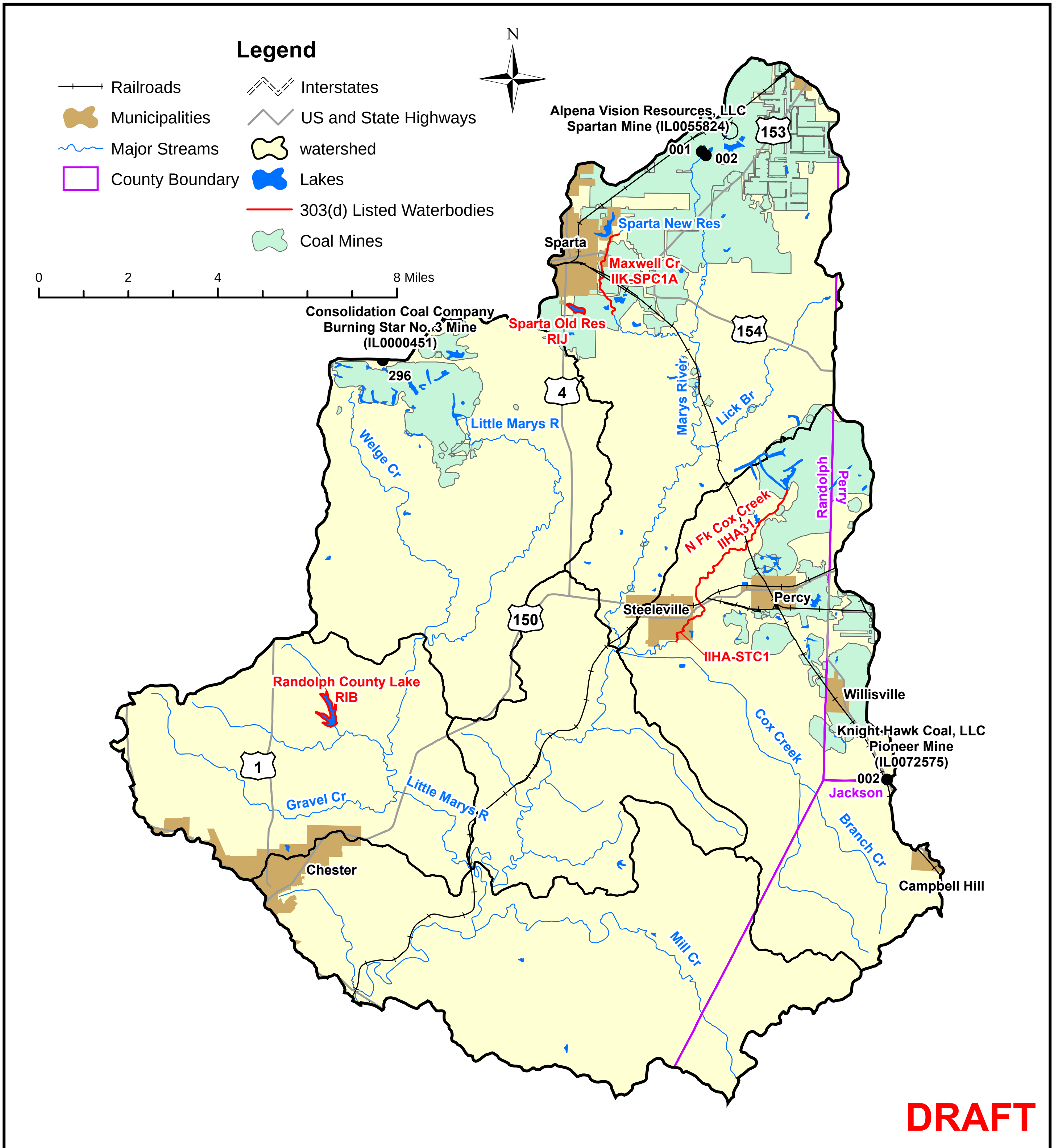

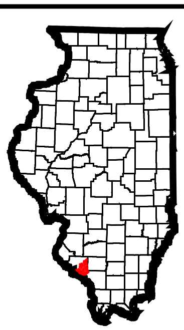

Figure 5-5
Coal Mines
Marys River - North Fork Cox Creek Watershed

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Section 6
Approach to Developing TMDL and Identification of Data Needs

Illinois EPA is currently developing TMDLs for pollutants that have numeric water quality standards. Of the pollutants impairing stream segments in the Mary's River/ North Fork Cox Creek watershed, dissolved oxygen, TDS, and sulfates are the parameters with numeric water quality standards. For lakes within the watershed, manganese and total phosphorus are the parameters with numeric water quality standards. Refer to Table 1-1 for a list of all segments and associated impairments. Illinois EPA believes that addressing these impairments should lead to an overall improvement in water quality due to the interrelated nature of the other listed pollutants. Refer to Table 1-1 for a list of all impairments within the watershed. Recommended technical approaches for developing TMDLs for streams and lakes are presented in this section. Additional data needs are also discussed.

6.1 Simple and Detailed Approaches for Developing TMDLs

The range of analyses used for developing TMDLs varies from simple to complex. Examples of a simple approach include mass-balance, load-duration, and simple watershed and receiving water models. Detailed approaches incorporate the use of complex watershed and receiving water models. Simple approaches typically require less data than detailed approaches and therefore these are the analyses recommended for the Mary's River/North Fork Cox Creek watershed except for stream segments with major point sources whose NDPES permit may be affected by the TMDL's WLA. Establishing a link between pollutant loads and resulting water quality is one of the most important steps in developing a TMDL. As discussed above, this link can be established through a variety of techniques. The objective of the remainder of this section is to recommend approaches for establishing these links for the constituents of concern in the Mary's River/North Fork Cox Creek watershed.

6.1.1 Recommended Approach for DO TMDLs for Segments with Major Point Sources

Maxwell Creek segment IIK-SP-CIA receives effluent from the Sparta facility. For this segment a more complicated approach that would also incorporate the impacts of stream plant activity, and possibly sediment oxygen demand (SOD), and would require a more sophisticated numerical model and an adequate level of measured data to aide in model parameterization is recommended.

Available instream water quality data for the impaired stream segment are very limited, particularly spatially. Therefore additional data collection is recommended for the segment. Specific data requirements include a synoptic (snapshot in time) water quality survey of this reach with careful attention to the location of the point source dischargers. This survey should include measurements of flow, hydraulics, DO, temperature, nutrients, and CBOD. The collected data will be used to support the model development and parameterization and will lend significant confidence to the TMDL conclusions.

This newly collected data could then be used to support the development and parameterization of a more sophisticated DO model for this stream and therefore, the use of the QUAL2E model (Brown and Barnwell 1985) could be utilized to accomplish the TMDL analysis for Maxwell Creek. QUAL2E is well-known and USEPA-supported. It simulates DO dynamics as a function of nitrogenous and carbonaceous oxygen demand, atmospheric reaeration, SOD, and phytoplankton photosynthesis and respiration. The model also simulates the fate and transport of nutrients and BOD and the presence and abundance of phytoplankton (as chlorophyll-a). Stream hydrodynamics and temperature are important controlling parameters in the model. The model is essentially only suited to steady-state simulations.

In addition to the QUAL2E model, a simple watershed model such as PLOAD, Unit Area Loads, or the Watershed Management Model is recommended to estimated BOD and nutrient loads from nonpoint sources in the watershed. This model will allow for allocation between point and nonpoint source loads and provide an understanding of percentage of loadings from point sources and nonpoint sources in the watershed.

6.1.2 Recommended Approach for TDS and Sulfate TMDLs

Segment IIHA-31 of North Fork Cox Creek is listed for sulfates and TDS. Segment IIHA-STC1 of North Fork Cox Creek is listed for TDS. The available data on the segments suggest that impairments do exist; however, data are limited to one or two samples collected more than five years ago. It is recommended that more data be collected on both segments to confirm the TDS and sulfate impairments. If the collected data show that the impairments do exist, an empirical loading and spreadsheet analysis will be utilized to calculate these TMDLs.

6.2 Approaches for Developing a TMDL for Lakes in the Mary's River/North Fork Cox Creek Watershed

Recommended TMDL approaches for Randolph County Lake and Sparta Old Reservoir will be discussed in this section.

6.2.1 Recommended Approach for Total Phosphorus TMDLs

Both Randolph County Lake and Sparta Old Reservoir are impaired for phosphorus. Sparta Old Reservoir has had phosphorus samples collected in the past ten years, while Randolph County Lake has not. The last time phosphorus samples were collected on the lake was 1993. It is recommended that more data be collected for Randolph County Lake. Once data have been collected and impairment is confirmed, it is recommended that the BATHTUB model be used for the lake phosphorus assessments in this watershed. The BATHTUB model performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network that accounts for advective and diffusive transport and nutrient sedimentation. The model relies on empirical relationships to predict lake trophic conditions and subsequent DO conditions as functions of total phosphorus and nitrogen loads, residence time, and mean depth. (USEPA 1997). Oxygen conditions in the model are simulated as meta and hypolimnetic depletion rates, rather than explicit concentrations. Watershed loadings to the lakes will be based on empirical data or tributary data available in the lake watersheds.

6.2.2 Recommended Approach for Manganese TMDL

Sparta Old Reservoir is impaired for both total phosphorus and manganese. The applicable water quality standard for manganese is 150 µg/L. It is assumed that the only controllable sources of manganese to the lake are those which enter from lake sediments during periods of low dissolved oxygen. It is thought that the manganese in the lake sediments can be (partially) controlled by reducing phosphorus loads and increasing hypolimnetic DO concentrations. Two sediment samples of manganese have been collected in the lake since 1990. The results of these samples could be used as a screening tool to determine if the assumptions made about manganese sources are plausible. If this is determined to be the case, it is assumed that development of the phosphorus TMDL described above will, in turn, control the manganese concentrations. Therefore, the manganese target is maintenance of hypolimnetic DO concentrations above zero which would prevent manganese bound in the sediment from entering the water column. The lack of DO in lake bottom waters is presumed to be due to the effects of nutrient enrichment, as there are no significant sources of oxygen demanding materials to the lake. For this reason, attainment of the total phosphorus standard is expected to result in oxygen concentrations that will reduce sediment manganese flux to natural background levels. The TMDL target for manganese is set as a total phosphorus concentration of 0.050 mg-P/l. The recommended approach for the lake phosphorus TMDL was discussed above.

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CDM

Illinois Environmental
Protection Agency

Stage 2 Data Report

March 2007

Final Report

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Contents

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Figures

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Tables

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Section 1
Introduction

The Illinois Environmental Protection Agency (Illinois EPA) has a three-stage approach to total maximum daily load (TMDL) development. The stages are:

Stage 1 – Watershed Characterization, Data Analysis, Methodology Selection

Stage 2 – Data Collection (optional)

Stage 3 – Model Calibration, TMDL Scenarios, Implementation Plan

This report addresses data collection associated with Stage 2 TMDL development for the following watersheds:

- Bay Creek
- Cahokia Creek/Holiday Shores Lake
- Cedar Creek/Cedar Lake
- Crab Orchard Creek/Crab Orchard Lake
- Crooked Creek
- Little Wabash River
- Mary's River/North Fork Cox Creek
- Sangamon River/Lake Decatur
- Shoal Creek
- South Fork Saline River/Lake of Egypt
- South Fork Sangamon River/Lake Taylorville

Sampling has been completed based on the recommendations presented in Section 6 of each watershed's Stage 1 TMDL report and the sampling plan described within the quality assurance project plan (QAPP). The Stage 2 data will supplement existing data collected and assessed as part of Stage 1 of TMDL development and will support the development of TMDLs under Stage 3 of the process. Where adequate supporting data exist, data collected during Stage 2 activities may also be used to support the delisting of certain parameters from the state 303(d) list.

The remaining sections of this report contain:

- **Section 2 Field Activities** includes information on sampling locations as well as field parameter, grab sample and continuous monitoring data
- **Section 3 Quality Assurance Review** discusses changes in the sampling plan from the original QAPP, data verification and validity, and conformance to the data quality objectives
- **Section 4 Conclusions** summarizes the Stage 2 work and makes recommendations for moving forward

Section 2
Field Activities

TMDL streams were sampled by CDM twice during the fall of 2006 to collect data needed to support water quality modeling and TMDL development. The first round of Stage 2 data collection took place between August 28 and September 29, 2006. The second round of Stage 2 data collection took place between October 16 and November 17, 2006. In addition, three segments within the Little Wabash River watershed were sampled by Illinois EPA between April and August of 2006. Over the course the sampling project, 32 streams (out of a possible 33) and one lake were sampled within the eleven Stage 2 watersheds. Table 2-1 contains data collection dates for each watershed.

Table 2-1: Stage 2 Data Collection Field Dates

Watershed	First Round Dates (2006)	Second Round Dates (2006)
Bay Creek	9/25-9/29	10/30-11/6
Cahokia Creek/Holiday Shores Lake	8/28-9/6	10/16-10/20
Cedar Lake	9/5-9/14	10/30-11/6
Crab Orchard Lake	9/5-9/14	10/30-11/6
Crooked Creek	9/5-9/14	10/16-10/20
South Fork Saline River/Lake of Egypt	9/25-9/29	10/30-11/6
Little Wabash River - CDM	9/5-9/14	10/30-11/16
Little Wabash River – Illinois EPA	4/18-8/8	
Mary's River	9/5-9/14	10/16-10/20
Sangamon River/Lake Decatur	8/28-9/6	10/30-11/3
Shoal	8/28-9/6	10/16-10/20
South Fork Sangamon River/Lake Taylorville	8/28-9/6	10/30-11/3

Sampling was conducted in accordance with the QAPP by CDM personnel at stream and lake locations with sufficient water and access. When time permitted, alternate locations were investigated if water and/or access were limited at original locations. Figures 2-1 through 2-11 show sampling locations used for Stage 2 data collection for each watershed. Refer to section 3.1 for further information related to sampling location changes from the original QAPP. Appendix A contains pictures of each sampling location. The sampling and analysis activities conducted at each sampling location included:

- In-stream field parameterization
- Grab samples for laboratory analysis
- Continuous monitoring
- Stream gaging

2.1 Instream field parameters

Water quality measurements for pH, temperature, dissolved oxygen (DO), conductivity, and turbidity were taken at each accessible sampling location where water was present using an In-Situ 9500 Profiler water quality meter. In-Situ 9500 Profilers were calibrated each morning of field activity. Water quality readings were taken at each accessible site with adequate water at the center of flow and values were recorded in field books. These values are presented in Table 2-2. Table 2-2 also contains sample location latitude and longitude as well as explanatory information as to why a limited number of sites were not sampled.

At each site with adequate and safely wadeable streamflow, flow measurements were recorded using a Marsh McBirney 2000 flow meter. Appendix B contains flow meter data and stream discharge analysis for these sites.

2.2 Grab Samples

Grab samples were collected based on the causes of impairment identified in the 303(d) list as well as data needed to support TMDL development under Stage 3. Samples collected on Owl Creek and South Fork Sangamon River were analyzed by Prairie Analytical Laboratories in Springfield, IL and all other samples collected by CDM were analyzed by ARDL, Inc in Mt. Vernon, IL. Samples were delivered in person to the laboratory or exchanged with laboratory personnel in the field. Select segments in the Little Wabash watershed (Elm River segment CD01, and Little Wabash River segments C09 and C33) were sampled by Illinois EPA and analyzed by the Illinois EPA Laboratory in Champaign, IL.

Table 2-3 contains data collected at each location associated with impairment status. Values shown in bold face with gray background violated the applicable water quality standard. All data analyzed by the laboratories are contained in Appendix C. This appendix includes the data shown in Table 2-3 as well as all other parameters that were sampled in order to support Stage 3 TMDL development. In addition, Appendix C shows data qualifiers as well as detection limits for all samples.

2.3 Continuous Monitoring

In-Situ 9500 Professional XP multi-parameter data-logging sondes were used for continuous data measurements on streams impaired by low DO and/or pH. The sondes were calibrated prior to deployment then deployed for at least 3 days at select locations with adequate water and access. DO, pH, conductivity and temperature data were recorded at 15 minute intervals during sonde deployment, after which the sonde was removed and data were downloaded to a laptop computer. The continuous data associated with impairment causes are presented in Appendix D. Because sondes were not field checked at the time of retrieval, there is a possibility that some experienced times of drying or build-up of sedimentation during deployment. A column was added to the data presented in Appendix D to estimate acceptable or “suspect” data. Data were deemed suspect when low conductivity or high temperature values indicate that the meter was likely out of the water or also at times when field log books indicated that the sonde had not yet been deployed or had been pulled from the stream. The data that were deemed acceptable were plotted on Figures D-1 through D-26. The charts are grouped by watershed and show data collected during the first and second round of sampling at each location.

Violations of the instantaneous DO standard (5.0 mg/L minimum) were not recorded during either monitoring period on the following segments that are currently listed for impairment caused by low DO:

- Cedar Creek AJF16 (Figure D-1)
- Big Muddy River N99 (Figure D-4)
- Shoal Creek OI05 (Figures D-22 and D-23)
- South Fork Saline River ATH08 (Figure D-24)

According to Table B-2 of the Illinois Integrated Water Quality Report (2006), the aquatic life use may also be impaired if DO concentrations are below 6.0 mg/L for more than 16 hours of any 24 hour period. Appendix D also contains this analysis for the segments that did not violate the instantaneous minimum standard. The number of values recorded below 6.0 mg/L during any 24 hour period were counted and if any count was above 64 (64 values equates to 16 hours worth of data), the stream was considered to be potentially impaired by low DO. The following segments did not experience a violation of either the 5.0 mg/L instantaneous standard or the 6.0 mg/L standard as described above:

- Cedar Creek AJF16 (Figure D-1)
- Shoal Creek OI05 (Figures D-22 and D-23)
- South Fork Saline River ATH08 (Figure D-24)

Violations of the pH standard (6.5 minimum, 9.0 maximum) were not recorded during either monitoring period on the following segments that are currently listed for impairment caused by pH:

- Crab Orchard Creek ND12 (Figure D-5)
- Briers Creek ATHS01 (Figure D-25)

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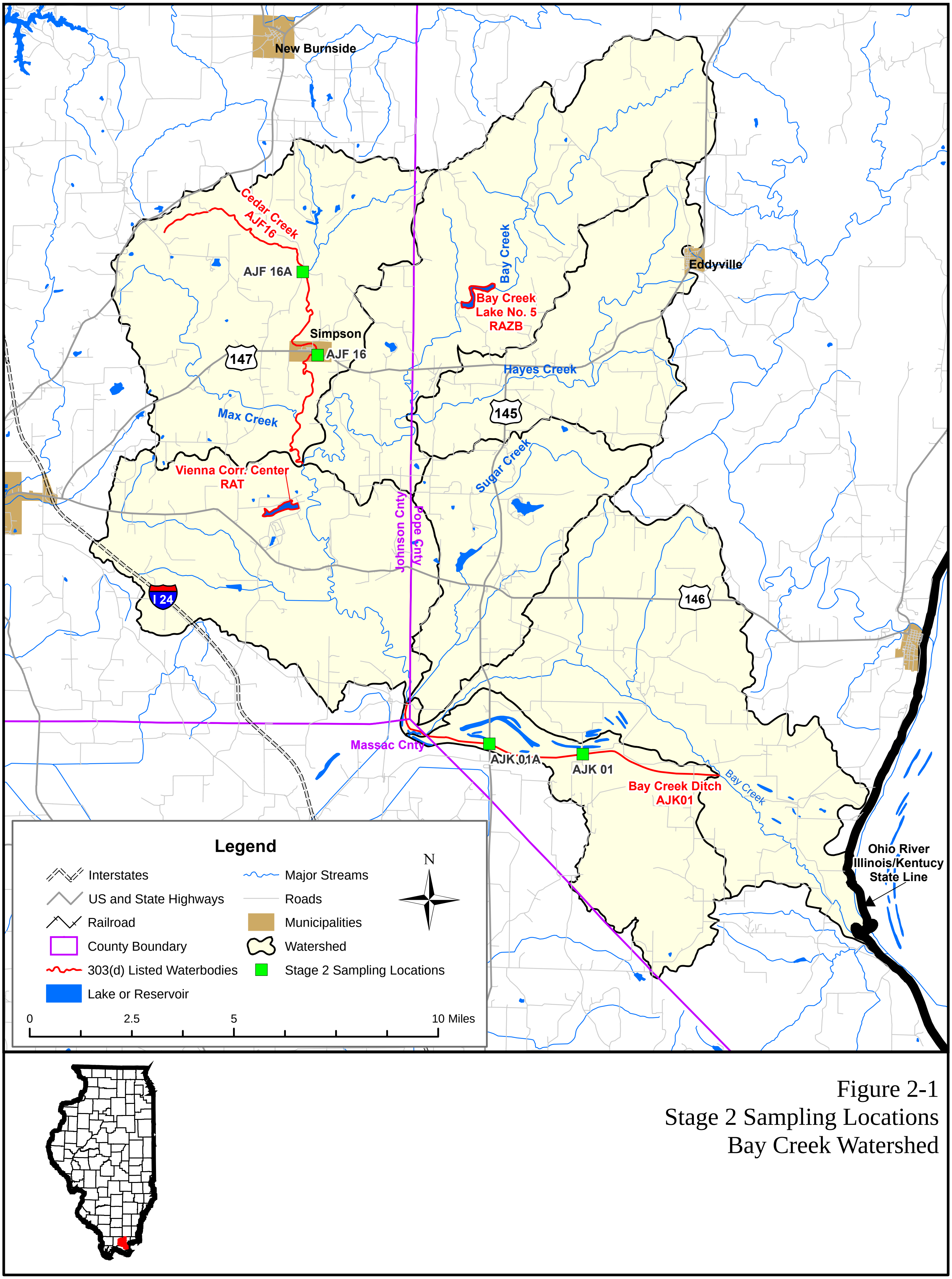

Figure 2-1
Stage 2 Sampling Locations
Bay Creek Watershed

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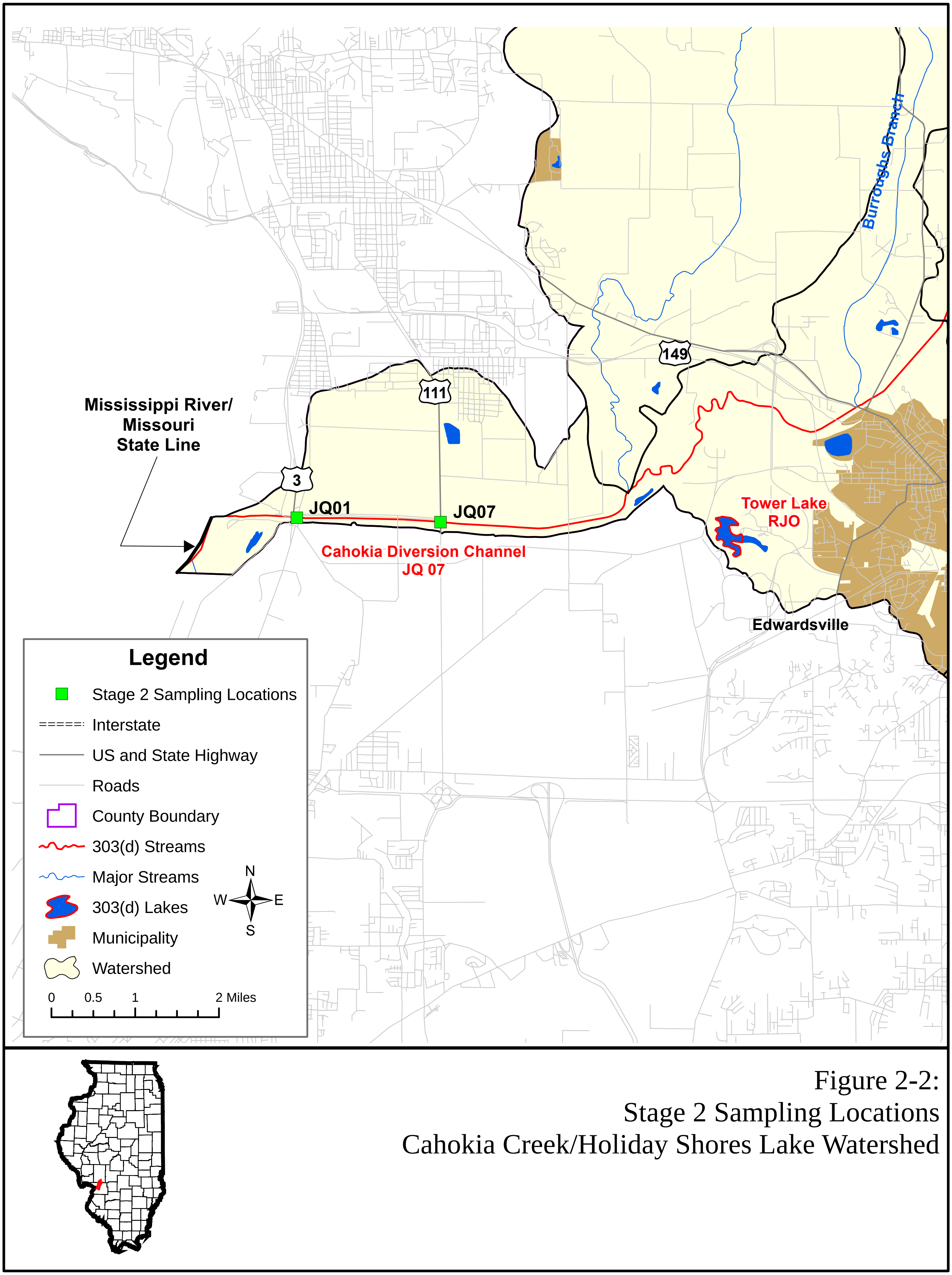

Figure 2-2:
Stage 2 Sampling Locations
Cahokia Creek/Holiday Shores Lake Watershed

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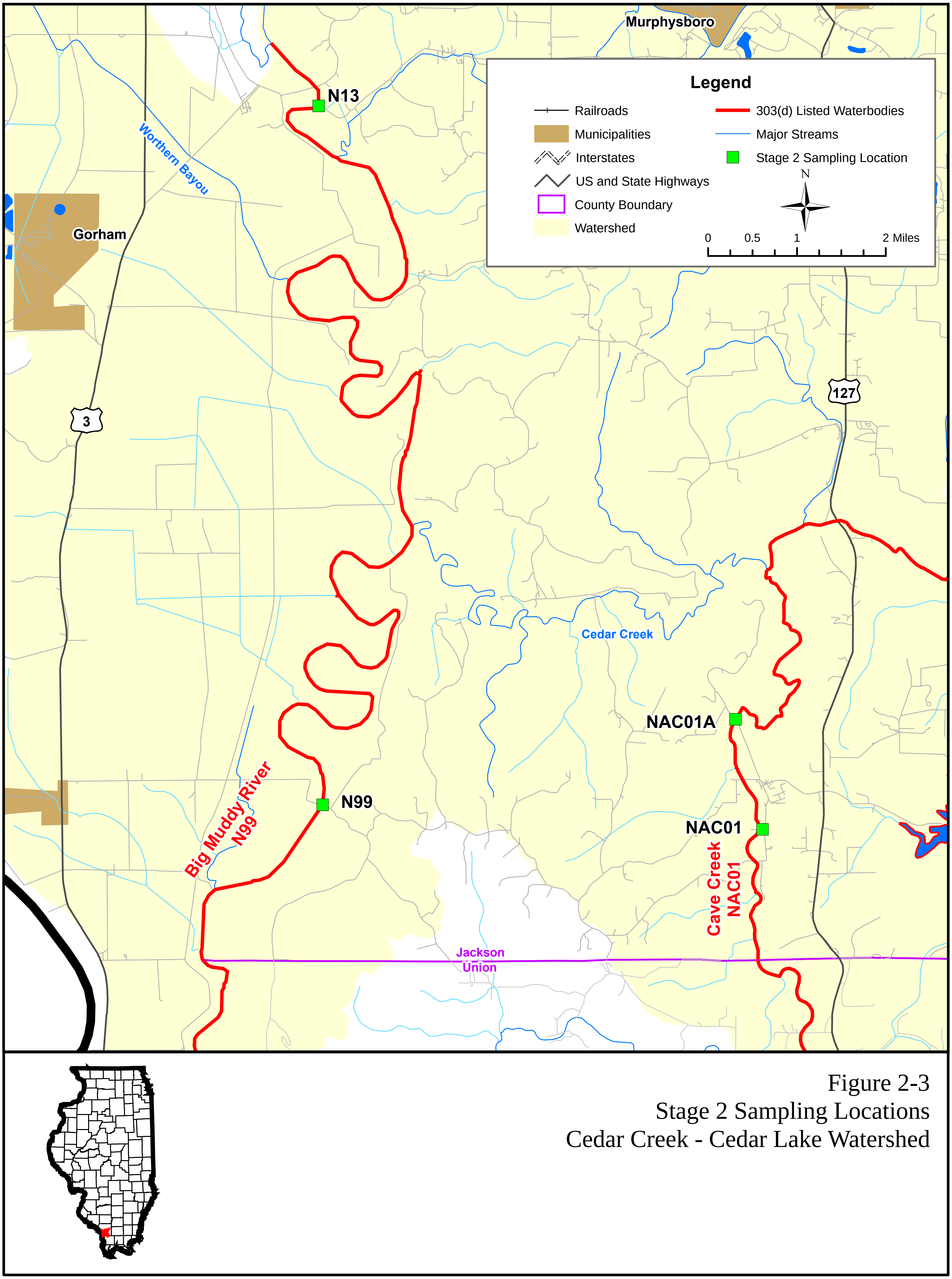

Figure 2-3
Stage 2 Sampling Locations
Cedar Creek - Cedar Lake Watershed

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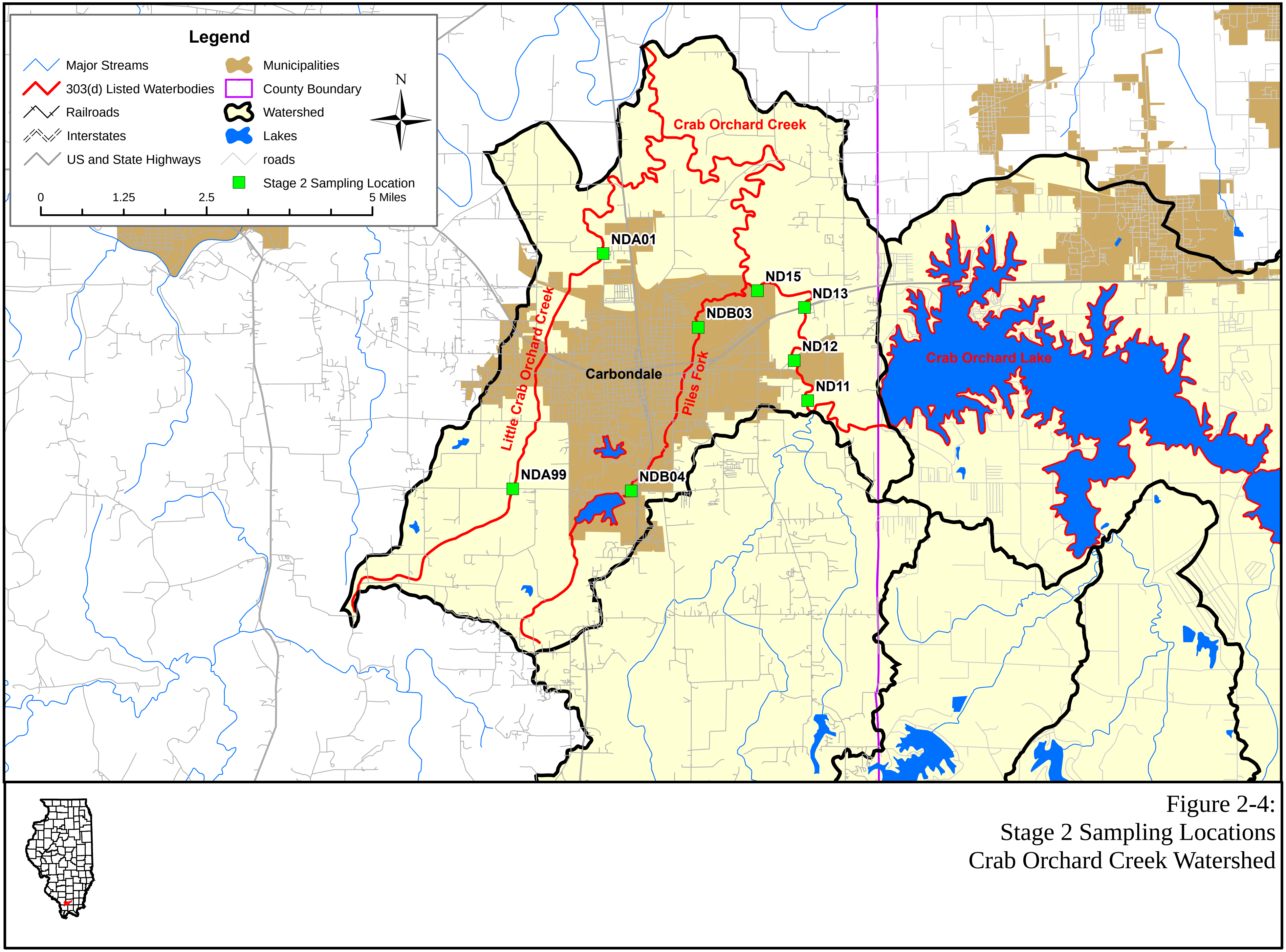

Figure 2-4:
Stage 2 Sampling Locations
Crab Orchard Creek Watershed

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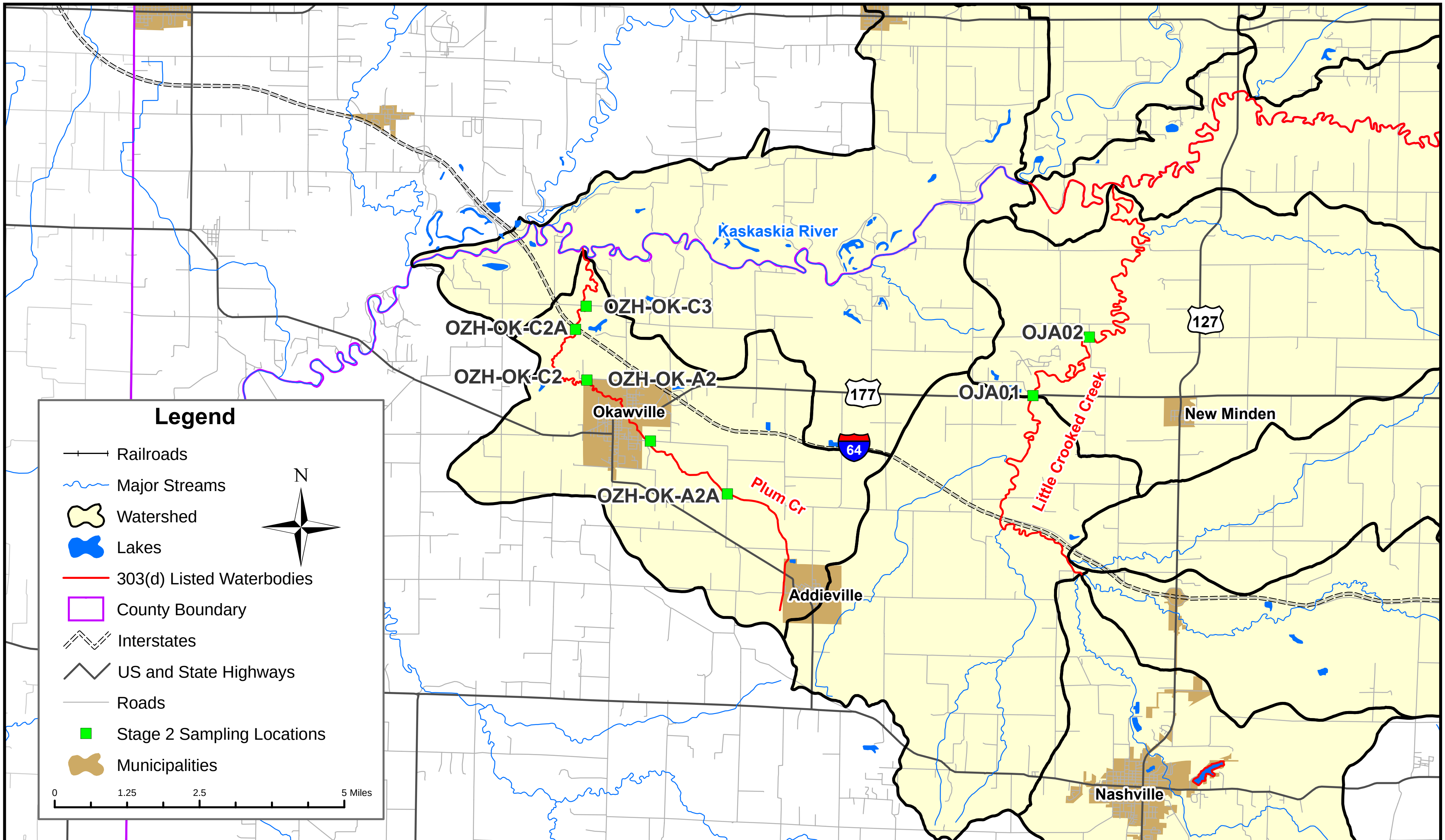

Figure 2-5
Stage 2 Sampling Locations
Crooked Creek Watershed

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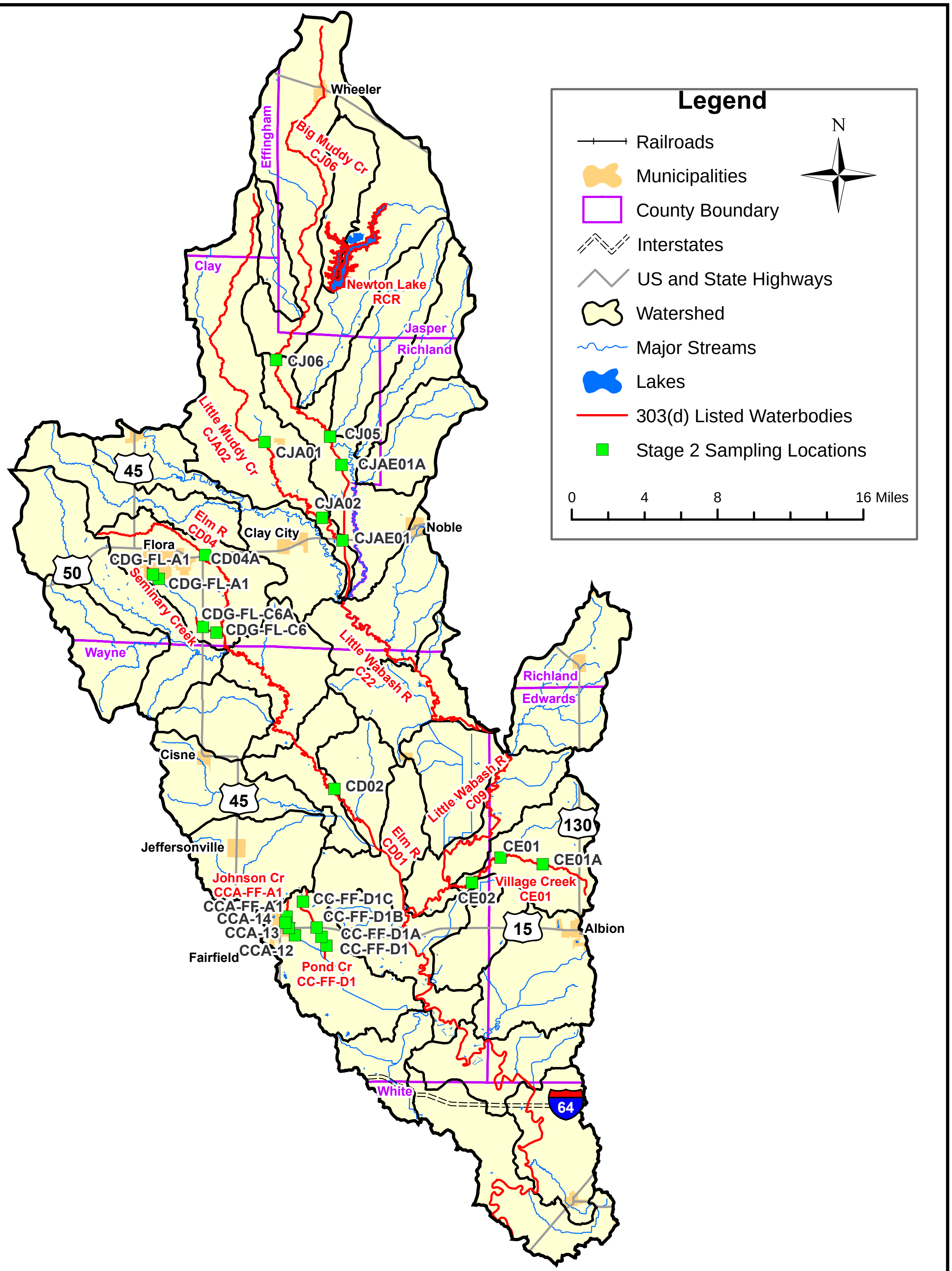

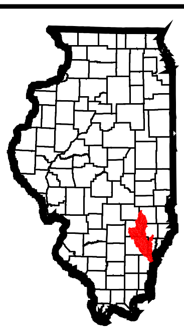

Figure 2-6:
Stage 2 Sampling Locations
Little Wabsash River Watershed

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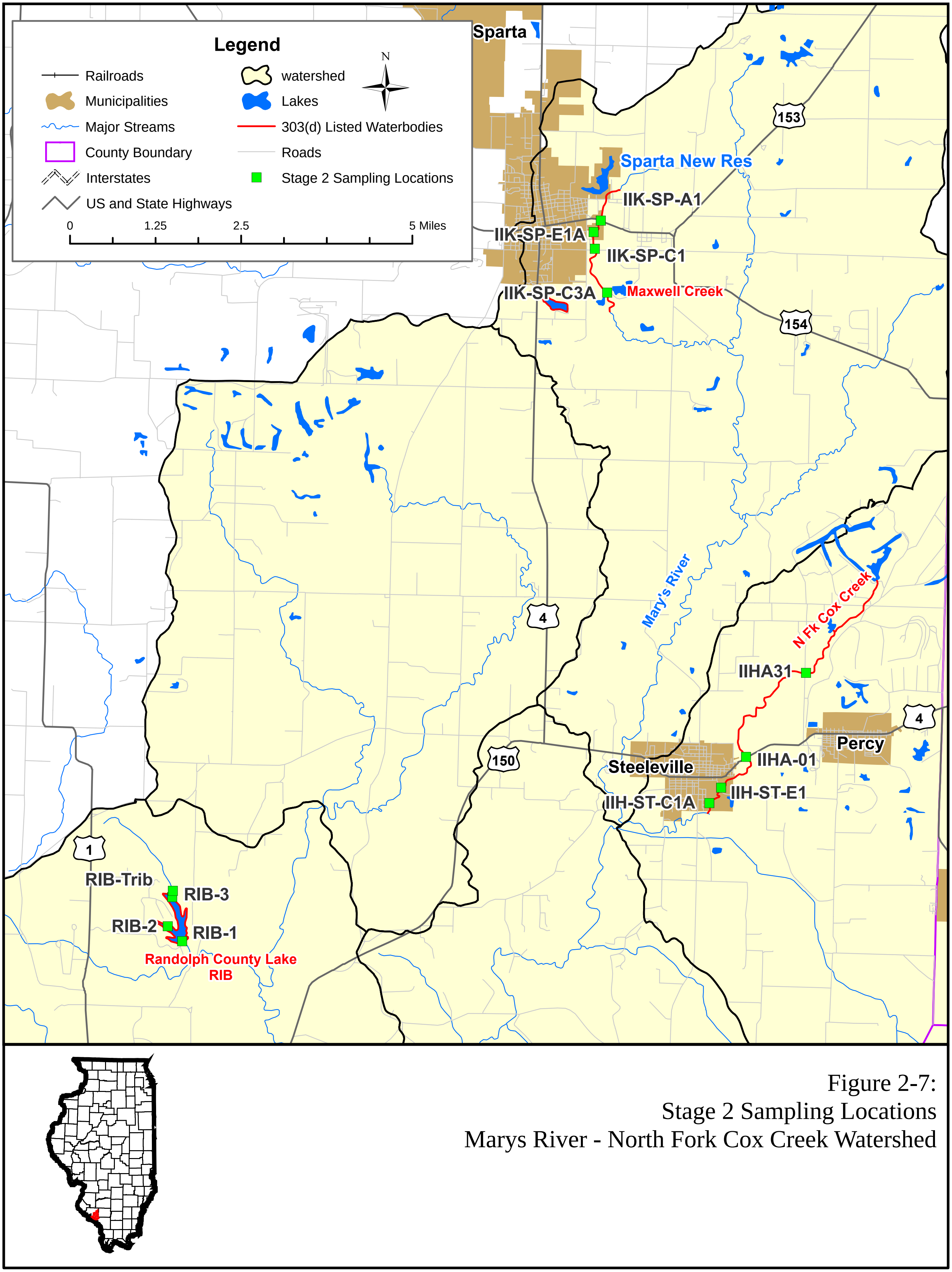

Figure 2-7:
Stage 2 Sampling Locations
Marys River - North Fork Cox Creek Watershed

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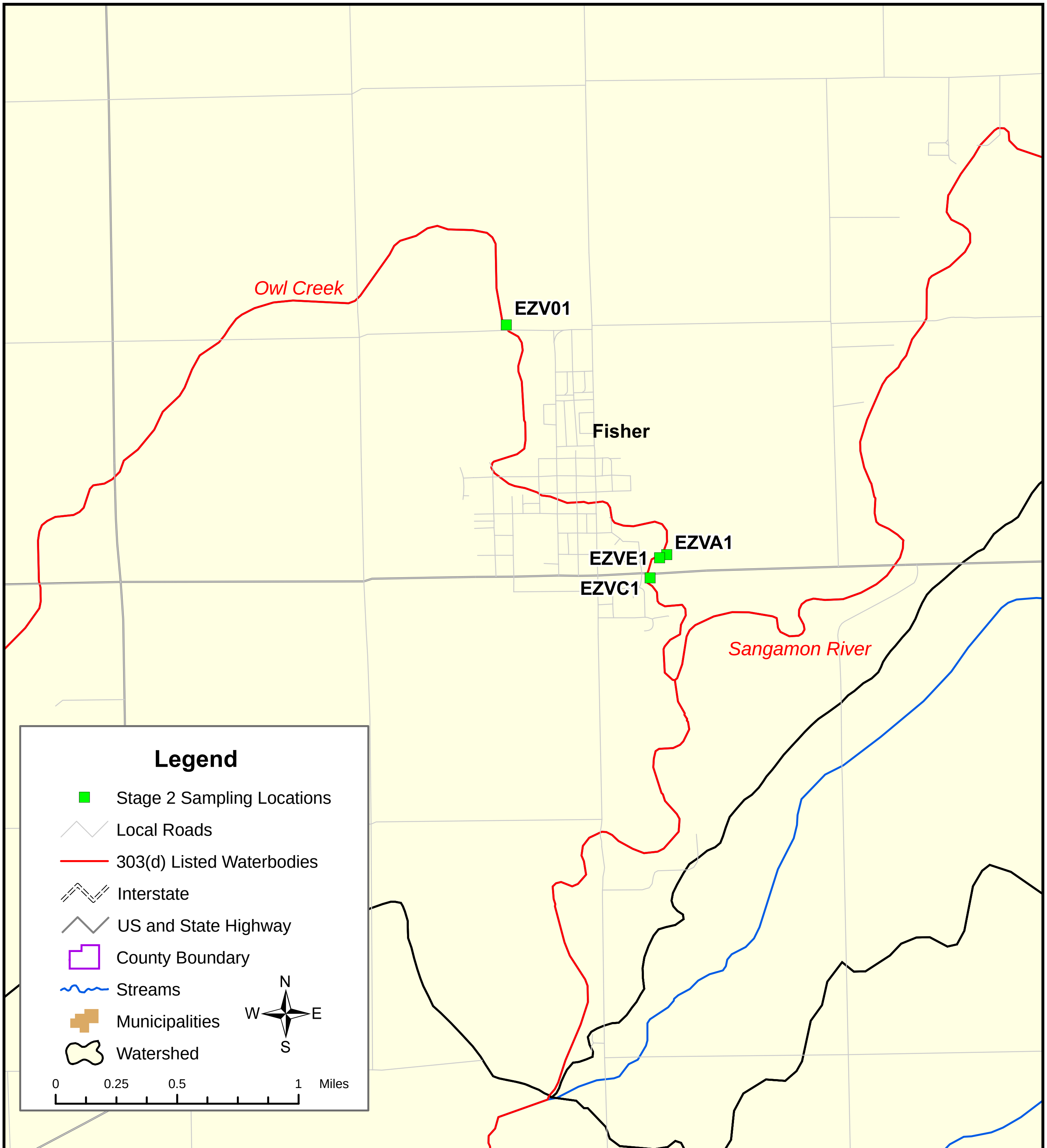

Figure 2-8:
Stage 2 Sampling Locations
Sangamon River - Lake Decatur Watershed

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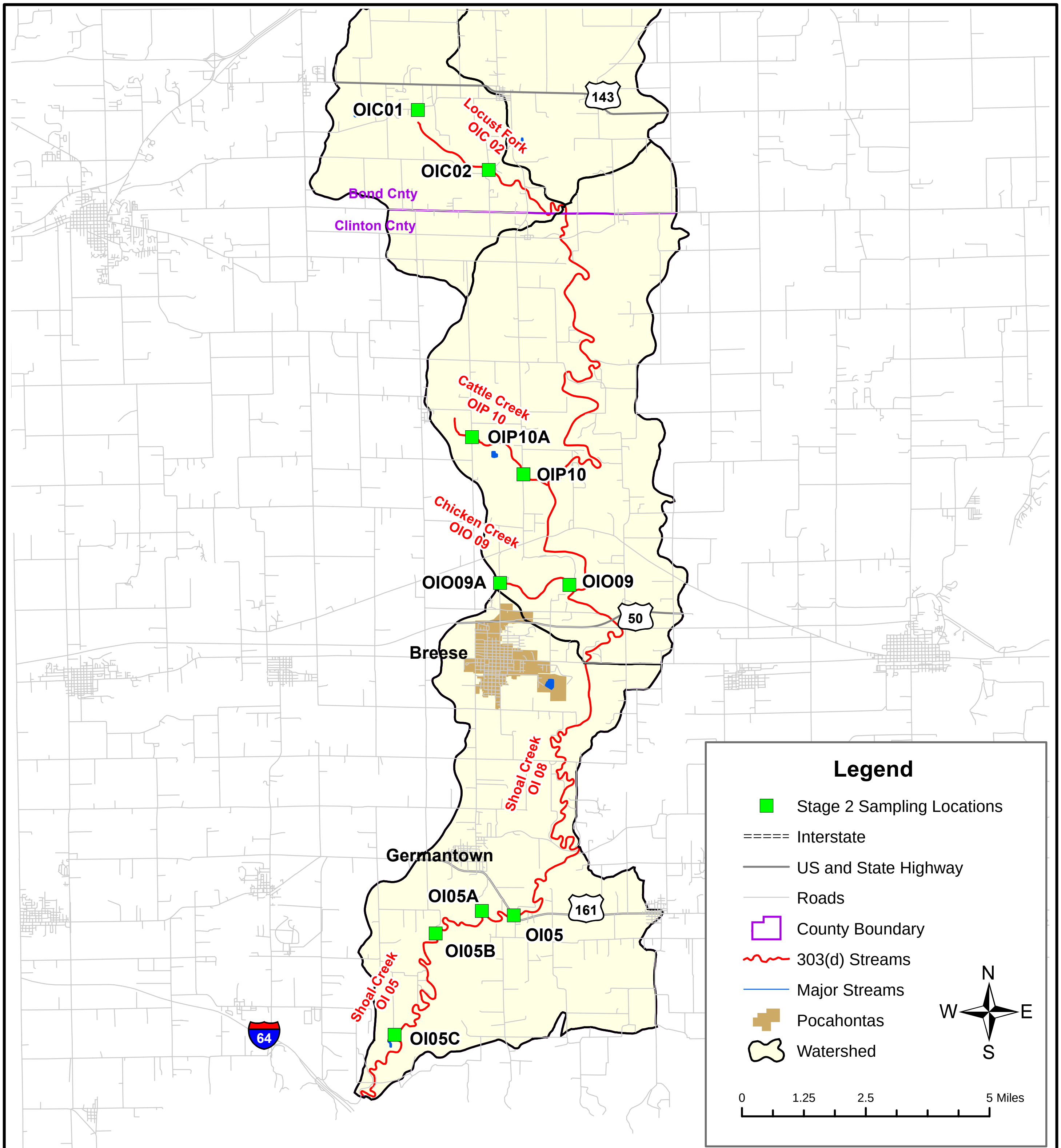

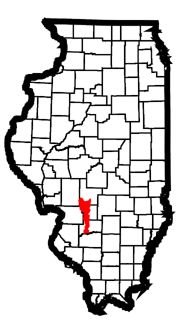

Figure 2-9:
Stage 2 Sampling Locations
Shoal Creek Watershed

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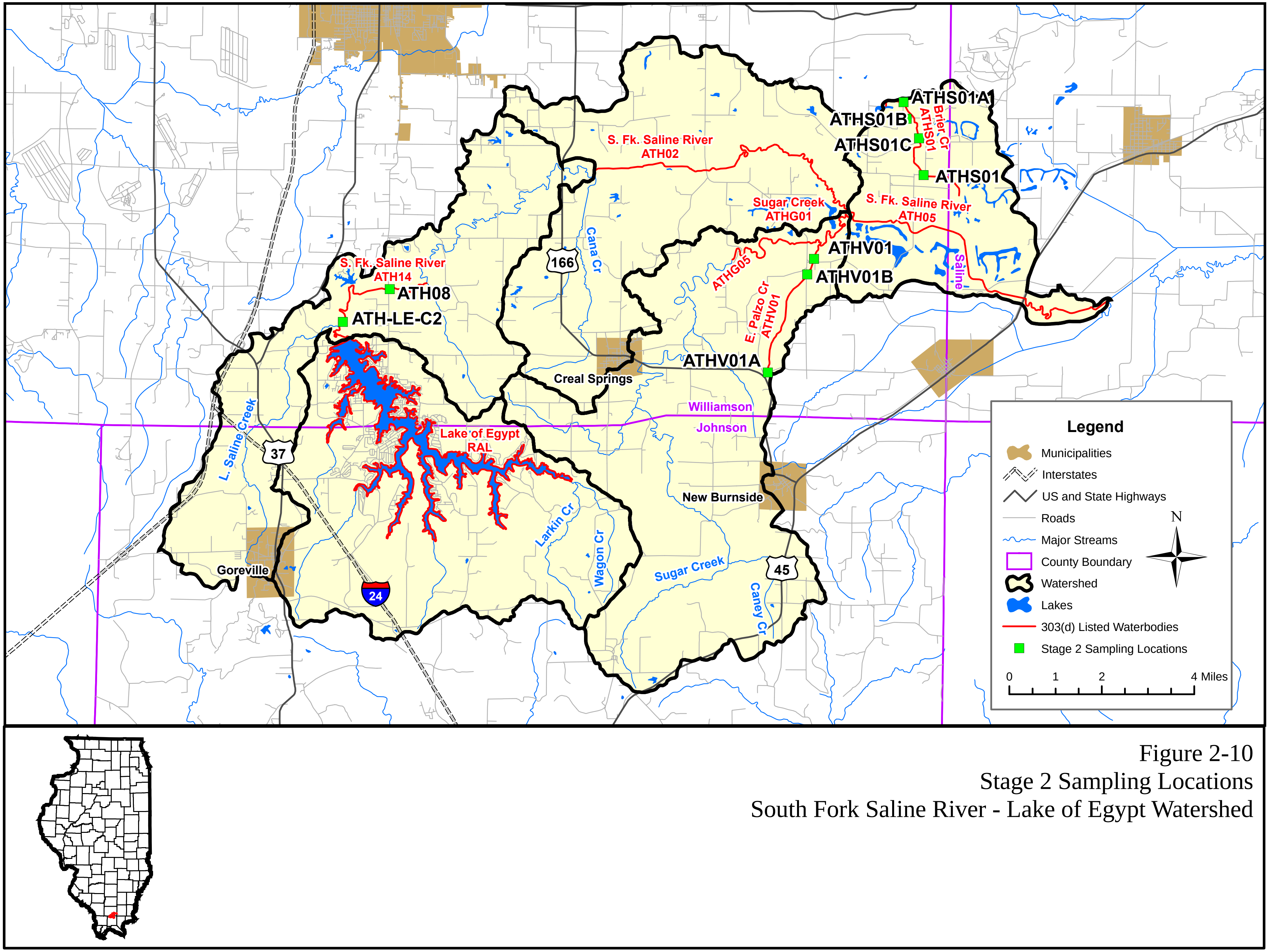

Figure 2-10
Stage 2 Sampling Locations
South Fork Saline River - Lake of Egypt Watershed

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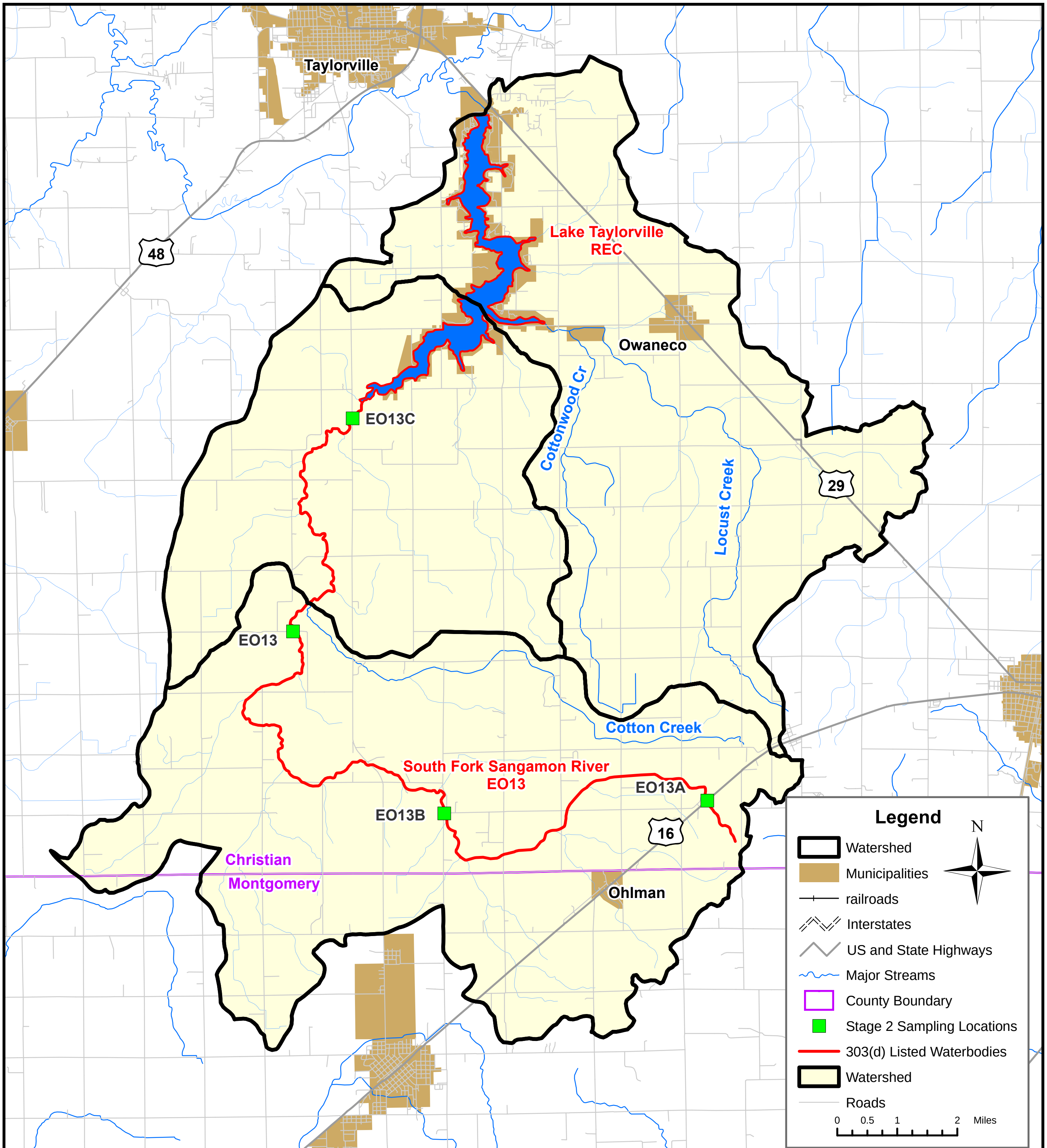

Figure 2-11:
Stage 2 Sampling Locations
South Fork Sangamon River - Lake Taylorville Watershed

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Table 2-2: Field Measurements

Watershed	Water body	Sample Site	Latitude	Longitude	Date	Time	pH (s.u.)	Conductivity (uS/cm)	Turbidity (NTU)	DO (mg/l)	Temp. °C	Depth (ft)
Bay Creek	Cedar Creek	AJF16	37.4661	88.7508	9/25/2006	18:00	6.5	117.0	7.8	8.9	63.9	NA
	Cedar Creek	AJF16	37.4661	88.7508	11/3/2006	11:05	7.2	164.5	8.6	11.0	7.0	NA
	Cedar Creek	AJF16A	37.4954	88.7592	9/25/2006	18:15	6.6	81.0	15.6	9.4	64.0	NA
	Cedar Creek	AJF16A	37.4954	88.7592	11/2/2006	13:30	7.3	101.8	5.4	11.6	9.2	NA
	Bay Creek Ditch	AJK01	37.3245	88.6337	9/25/2006	15:58	6.3	74.0	17.2	5.6	66.6	NA
	Bay Creek Ditch	AJK01	37.3245	88.6337	10/31/2006	8:15	7.2	91.6	20.4	8.2	12.8	NA
	Bay Creek Ditch	AJK01A	37.3282	88.6747	9/25/2006	NOT SAMPLED *Site flooded over banks into surrounding fields with no access/alternate site not located*						NA
	Bay Creek Ditch	AJK01A	37.3282	88.6747	10/31/2006	8:45	7.1	91.1	44.5	6.1	13.2	NA
Cahokia Creek/Holiday Shores Lake	Cahokia Diversion Ditch	JQ01	38.8054	90.1023	8/31/2006	13:40	7.4	606.7	62.3	3.4	23.9	NA
	Cahokia Diversion Ditch	JQ01	38.8054	90.1023	10/17/2006	14:45	8.3	459.8	92.9	9.6	12.6	NA
	Cahokia Diversion Ditch	JQ07	38.8050	90.0673	8/31/2006	14:45	7.4	498.6	68.0	5.3	23.0	NA
	Cahokia Diversion Ditch	JQ07	38.8050	90.0673	10/17/2006	14:15	8.3	427.0	115.8	9.4	12.8	NA
Cedar Creek	Big Muddy River	N13	37.7392	89.4284	9/7/2006	11:15	7.6	646.1	45.5	8.1	29.9	NA
	Big Muddy River	N13	37.7392	89.4284	11/1/2006	10:45	7.1	319.1	258.5	8.2	11.2	NA
	Big Muddy River	N99	37.6252	89.4284	9/7/2006	12:15	7.7	749.5	40.2	10.1	23.6	NA
	Big Muddy River	N99	37.6252	89.4284	11/1/2006	9:45	7.4	333.4	188.4	7.8	11.5	NA
	Cave Creek	NAC01	37.6154	89.3395	9/11/2006	11:45	7.8	288.4	N/A	7.6	20.4	NA
	Cave Creek	NAC01	37.6154	89.3395	11/1/2006	11:45	7.8	213.2	24.0	10.6	9.8	NA
	Cave Creek	NAC01A	37.6380	89.5660	9/11/2006	11:15	7.5	330.3	N/A	4.9	20.5	NA
	Cave Creek	NAC01A	37.6380	89.5660	11/1/2006	12:15	7.7	227.7	20.6	10.1	10.2	NA
Crab Orchard Creek	Crab Orchard Creek	ND11	37.7198	89.1717	9/6/2006	12:15	7.3	385.9	N/A	5.2	20.1	NA
	Crab Orchard Creek	ND11	37.7198	89.1717	11/1/2006	14:00	7.7	229.6	26.7	10.1	11.7	NA
	Crab Orchard Creek	ND12	37.7286	89.1753	9/6/2006	13:15	7.3	502.7	N/A	6.4	24.2	NA
	Crab Orchard Creek	ND12	37.7286	89.1753	11/1/2006	15:00	7.7	233.4	52.2	10.4	11.7	NA
	Crab Orchard Creek	ND13	37.7402	89.1723	9/6/2006	15:00	7.4	494.1	N/A	6.0	22.2	NA
	Crab Orchard Creek	ND13	37.7402	89.1723	11/1/2006	15:45	7.3	234.7	19.0	11.1	11.8	NA
	Crab Orchard Creek	ND15	37.7440	89.1852	9/6/2006	16:30	7.0	470.0	N/A	6.8	22.4	NA
	Crab Orchard Creek	ND15	37.7440	89.1852	11/1/2006	NOT SAMPLED *Site located behind Walmart parking lot and not accessible due to large chain link fence/no available alternate sites*						NA
	Little Crab Orchard Creek	NDA01	37.7525	89.2276	9/6/2006	18:00	7.3	242.5	N/A	2.1	19.2	NA
	Little Crab Orchard Creek	NDA01	37.7525	89.2276	11/2/2006	8:30	7.0	225.5	30.4	8.2	6.3	NA
	Little Crab Orchard Creek	NDA99	37.7011	89.2531	9/9/2006	NOT SAMPLED *Site dry and road crossings in the vacinity of site were also dry*						NA
	Little Crab Orchard Creek	NDA99	37.7011	89.2531	11/2/2006	10:30	8.7	190.5	17.0	12.3	5.5	NA
	Piles Fork	NDB03	37.7361	89.2016	9/7/2006	10:00	7.3	404.0	7.4	1.6	18.5	NA
	Piles Fork	NDB03	37.7361	89.2016	11/2/2006	9:15	7.7	240.7	25.5	10.3	7.3	NA
	Piles Fork	NDB04	37.7004	89.2205	9/9/2006	7:40	7.7	753.7	7.8	3.6	17.6	NA
	Piles Fork	NDB04	37.7004	89.2205	11/2/2006	11:00	8.1	154.9	56.5	11.5	10.2	NA
Crooked Creek	Little Crooked Creek	OJA-01	38.4416	89.4170	9/7/2006	17:45	7.0	274.0	22.5	3.7	20.3	NA
	Little Crooked Creek	OJA-01	38.4416	89.4170	10/19/2006	14:05	7.5	335.4	84.1	4.7	12.0	NA
	Little Crooked Creek	OJA-02	38.4564	89.3992	9/8/2006	11:15	7.0	284.8	20.2	3.1	19.7	NA
	Little Crooked Creek	OJA-02	38.4564	89.3992	10/19/2006	14:35	7.3	332.5	48.1	3.8	12.4	NA
	Plum Creek	OZH-OK-A2	38.4290	89.5387	9/8/2006	14:00	7.9	663.3	10.4	6.8	23.9	NA
	Plum Creek	OZH-OK-A2	38.4290	89.5387	10/19/2006	10:50	7.6	390.6	51.8	5.3	11.2	NA
	Plum Creek	OZH-OK-A2A	38.4160	89.5140	9/8/2006	16:45	7.8	503.2	56.9	8.5	22.3	NA
	Plum Creek	OZH-OK-A2A	38.4160	89.5140	10/19/2006	11:20	7.8	341.6	74.7	9.0	9.8	NA
	Plum Creek	OZH-OK-C2	38.4441	89.5592	9/8/2006	12:45	7.3	367.1	11.2	1.1	18.8	NA
	Plum Creek	OZH-OK-C2	38.4441	89.5592	10/19/2006	10:15	7.4	361.7	66.4	2.5	12.0	NA
	Plum Creek	OZH-OK-C2A	38.4568	89.5630	9/8/2006	17:30	7.8	977.9	13.4	4.6	20.7	NA
	Plum Creek	OZH-OK-C2A	38.4568	89.5630	10/19/2006	13:40	7.7	433.1	48.8	3.2	11.5	NA
	Plum Creek	OZH-OK-C3	38.4626	89.5598	9/8/2006	15:00	7.7	983.2	38.5	4.1	21.2	NA
	Plum Creek	OZH-OK-C3	38.4626	89.5598	10/19/2006	9:35	7.5	384.1	556.5	5.2	11.7	NA

Table 2-2: Field Measurements

Watershed	Water body	Sample Site	Latitude	Longitude	Date	Time	pH (s.u.)	Conductivity (uS/cm)	Turbidity (NTU)	DO (mg/l)	Temp. °C	Depth (ft)
Little Wabash	Little Wabash River	C09	38.4407	88.2581	1/25/2005	14:00	7.3	415	42	12.1	1.1	NA
	Little Wabash River	C09	38.4407	88.2581	3/17/2005	8:00	8.3	700	23	14.9	7	NA
	Little Wabash River	C09	38.4407	88.2581	4/19/2005	14:30	7.8	535	50	7.3	18.8	NA
	Little Wabash River	C09	38.4407	88.2581	5/9/2005	10:30	7.3	738	60	6.7	19.7	NA
	Little Wabash River	C09	38.4407	88.2581	6/23/2005	7:30	7.7	690	47	5.1	26	NA
	Little Wabash River	C09	38.4407	88.2581	8/23/2005	13:00	7.2	290	70	4.2	27.1	NA
	Little Wabash River	C09	38.4407	88.2581	9/27/2005	16:00	7.8	533	25	7.5	24.6	NA
	Little Wabash River	C09	38.4407	88.2581	10/27/2005	14:00	7.8	550	11	8.7	11.7	NA
	Little Wabash River	C09	38.4407	88.2581	12/6/2005	13:00	7.6	375	70	11.8	1.6	NA
	Little Wabash River	C09	38.4407	88.2581	2/1/2006	13:00	7.6	390	200	9.3	6.8	NA
	Little Wabash River	C09	38.4407	88.2581	3/15/2006	10:00	6.6	150	130	6.2	12.4	NA
	Little Wabash River	C09	38.4407	88.2581	4/18/2006	16:00	7.9	572	40	8.1	20.1	NA
	Little Wabash River	C09	38.4407	88.2581	4/26/2006	10:00	7.8	580	59	7.2	17.7	NA
	Little Wabash River	C09	38.4407	88.2581	5/1/2006	9:45	7.5	543	75	6.4	16.2	NA
	Little Wabash River	C09	38.4407	88.2581	5/10/2006	10:00	7.4	475		6.2	18.5	NA
	Little Wabash River	C09	38.4407	88.2581	5/17/2006	11:00	7.4	421	70	7.4	14.7	NA
	Little Wabash River	C09	38.4407	88.2581	5/24/2006	9:45	7.5	473		6.6	18.9	NA
	Little Wabash River	C09	38.4407	88.2581	5/31/2006	10:20	7.2	352		4	25.3	NA
	Little Wabash River	C09	38.4407	88.2581	6/7/2006	10:15	7.2	345		4.3	23.3	NA
	Little Wabash River	C09	38.4407	88.2581	6/15/2006	8:50	7.4	536	55	5.2	23.9	NA
	Little Wabash River	C09	38.4407	88.2581	6/22/2006	10:05	7.5	608	65	4.4	28.4	NA
	Little Wabash River	C09	38.4407	88.2581	6/27/2006	10:40	7.44	462	64	4.9	24.17	NA
	Little Wabash River	C09	38.4407	88.2581	7/5/2006	10:30	7.2	321		4.4	27.5	NA
	Little Wabash River	C09	38.4407	88.2581	7/12/2006	10:30	7.3	456		3.8	25.3	NA
	Little Wabash River	C09	38.4407	88.2581	7/20/2006	10:00	7.4	372		4.8	29.4	NA
	Little Wabash River	C09	38.4407	88.2581	7/27/2006	10:00	7.2	239		4.8	26.4	NA
	Little Wabash River	C09	38.4407	88.2581	8/1/2006	8:30	7.3	306	65	4.5	30.3	NA
	Little Wabash River	C09	38.4407	88.2581	8/8/2006	11:05	7.3	392	55	4.75	28.4	NA
	Little Wabash River	C33	38.2699	88.1377	4/18/2006	11:00	7.1	418	35	4.4	19.8	NA
	Little Wabash River	C33	38.2699	88.1377	4/26/2006	12:15	7.7	607	56	6	19	NA
	Little Wabash River	C33	38.2699	88.1377	5/1/2006	11:45	7.7	597	58	6.8	16.8	NA
	Little Wabash River	C33	38.2699	88.1377	5/10/2006	12:20	7.3	409		5.3	18.7	NA
	Little Wabash River	C33	38.2699	88.1377	5/17/2006	14:00	7.4	462	90	7.2	15.5	NA
	Little Wabash River	C33	38.2699	88.1377	5/24/2006	12:15	7.4	494		6.4	19.9	NA
	Little Wabash River	C33	38.2699	88.1377	5/31/2006	12:40	7.2	449		3.9	25.4	NA
	Little Wabash River	C33	38.2699	88.1377	6/7/2006	12:30	6.8	286		3	23.01	NA
	Little Wabash River	C33	38.2699	88.1377	6/15/2006	11:05	7.5	511	45	8.1	25.1	NA
	Little Wabash River	C33	38.2699	88.1377	6/22/2006	12:00	7.2	546	38	3	29.8	NA
	Little Wabash River	C33	38.2699	88.1377	6/27/2006	11:50	7.4	548	61	4.8	26.17	NA
	Little Wabash River	C33	38.2699	88.1377	7/5/2006	13:00	7.3	334		5.8	29	NA
	Little Wabash River	C33	38.2699	88.1377	7/12/2006	12:30	7.1	326		3.4	25.3	NA
	Little Wabash River	C33	38.2699	88.1377	7/20/2006	12:20	6.9	247		3.4	29.9	NA
	Little Wabash River	C33	38.2699	88.1377	7/27/2006	12:10	7.5	308		6.4	27.4	NA
	Little Wabash River	C33	38.2699	88.1377	8/1/2006	10:30	7.3	296	40	4.7	30.8	NA
	Little Wabash River	C33	38.2699	88.1377	8/8/2006	13:30	7.3	361	40	4.9	29.8	NA
	Johnson Creek	CCA12	38.3732	88.3449	9/9/2006	13:05	8.2	1402.0	13.4	14.2	28.4	NA
	Johnson Creek	CCA12	38.3732	88.3449	11/14/2006	9:45	7.5	651.4	645.5	7.7	7.0	NA
	Johnson Creek	CCA13	38.3789	88.3511	9/9/2006	14:30	8.6	1517.0	3.1	14.9	25.4	NA
	Johnson Creek	CCA13	38.3789	88.3511	11/14/2006	10:15	7.7	649.4	19.0	12.8	8.1	NA
	Johnson Creek	CCA14A	38.3830	88.3546	9/9/2006	15:25	7.6	836.0	3.6	5.7	21.6	NA

Table 2-2: Field Measurements

Watershed	Water body	Sample Site	Latitude	Longitude	Date	Time	pH (s.u.)	Conductivity (uS/cm)	Turbidity (NTU)	DO (mg/l)	Temp. °C	Depth (ft)
Little Wabash (cont.)	Johnson Creek	CCA14A	38.3830	88.3546	11/14/2006	10:25	7.7	694.2	2.4	12.5	8.0	NA
	Johnson Creek	CCAFFA1A	38.3881	88.3535	9/10/2006	10:50	7.4	788.0	5.9	3.8	19.8	NA
	Johnson Creek	CCAFFA1A	38.3881	88.3535	11/14/2006	10:45	7.4	789.8	4.3	12.3	7.5	NA
	Pond Creek	CCFFD1	38.3648	88.3130	9/9/2006	10:30	7.7	576.0	8.6	7.1	19.5	NA
	Pond Creek	CCFFD1	38.3648	88.3130	10/31/2006	10:10	7.6	8719.7	29.2	8.2	3.8	NA
	Pond Creek	CCFFD1A	38.3720	88.3181	9/9/2006	NOT SAMPLED *Site Dry/no available alternate sites*						NA
	Pond Creek	CCFFD1A	38.3720	88.3181	11/9/2006	12:15	7.3	742.5	9.1	11.2	13.6	NA
	Pond Creek	CCFFD1B	38.3793	88.3230	9/9/2006	11:45	7.5	784.0	10.0	8.6	22.9	NA
	Pond Creek	CCFFD1B	38.3793	88.3230	11/9/2006	11:35	7.3	827.9	4.1	12.1	12.7	NA
	Pond Creek	CCFFD1C	38.3999	88.3370	9/10/2006	12:10	8.0	3941.0	17.8	11.9	19.3	NA
	Pond Creek	CCFFD1C	38.3999	88.3370	10/31/2006	11:20	8.8	1394.0		14.4	4.4	NA
	Elm River	CD01	38.5184	88.1320	1/26/2005	13:00	7.1	388	36	9.1	1.4	NA
	Elm River	CD01	38.5184	88.1320	3/15/2005	11:30	8.4	950	7.2	14.6	6.2	NA
	Elm River	CD01	38.5184	88.1320	4/20/2005	11:30	7.4	670	60	6.7	20.1	NA
	Elm River	CD01	38.5184	88.1320	5/5/2005	13:00	7.5	625	27	7.6	13.8	NA
	Elm River	CD01	38.5184	88.1320	6/23/2005	10:00	7.5	1050	22	5.2	24.7	NA
	Elm River	CD01	38.5184	88.1320	8/18/2005	11:00	7.6	730	34	3.6	24.6	NA
	Elm River	CD01	38.5184	88.1320	9/29/2005	11:30	7.6	700	17	3.6	18.5	NA
	Elm River	CD01	38.5184	88.1320	10/18/2005	11:30	7.5	680	8.2	5.9	15	NA
	Elm River	CD01	38.5184	88.1320	12/8/2005	10:30	7.4	321	65	9.6	0.3	NA
	Elm River	CD01	38.5184	88.1320	2/1/2006	15:00	7.5	430	80	9.1	7	NA
	Elm River	CD01	38.5184	88.1320	3/1/2006	13:30	7.4	840	42	10.2	9.1	NA
	Elm River	CD01	38.5184	88.1320	4/6/2006	11:00	7.3	440	90	8.6	13.5	NA
	Elm River	CD01	38.5184	88.1320	4/18/2006	14:30	7.3	670	40	5.6	20.9	NA
	Elm River	CD01	38.5184	88.1320	4/26/2006	11:15	7.5	860		6.2	15.9	NA
	Elm River	CD01	38.5184	88.1320	5/1/2006	11:00	7.4	958		5.9	15.2	NA
	Elm River	CD01	38.5184	88.1320	5/10/2006	11:10	7.2	489		5	18.2	NA
	Elm River	CD01	38.5184	88.1320	5/17/2006	9:30	7.1	484	35	7	13.8	NA
	Elm River	CD01	38.5184	88.1320	5/24/2006	11:20	7.2	594		5.7	18.5	NA
	Elm River	CD01	38.5184	88.1320	5/31/2006	11:30	7.2	605		3.8	25.7	NA
	Elm River	CD01	38.5184	88.1320	6/7/2006	11:25	7	346		4.5	23.4	NA
	Elm River	CD01	38.5184	88.1320	6/15/2006	9:50	7.1	622		4.6	22.5	NA
	Elm River	CD01	38.5184	88.1320	6/22/2006	11:15	7.1	443		4.6	27.9	NA
	Elm River	CD01	38.5184	88.1320	6/27/2006	9:15	6.77	229	91	5	21.95	NA
	Elm River	CD01	38.5184	88.1320	7/5/2006	11:50	7.2	588		3.6	26.6	NA
	Elm River	CD01	38.5184	88.1320	7/12/2006	11:30	7.2	569		4.2	23.9	NA
	Elm River	CD01	38.5184	88.1320	7/20/2006	11:15	7	285		2.8	28.2	NA
	Elm River	CD01	38.5184	88.1320	7/27/2006	11:05	7.1	346		3.5	25.8	NA
	Elm River	CD01	38.5184	88.1320	8/1/2006	9:20	7.3	382		4	27.8	NA
	Elm River	CD01	38.5184	88.1320	8/8/2006	12:20	7.1	425		4.1	26.3	NA
	Elm River	CD02	38.6751	88.4362	9/8/2006	17:45	7.5	344.0	15.9	8.1	23.2	NA
	Elm River	CD02	38.6751	88.4362	11/8/2006	NOT SAMPLED *Miscommunication between field crews caused error in sampling*						NA
	Elm River	CD02A	38.4894	88.3051	9/12/2006	12:51	7.2	404.0	15.7	3.8	22.0	NA
	Elm River	CD02A	38.4894	88.3051	11/8/2006	NOT SAMPLED *Miscommunication between field crews caused error in sampling*						NA
	Seminary Creek	CDFGLC6	38.6180	88.4384	9/8/2006	12:25	7.7	708.0	4.2	6.6	19.5	NA
	Seminary Creek	CDFGLC6	38.6180	88.4384	11/8/2006	17:00	7.5	527.6	17.5	10.5	12.4	NA
	Seminary Creek	CDFGLC6A	38.6135	88.4245	9/8/2006	11:10	7.7	720.0	201.2	7.0	20.1	NA
	Seminary Creek	CDFGLC6A	38.6135	88.4245	11/8/2006	16:45	7.3	561.7	15.1	12.0	13.5	NA
	Seminary Creek	CDGFLA1	38.6561	88.4832	9/8/2006	15:40	7.9	558.0	7.0	10.0	22.0	NA
	Seminary Creek	CDGFLA1	38.6561	88.4832	11/8/2006	14:45	7.3	385.0	12.5	14.3	12.7	NA

Table 2-2: Field Measurements

Watershed	Water body	Sample Site	Latitude	Longitude	Date	Time	pH (s.u.)	Conductivity (uS/cm)	Turbidity (NTU)	DO (mg/l)	Temp. °C	Depth (ft)
Little Wabash (cont.)	Seminary Creek	CDGFLA1A	38.6595	88.4890	9/8/2006	13:45	7.4	362.0	22.7	2.6	19.0	NA
	Seminary Creek	CDGFLA1A	38.6595	88.4890	11/8/2006	15:50	7.2	429.8	16.8	15.1	12.7	NA
	Village Creek	CE01	38.4348	88.1369	9/6/2006	17:30	8.1	610.0	11.4	9.9	24.9	NA
	Village Creek	CE01	38.4348	88.1369	11/14/2006	8:45	7.5	697.9	8.0	10.6	6.8	NA
	Village Creek	CE01A	38.4294	88.0943	9/12/2006	17:05	7.2	327.0	145.2	5.8	22.6	NA
	Village Creek	CE01A	38.4294	88.0943	11/9/2006	13:45	7.2	607.2	8.7	11.2	14.2	NA
	Village Creek	CE02	38.4150	88.1659	9/6/2006	15:20	7.8	568.0	15.7	7.9	25.0	NA
	Village Creek	CE02	38.4150	88.1659	11/9/2006	12:55	7.5	587.4	14.1	10.7	13.1	NA
	Big Muddy Creek	CJ05	38.7693	88.3093	9/7/2006	16:45	8.2	63.1	11.4	10.5	23.6	NA
	Big Muddy Creek	CJ05	38.7693	88.3093	11/8/2006	11:30	7.4	457.0	32.5	12.4	8.3	NA
	Big Muddy Creek	CJ06	38.8298	88.3642	9/7/2006	18:10	7.5	588.0	34.6	4.9	21.8	NA
	Big Muddy Creek	CJ06	38.8298	88.3642	11/8/2006	11:00	7.3	455.1	15.8	11.6	10.6	NA
	Little Muddy Creek	CJA01	38.7647	88.3760	9/12/2006	10:20	7.0	321.0	9.5	3.4	20.9	NA
	Little Muddy Creek	CJA01	38.7647	88.3760	11/13/2006	12:00	7.0	267.9	113.2	10.1	7.4	NA
	Little Muddy Creek	CJA02	38.7047	88.3174	9/7/2006	14:20	6.8	554.0	45.9	2.8	20.4	NA
	Little Muddy Creek	CJA02	38.7047	88.3174	11/8/2006	12:30	7.0	497.0	35.8	9.3	10.4	NA
	Big Muddy Diversion Ditch	CJAE01	38.6865	88.2967	9/7/2006	12:10	7.1	1946.0	26.9	9.1	22.2	NA
	Big Muddy Diversion Ditch	CJAE01	38.6865	88.2967	11/8/2006	13:05	7.3	478.2	30.8	10.8	11.7	NA
	Big Muddy Diversion Ditch	CJAE01A	38.7467	88.2977	9/7/2006	15:45	8.1	908.0	6.5	10.3	24.3	NA
	Big Muddy Diversion Ditch	CJAE01A	38.7467	88.2977	11/13/2006	12:30	7.6	452.9	37.8	9.8	8.2	NA
Mary's River/North Fork Cox Creek	North Fork Cox Creek	IIHA01	38.0114	89.6460	9/9/2006	17:40	7.9	2073.0	N/A	10.0	22.0	NA
	North Fork Cox Creek	IIHA01	38.0114	89.6460	10/18/2006	14:25	8.3	2995.0	13.5	8.1	15.4	NA
	North Fork Cox Creek	IIHA31	38.0293	89.6303	9/9/2006	17:10	8.2	3491.0	N/A	9.6	23.9	NA
	North Fork Cox Creek	IIHA31	38.0293	89.6303	10/18/2006	14:45	8.4	3215.0	8.5	8.6	15.5	NA
	North Fork Cox Creek	IIHA-STC1	38.0015	89.6557	9/9/2006	16:15	7.8	3019.0	N/A	7.1	21.9	NA
	North Fork Cox Creek	IIHA-STC1	38.0015	89.6557	10/18/2006	14:00	8.1	1990.0	20.0	7.0	14.9	NA
	North Fork Cox Creek	IIHA-STE1	38.0048	89.6526	9/9/2006	15:45	7.8	3422.0	N/A	6.9	20.7	NA
	North Fork Cox Creek	IIHA-STE1	38.0048	89.6526	10/18/2006	13:40	8.0	2505.0	16.3	6.0	14.7	NA
	Maxwell Creek	IIKSPA1	38.1242	89.6870	9/7/2006	NOT SAMPLED						NA
	Maxwell Creek	IIKSPA1	38.1242	89.6870	10/17/2006	*Site dry during both visits/available alternate locations also dry*						NA
	Maxwell Creek	IIKSPC1	38.1182	89.6885	9/7/2006	15:30	7.3	968.1	4.8	2.0	24.3	NA
	Maxwell Creek	IIKSPC1	38.1182	89.6885	10/17/2006	8:20	7.1	561.5	22.3	20.2	18.4	NA
	Maxwell Creek	IIKSPC3A	38.1090	89.6850	9/7/2006	15:00	7.5	997.0	4.4	2.6	21.6	NA
	Maxwell Creek	IIKSPC3A	38.1090	89.6850	10/17/2006	8:45	7.5	457.8	19.2	6.5	15.4	NA
	Maxwell Creek	IIKSPE1A	38.1218	89.6889	9/7/2006	NOT SAMPLED						NA
	Maxwell Creek	IIKSPE1A	38.1218	89.6889	10/17/2006	*Site dry during both visits/available alternate locations also dry*						NA
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:00	9.1	279.7	N/A	13.9	25.6	1
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:02	9.1	279.5	N/A	13.9	24.9	2
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:04	9.1	279.2	N/A	13.8	24.7	3
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:06	9.1	278.8	N/A	13.9	24.6	4
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:08	9.0	279.3	N/A	13.2	24.4	5
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:10	9.0	279.7	N/A	12.6	24.3	6
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:12	8.9	280.4	N/A	11.8	24.2	7
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:14	8.2	286.0	N/A	6.2	23.9	8
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:16	7.8	287.4	N/A	4.4	23.7	9
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:18	7.6	288.9	N/A	2.5	23.5	10
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:20	7.3	290.3	N/A	0.3	23.1	11
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:22	7.3	296.0	N/A	0.1	22.7	12
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:24	7.1	317.6	N/A	0.0	21.2	13
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:26	7.1	332.7	N/A	0.0	18.5	14
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:28	7.1	330.3	N/A	0.0	17.1	15

Table 2-2: Field Measurements

Watershed	Water body	Sample Site	Latitude	Longitude	Date	Time	pH (s.u.)	Conductivity (uS/cm)	Turbidity (NTU)	DO (mg/l)	Temp. °C	Depth (ft)
Mary's River/North Fork Cox Creek (cont.)	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:30	7.1	329.6	N/A	0.0	16.1	16
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:32	7.1	329.9	N/A	0.0	14.7	17
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:34	7.1	330.0	N/A	0.0	13.6	18
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:36	7.1	332.4	N/A	0.0	12.4	19
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:38	7.1	335.4	N/A	0.0	11.8	20
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:40	7.1	341.7	N/A	0.0	11.3	21
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:42	7.1	347.9	N/A	0.0	10.9	22
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:44	7.1	350.1	N/A	0.0	10.8	23
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:46	7.1	352.6	N/A	0.0	10.6	24
	Randolph County Lake	RIB-1	37.9707	89.7962	9/9/2006	12:48	7.0	363.8	N/A	0.0	10.2	25
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	8.0	306.1	5.6	7.1	15.8	0
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	7.8	305.0	6.7	5.4	15.7	3.28
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	7.8	304.9	5.9	5.4	15.7	6.56
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	7.8	303.6	6.6	5.3	15.6	9.84
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	7.7	303.5	7.1	5.3	15.6	13.12
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	7.6	304.0	11.9	4.5	13.3	16.4
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	7.5	371.4	9.8	0.6	12.7	19.68
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	7.6	392.9	8.3	0.5	10.9	22.96
	Randolph County Lake	RIB-1	37.9707	89.7962	10/18/2006	10:25	7.5	435.0	63.4	0.3	10.1	26.24
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:00	9.0	286.4	N/A	13.3	27.0	1
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:02	9.0	282.2	N/A	13.8	26.8	2
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:04	9.1	279.7	N/A	14.7	25.0	3
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:06	9.0	280.2	N/A	14.3	24.7	4
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:08	8.9	282.2	N/A	12.5	24.4	5
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:10	8.6	286.3	N/A	9.0	24.1	6
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:12	8.1	290.2	N/A	6.0	24.0	7
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:14	7.8	292.2	N/A	4.0	23.9	8
	Randolph County Lake	RIB-2	37.9738	89.8000	9/9/2006	14:16	7.7	292.7	N/A	3.1	23.8	9
	Randolph County Lake	RIB-2	37.9738	89.8000	10/18/2006	12:05	8.0	304.9	10.3	7.1	16.0	0
	Randolph County Lake	RIB-2	37.9738	89.8000	10/18/2006	12:05	7.9	304.5	7.0	6.7	15.9	3.28
	Randolph County Lake	RIB-2	37.9738	89.8000	10/18/2006	12:05	7.8	304.5	6.6	6.4	15.9	6.56
	Randolph County Lake	RIB-2	37.9738	89.8000	10/18/2006	12:05	7.8	304.5	6.3	6.3	15.8	9.84
	Randolph County Lake	RIB-3	37.9800	89.7990	9/9/2006	13:00	9.0	283.0	N/A	13.2	26.4	1
	Randolph County Lake	RIB-3	37.9800	89.7990	9/9/2006	13:02	9.0	283.3	N/A	12.9	26.5	2
	Randolph County Lake	RIB-3	37.9800	89.7990	9/9/2006	13:04	9.0	281.0	N/A	12.8	25.8	3
	Randolph County Lake	RIB-3	37.9800	89.7990	9/9/2006	13:06	9.0	280.4	N/A	12.9	25.0	4
	Randolph County Lake	RIB-3	37.9800	89.7990	9/9/2006	13:08	9.0	279.7	N/A	12.9	24.6	5
	Randolph County Lake	RIB-3	37.9800	89.7990	9/9/2006	13:10	9.0	279.7	N/A	12.6	24.5	6
	Randolph County Lake	RIB-3	37.9800	89.7990	10/18/2006	11:15	8.0	305.0	8.8	7.9	16.0	0
	Randolph County Lake	RIB-3	37.9800	89.7990	10/18/2006	11:15	7.9	304.7	8.7	7.1	16.0	3.28
	Randolph County Lake	RIB-3	37.9800	89.7990	10/18/2006	11:15	7.8	304.7	10.4	6.7	16.0	6.56
	Randolph County Lake Tributary	RIB-Trib	37.9813	89.7988	9/9/2006	13:20	9.0	284.0	N/A	12.9	28.4	NA
	Randolph County Lake Tributary	RIB-Trib	37.9813	89.7988	10/18/2006	11:45	8.1	341.7	46.3	8.3	16.2	NA
Sangamon River/Lake Decatur	Owl Creek	EZV01	40.3254	88.3531	8/30/2006	12:50	7.4	669.0	50.8	8.5	21.2	NA
	Owl Creek	EZV01	40.3254	88.3531	11/2/2006	9:25	8.2	856.7		12.2	5.1	NA
	Owl Creek	EZVA1	40.3115	88.3409	8/30/2006	11:05	7.7	606.9	52.3	6.5	19.0	NA
	Owl Creek	EZVA1	40.3115	88.3409	11/2/2006	10:33	8.2	856.3		11.8	4.7	NA
	Owl Creek	EZVC1	40.3101	88.3423	8/30/2006	10:25	7.3	1450.0	25.6	5.0	21.0	NA
	Owl Creek	EZVC1	40.3101	88.3423	11/2/2006	12:20	8.1	990.7		11.7	6.0	NA
	Owl Creek	EZVE1	40.3113	88.3415	8/30/2006	10:45	7.5	1497.0	20.3	11.1	21.5	NA
	Owl Creek	EZVE1	40.3113	88.3415	11/2/2006	12:59	8.3	859.8		12.5	6.1	NA

Table 2-2: Field Measurements

Watershed	Water body	Sample Site	Latitude	Longitude	Date	Time	pH (s.u.)	Conductivity (uS/cm)	Turbidity (NTU)	DO (mg/l)	Temp. °C	Depth (ft)
Shoal Creek	Shoal Creek	OI05	38.5361	89.5213	9/1/2006	12:35	7.5	563.4	38.7	9.1	22.9	NA
	Shoal Creek	OI05	38.5361	89.5213	10/17/2006	11:30	7.9	604.4	39.7	8.5	12.0	NA
	Shoal Creek	OI05A	38.5370	89.5330	9/1/2006	NOT SAMPLED						NA
	Shoal Creek	OI05A	38.5370	89.5330	10/17/2006	*Site located at end of private road with chained fence/alternate location not located*						NA
	Shoal Creek	OI05B	38.5333	89.5496	9/1/2006	14:20	7.8	542.2	43.0	10.8	26.2	NA
	Shoal Creek	OI05B	38.5333	89.5496	10/17/2006	11:15	7.9	542.4	72.7	8.7	12.3	NA
	Shoal Creek	OI05C	38.5020	89.5661	9/1/2006	15:40	7.8	535.3	43.5	10.2	23.5	NA
	Shoal Creek	OI05C	38.5020	89.5661	10/16/2006	10:30	8.0	578.9	46.0	9.4	12.1	NA
	Locust Fork	OIC01	38.7715	89.5556	8/31/2006	NOT SAMPLED *Site dry/no other road crossings on segment*						NA
	Locust Fork	OIC01	38.7715	89.5556	10/19/2006	12:20	7.8	401.1	24.3	3.8	10.0	NA
	Locust Fork	OIC02	38.7536	89.5288	8/31/2006	17:50	8.0	499.6	23.2	9.4	24.2	NA
	Locust Fork	OIC02	38.7536	89.5288	10/17/2006	13:00	7.7	422.2	26.9	5.2	14.2	NA
	Chicken Creek	OIO09	38.6407	89.5025	9/1/2006	NOT SAMPLED						NA
	Chicken Creek	OIO09	38.6407	89.5025	10/17/2006	*Sites dry during both visits/sites located at only two road crossings on segment*						NA
	Chicken Creek	OIO09A	38.6373	89.5260	9/1/2006							NA
	Chicken Creek	OIO09A	38.6373	89.5260	10/17/2006							NA
	Cattle Creek	OIP10	38.6649	89.5170	8/31/2006	NOT SAMPLED *Site dry/no other road crossings on segment*						NA
	Cattle Creek	OIP10	38.6649	89.5170	10/17/2006	12:05	7.9	928.0	105.6	2.0	14.2	NA
	Cattle Creek	OIP10A	38.6744	89.5359	8/31/2006	NOT SAMPLED						NA
	Cattle Creek	OIP10A	38.6744	89.5359	10/17/2006	*Site dry/no other road crossings on segment*						NA
South Fork Saline River/Lake of Egypt	South Fork Saline River	ATH08	37.6399	88.9281	9/26/2006	10:20	7.1	165.0	0.6	8.7	23.6	NA
	South Fork Saline River	ATH08	37.6399	88.9281	10/31/2006	11:15	6.6	213.1	10.0	8.8	19.0	NA
	South Fork Saline River	ATH14	NA	NA	9/26/2006	NOT SAMPLED						NA
	South Fork Saline River	ATH14	NA	NA	10/31/2006	*Sites located on private property and/or not accessible by roads*						NA
	South Fork Saline River	ATHLEC1	NA	NA	9/26/2006	*No other road crossings available on segment*						NA
	South Fork Saline River	ATHLEC1	NA	NA	10/31/2006							NA
	South Fork Saline River	ATHLEC2	37.6295	88.9465	9/26/2006	9:45	6.6	81.0	15.6	9.4	18.1	NA
	South Fork Saline River	ATHLEC2	37.6295	88.9465	10/31/2006	12:00	6.8	137.7	11.6	9.6	17.1	NA
	Briers Creek	ATHS01	37.6766	88.7178	9/11/2006	11:30	7.6	1997.0	2.0	9.1	21.3	NA
	Briers Creek	ATHS01	37.6766	88.7178	9/27/2006	9:00	7.3	1392.0	3.4	10.2	15.5	NA
	Briers Creek	ATHS01	37.6766	88.7178	10/30/2006	16:30	7.1	1281.0	19.6	9.4	13.7	NA
	Briers Creek	ATHS01	37.6766	88.7178	11/15/2006	10:25	7.0	700.1	185.3	4.6	9.4	NA
	Briers Creek	ATHS01A	37.6995	88.7257	9/11/2006	10:00	7.1	765.0	5.6	9.7	17.9	NA
	Briers Creek	ATHS01A	37.6995	88.7257	9/27/2006	11:30	7.5	817.0	1.9	9.7	17.0	NA
	Briers Creek	ATHS01A	37.6995	88.7257	11/2/2006	12:00	8.0	862.8	3.0	8.5	9.5	NA
	Briers Creek	ATHS01A	37.6995	88.7257	11/15/2006	11:10	6.8	226.1	36.3	5.4	10.2	NA
	Briers Creek	ATHS01B	37.6943	88.7245	9/11/2006	10:25	7.2	507.0	6.2	9.5	17.8	NA
	Briers Creek	ATHS01B	37.6943	88.7245	9/27/2006	10:35	6.7	500.0	0.5	9.7	17.3	NA
	Briers Creek	ATHS01B	37.6943	88.7245	11/2/2006	12:20	7.4	726.7	2.9	9.9	9.5	NA
	Briers Creek	ATHS01B	37.6943	89.7640	11/15/2006	11:30	6.8	198.9	69.1	4.0	10.0	NA
	Briers Creek	ATHS01C	37.6882	88.7195	9/11/2006	12:55	6.8	2071.0	21.5	6.3	19.0	NA
	Briers Creek	ATHS01C	37.6882	88.7195	9/27/2006	9:30	7.0	1571.0	2.2	9.8	15.1	NA
	Briers Creek	ATHS01C	37.6882	88.7195	10/31/2006	14:30	7.4	1296.0	4.5	9.4	12.0	NA
	Briers Creek	ATHS01C	37.6882	88.7195	11/15/2006	10:45	7.0	848.6	90.7	8.8	9.5	NA
	East Palzo Creek	ATHV01	37.6502	88.7608	9/11/2006	10:40	6.9	375.0	16.4	6.7	22.7	NA
	East Palzo Creek	ATHV01	37.6502	88.7608	9/27/2006	NOT SAMPLED *Site flooded over road with no safe access/no other road crossings on segment*						NA
	East Palzo Creek	ATHV01	37.6502	88.7608	10/31/2006	13:40	6.5	490.6	14.2	7.6	12.4	NA
	East Palzo Creek	ATHV01	37.6502	88.7608	11/15/2006	10:00	6.3	554.5	200.0	5.1	9.4	NA
	East Palzo Creek	ATHV01A	37.6143	88.7788	9/11/2006	8:25	7.2	1878.0	1.7	6.6	18.8	
	East Palzo Creek	ATHV01A	37.6143	88.7788	9/27/2006	NOT SAMPLED						NA
	East Palzo Creek	ATHV01A	37.6143	88.7788	10/31/2006	*Site dry/no other road crossings on segment*						NA
	East Palzo Creek	ATHV01A	37.6143	88.7788	11/15/2006	9:05	6.8	158.9	81.9	9.0	9.4	NA
	East Palzo Creek	ATHV01B	37.6452	88.7635	9/11/2006	8:55	6.9	481.0	28.8	6.0	19.1	NA
	East Palzo Creek	ATHV01B	37.6452	88.7635	9/26/2006	12:30	6.2	405.0	4.6	10.9	17.4	NA
	East Palzo Creek	ATHV01B	37.6452	88.7635	10/31/2006	13:00	6.4	498.2	23.8	8.7	12.4	NA
	East Palzo Creek	ATHV01B	37.6452	88.7635	11/15/2006	9:35	6.1	435.0	243.8	5.6	9.4	NA

Table 2-2: Field Measurements

Watershed	Water body	Sample Site	Latitude	Longitude	Date	Time	pH (s.u.)	Conductivity (uS/cm)	Turbidity (NTU)	DO (mg/l)	Temp. °C	Depth (ft)
South Fork Sangamon River/ Lake Taylorville	South Fork Sangamon River	EO13	39.4072	89.3164	8/30/2006	18:10	7.3	719.3	7.2	6.3	20.4	NA
	South Fork Sangamon River	EO13	39.4072	89.3164	11/2/2006	16:50	7.7	528.5		6.5	6.1	NA
	South Fork Sangamon River	EO13A	39.2700	89.1880	8/30/2006	19:55	7.3	754.7	7.6	9.7	21.6	NA
	South Fork Sangamon River	EO13A	39.2700	89.1880	11/2/2006	NOT SAMPLED *Miscommunication between field crews caused error in sampling*						NA
	South Fork Sangamon River	EO13B	39.3630	89.2700	8/30/2006	19:25	7.6	1112.0	60.1	8.3	21.6	NA
	South Fork Sangamon River	EO13B	39.3630	89.2700	11/2/2006	NOT SAMPLED *Miscommunication between field crews caused error in sampling*						NA
	South Fork Sangamon River	EO13C	39.4590	89.2970	8/30/2006	18:55	7.0	56.9	96.0	3.8	21.1	NA
	South Fork Sangamon River	EO13C	39.4590	89.2970	11/2/2006	16:25	8.2	954.1		5.8	6.4	NA

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Table 2-3: Data Associated with Impairment Status

Watershed	Water body	Sample Site	Date	Time	pH(1)	DO(1)	Total Mn	Sulfates	TDS	Total Boron	Dissolved Zinc (6)	Dissolved Iron	Total Silver	Dissolved Copper (6)	TP	Atrazine (5)	Ammonia
					Causes of Impairment												
					s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L
Bay Creek	Cedar Creek	AJF16	9/25/2006	18:00		8.9	0.25										
			11/3/2006	11:05		11.0	0.12										
		AJF16A	9/25/2006	18:15		9.4	0.23										
			11/2/2006	13:30		11.6	0.08										
	Bay Creek Ditch	AJK01	9/25/2006	15:58		5.6	0.16										
			10/31/2006	8:15		8.2	0.05										
		AJK01A	10/31/2006	8:45		6.1	0.06										
Cahokia Creek/Holiday Shores Lake	Cahokia Diversion Ditch	JQ07	10/4/2006	16:35		5.3								ND			
			10/17/2006	14:15		9.4								ND			
		JQ01	10/4/2006	16:20		**3.4**								ND			
			10/17/2006	14:45		9.6								ND			
Cedar Creek	Big Muddy River	N99	9/7/2006	12:15		10.1		186									
			11/1/2006	9:45		7.8		75									
		N13	9/7/2006	11:15		8.1		144									
			11/1/2006	10:45		8.2		68									
	Cave Creek	NAC01	9/11/2006	11:45		7.6											
			11/1/2006	11:45		10.6											
		NAC01A	9/11/2006	11:15		**4.9**											
			11/1/2006	12:15		10.1											
Crab Orchard Lake	Crab Orchard Creek	ND11	9/6/2006	12:15	7.3	5.2	1.00										
			11/1/2006	14:00	7.7	10.1	0.26										
		ND12	9/6/2006	13:15	7.3		0.17										
			11/1/2006	15:00	7.7		ND										
		ND13	9/6/2006	15:00		6.0											
			11/1/2006	15:45		11.1											
		ND15	9/6/2006	16:30		6.8											
	Little Crab Orchard Creek	NDA01	9/6/2006	18:00		**2.1**	**2.00**										
			11/2/2006	8:30		8.2	0.20										
		NDA99	11/2/2006	10:30		12.3	0.03										
	Piles Fork	NDB03	9/7/2006	10:00		**1.6**											
			11/2/2006	9:15		10.3											
		NDB04	9/9/2006	7:40		**3.6**											
			11/2/2006	11:00		11.5											
Crooked Creek	Plum Creek	OZH-OK-A2	9/8/2006	14:00		6.8	0.65										
			10/19/2006	10:50		5.3	0.33										
		OZH-OK-A2A	9/8/2006	16:25		8.5	0.20										
			10/19/2006	11:20		9.0	0.22										
		OZH-OK-C2	9/8/2006	12:45		**1.1**											
			10/19/2006	10:15		**2.5**											
		OZH-OK-C2A	9/8/2006	17:30		**4.6**											
			10/19/2006	13:40		**3.2**											
		OZH-OK-C3	9/9/2006	15:00		**4.1**	0.30										
			10/19/2006	9:35		5.2	0.77										
	Little Crooked Creek	OJA-01	9/7/2006	17:45		**3.7**	0.14										
			10/19/2006	14:05		**4.7**	0.17										
		OJA-02	9/8/2006	11:15		**3.1**	0.14										
			10/19/2006	14:35		**3.8**	0.17										

Table 2-3: Data Associated with Impairment Status

Watershed	Water body	Sample Site	Date	Time	Causes of Impairment												
					pH[1]	DO[1]	Total Mn	Sulfates	TDS	Total Boron	Dissolved Zinc [6]	Dissolved Iron	Total Silver	Dissolved Copper [6]	TP	Atrazine [5]	Ammonia
					s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L
Little Wabash	Village Creek	CE01	9/6/2006	17:30		9.9	0.17										
			11/14/2006	8:45		10.6	0.10										
		CE02	9/6/2006	15:20		7.9	0.80										
			11/9/2006	12:55		10.7	0.11										
		CE01A	9/12/2006	17:05		5.8	0.41										
			11/9/2006	13:45		11.2	0.08										
	Johnson Creek	CCAFFA1A	9/10/2006	10:50		**3.8**											
			11/14/2006	10:45		12.3											
		CCA12	9/9/2006	13:05		14.2											
			11/14/2006	9:45		7.7											
		CCA13	9/9/2006	14:30		14.9											
			11/14/2006	10:15		12.8											
		CCA14A	9/9/2006	15:25		5.7											
			11/14/2006	10:25		12.5											
	Pond Creek	CCFFD1	9/9/2006	10:30		7.1											
			10/31/2006	10:10		8.2											
		CCFFD1A	11/9/2006	12:15		11.2											
		CCFFD1B	9/9/2006	11:45		8.6											
			11/9/2006	11:35		12.1											
		CCFFD1C	9/10/2006	12:10		11.9											
			10/31/2006	11:20		14.4											
	Seminary Creek	CDGFLA1	9/8/2006	15:40		10.0											
			11/8/2006	14:45		14.3											
		CDGFLA1A	9/8/2006	13:45		**2.6**											
			11/8/2006	15:50		15.1											
		CDFGLC6	9/8/2006	12:25		6.6											
			11/8/2006	17:00		10.5											
		CDFGLC6A	9/8/2006	11:10		7.0											
			11/8/2006	16:45		12.0											
	Big Muddy Creek	CJ06	9/7/2006	18:10		**4.9**	0.54										
			11/8/2006	11:00		11.6	0.39										
		CJ05	9/7/2006	16:45		10.5	0.04										
			11/8/2006	11:30		12.4	0.07										
	Little Muddy Creek	CJA02	9/7/2006	4:20		**2.8**	**1.30**										
			11/8/2006	12:30		9.3	0.39										
		CJA01	9/12/2006	10:20		**3.4**	**1.30**										
			11/13/2006	12:00		10.1	0.17										
	Big Muddy Diversion Ditch	CJAE01	9/7/2006	12:10		9.1											
			11/8/2006	13:05		10.8											
		CJAE01A	9/7/2006	15:45		10.3											
			11/13/2006	12:30		9.8											

Table 2-3: Data Associated with Impairment Status

Watershed	Water body	Sample Site	Date	Time	pH(1)	DO(1)	Total Mn	Sulfates	TDS	Total Boron	Dissolved Zinc (6)	Dissolved Iron	Total Silver	Dissolved Copper (6)	TP	Atrazine (5)	Ammonia
					Causes of Impairment												
					s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L
Little Wabash	Elm River	CD02A	9/12/2006	12:51		**3.8**											
		CD02	9/8/2006	17:45		8.1											
		CD01	4/18/2006	14:30												0.12	
			4/26/2006	11:15												0.16	
			5/1/2006	11:00												0.27	
			5/17/2006	9:30												**19.00**	
			5/24/2006	11:20												**15.00**	
			5/31/2006	11:30												8.30	
			6/7/2006	11:25												5.70	
			6/15/2006	9:50												2.80	
			6/22/2006	11:15												1.20	
			6/27/2006	9:15												4.20	
			7/5/2006	11:50												2.40	
			7/12/2006	11:30												0.92	
			7/20/2006	11:15												2.40	
			7/27/2006	11:05												2.60	
			8/1/2006	9:20												2.60	
			8/8/2006	12:20												1.60	
	Little Wabash River	C33 (4)	4/18/2006	11:00												0.55	
			4/26/2006	12:15			**0.35**									1.10	
			5/1/2006	11:45			**0.50**									0.71	
			5/10/2006	12:20			**0.41**										
			5/17/2006	14:00												**19.00**	
			5/24/2006	12:15			**0.38**									8.10	
			5/31/2006	12:40			**0.37**									**13.00**	
			6/7/2006	12:30			**0.44**									6.30	
			6/15/2006	11:05												5.30	
			6/22/2006	12:00			**0.76**									2.60	
			6/27/2006	11:50												2.50	
			7/5/2006	13:00			**0.50**									1.70	
			7/12/2006	12:30			**0.54**									1.00	
			7/20/2006	12:20			**0.46**									2.30	
			7/27/2006	12:10												0.64	
			8/1/2006	10:30												0.66	
			8/8/2006	13:30												0.50	

Table 2-3: Data Associated with Impairment Status

Watershed	Water body	Sample Site	Date	Time	pH [1]	DO [1]	Total Mn	Sulfates	TDS	Total Boron	Dissolved Zinc [6]	Dissolved Iron	Total Silver	Dissolved Copper [6]	TP	Atrazine [5]	Ammonia
					Causes of Impairment												
					s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L
Little Wabash	Little Wabash River	C09	3/17/2005	8:00		14.9											
			4/19/2005	14:30		7.3											
			5/9/2005	10:30		6.7											
			6/23/2005	7:30		5.1											
			8/23/2005	13:00		**4.2**											
			9/27/2005	16:00		7.5											
			10/27/2005	14:00		8.7											
			12/6/2005	13:00		11.8											
			2/1/2006	12:30		9.3											
			3/15/2006	10:00		6.2											
			4/18/2006	16:00												0.27	
			4/26/2006	10:00									ND			0.62	
			5/1/2006	9:45									ND			0.59	
			5/10/2006	10:00									ND				
			5/17/2006	11:00									ND			**20.00**	
			5/24/2006	9:45									ND			6.30	
			5/31/2006	10:20									ND			**24.00**	
			6/7/2006	10:15									ND			4.20	
			6/15/2006	8:50									ND			1.80	
			6/22/2006	10:05									ND			1.20	
			6/27/2006	10:40									ND			1.50	
			7/5/2006	10:30									ND			1.20	
			7/12/2006	10:30									ND			0.96	
			7/20/2006	10:00									ND			1.60	
			7/27/2006	10:00									ND			0.72	
			8/1/2006	8:30									ND			0.63	
			8/8/2006	11:05									ND			0.40	
			8/18/2006	16:00									ND				
Mary's River/North Fork Cox Creek	North Fork Cox Creek	IIHA31	9/9/2006	17:10				**1610**	**3110**								
			10/18/2006	14:45				**1830**	**2830**								
		IIHA01	9/9/2006	17:40				**1850**	**3090**								
			10/18/2006	14:25				**1630**	**2540**								
		IIHA-STE1	9/9/2006	15:40					**3090**								
			10/18/2006	13:40					**1340**								
		IIHA-STC1	9/9/2006	16:15					**2530**								
			10/18/2006	14:00					**1400**								
	Maxwell Creek	IIKSPC1	9/7/2006	15:30		**2.0**											
			10/17/2006	8:20		20.2											
		IIKSPC3A	9/7/2006	15:00		**2.6**											
			10/17/2006	8:45		6.5											
	Randolph County Lake	RIB-1 [3]	9/9/2006	12:00											0.04		
			10/18/2006	10:45											**0.130**		
		RIB-2 [3]	9/9/2006	14:00											0.04		
			10/18/2006	12:05											**0.053**		
		RIB-3 [3]	9/9/2006	13:00											0.04		
			10/18/2006	11:15											**0.100**		

Table 2-3: Data Associated with Impairment Status

Watershed	Water body	Sample Site	Date	Time	Causes of Impairment												
					pH[1]	DO[1]	Total Mn	Sulfates	TDS	Total Boron	Dissolved Zinc [6]	Dissolved Iron	Total Silver	Dissolved Copper [6]	TP	Atrazine [5]	Ammonia
					s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L
Sangamon River/ Lake Decatur	Owl Creek	EZV01	8/30/2006	12:50		8.5											
			11/2/2006	9:25		12.2											
		EZVA1	8/30/2006	11:05		6.5											
			11/2/2006	10:33		11.8											
		EZVE1	8/30/2006	10:45		11.1											
			11/2/2006	12:59		12.5											
		EZVC1	8/30/2006	10:25		**5.0**											
			11/2/2006	12:20		11.7											
Shoal Creek	Shoal Creek	OI05	9/1/2006	12:35		9.1											
			10/17/2006	11:30		8.5											
		OI05B	9/1/2006	14:20		10.8											
			10/17/2006	11:15		8.7											
		OI05C	9/1/2006	15:40		10.2											
			10/16/2006	10:30		9.4											
	Locust Fork	OIC01	10/19/2006	12:20		**3.8**	0.18										
		OIC02	8/31/2006	17:50		9.4	0.35										
			10/17/2006	13:00		5.2	0.08										
	Cattle Creek	OIP10	10/17/2006	12:05		**2.0**			928[2]					0.021			5.8
South Fork Saline River/ Lake of Egypt	Briers Creek	ATHS01	9/11/2006	11:30	7.6	9.1	0.65	**1250**	**1960**		0.020	0.310	ND				
			9/27/2006	9:00	7.3	10.2	**2.00**	**951**	**1490**		0.022	ND	ND				
			10//2006	11:30							ND	ND					
			10/30/2006	16:30			**1.50**	**656**	**1120**		0.035	ND	ND				
			11/15/2006	10:25			**1.40**	281	469		0.028	**1.10**	ND				
		ATHS01A	9/27/2006	11:30	7.5	9.7	0.10	294	678		ND	**1.10**	ND				
			10/4/2006	10:50							ND	ND					
			11/2/2006	12:00	8.0	8.5	0.11	219	597		0.012	ND	ND				
			11/15/2006	11:10	6.8	5.4	0.12	65	213		ND	**1.40**	ND				
		ATHS01B	9/13/2006	10:40			0.18	143	418			ND	ND				
			9/27/2006	10:35	6.7	9.7	0.17	196	414		ND	ND	ND				
			10/4/2006	11:05							0.013	ND					
			11/2/2006	12:20	7.4	9.9	0.22	373	608		0.018	ND	ND				
			11/15/2006	11:30	6.8	**4.0**						**2.10**					
		ATHS01C	9/11/2006	12:55			**8.70**	**1290**	**2150**			**5.00**	ND				
			9/27/2006	9:30	7.0	9.8	**4.10**	**1100**	**1660**		ND	0.78	ND				
			10/4/2006	11:20							ND	**2.20**					
			10/31/2006	14:30	7.4	9.4	**1.90**	**691**	**1190**		ND	0.17	ND				
			11/15/2006	10:45	7.0	8.8	0.93	338	667		ND	0.470	ND				

Table 2-3: Data Associated with Impairment Status

Watershed	Water body	Sample Site	Date	Time	Causes of Impairment												
					pH[1]	DO[1]	Total Mn	Sulfates	TDS	Total Boron	Dissolved Zinc [6]	Dissolved Iron	Total Silver	Dissolved Copper [6]	TP	Atrazine [5]	Ammonia
					s.u.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	ug/L	mg/L
South Fork Saline River/ Lake of Egypt	East Palzo Creek	ATHV01A	9/11/2006	10:40	6.9	6.7	**1.40**		**1560**			ND					
			10/31/2006	13:40	6.5	7.6	**1.80**		375			0.160		ND			
			11/15/2006	10:00	**6.3**	5.1	0.09		211			**2.60**		ND			
		ATHV01	9/11/2006	10:40	6.9	6.7	0.38		262			ND					
			10/4/2006	12:30								0.13		ND			
			10/31/2006	13:40	6.5	7.6	**1.80**		375			0.16		ND			
			11/15/2006	10:00	**6.3**	5.1	**2.10**		324			0.340		ND			
		ATHV01B	9/11/2006	8:55	6.9	6.0	0.41		388			ND					
			9/26/2006	12:30	**6.2**	10.9	1.00		323			ND		ND			
			10/4/2006	11:50								ND		ND			
			10/31/2006	13:00	**6.4**	8.7	**1.60**		341			ND		ND			
			11/15/2006	9:35	**6.1**	5.6	**1.60**		225			0.100		ND			
	South Fork Saline River	ATHLEC2	9/26/2006	9:45		9.4											
			10/31/2006	12:00		9.6											
		ATH08	9/26/2006	10:20		8.7											
			10/31/2006	11:15		8.8											
South Fork Sangamon River/ Lake Taylorville	South Fork Sangamon River	EO13A	8/30/2006	19:55		9.7	0.61			0.05							
		EO13	8/30/2006	18:10		6.3	0.49			0.20							
			11/2/2006	16:50		6.5	0.33			0.08							
		EO13B	8/30/2006	19:25		8.3	**1.18**			0.20							
		EO13C	8/30/2006	18:55		**3.8**	**5.49**			0.27							
			11/2/2006	16:25		5.8	0.38			0.13							

Shaded cells indicate exceedances of the applicable water quality standard

1 pH and DO values in this table represent field parameters sampled using the In-Site 9500 Profiler. Continuous DO and pH data are available in Appendix D.

2 Value shown is for conductivity. TDS standard corresponds to 1667 uS/cm specific conductance

3 Values shown were collected at one-foot depth.

4 Segment C33 is a source of public water. Therefore the applicable manganese standard is 150 ug/L.

5 Chronic criteria for atrazine is 9 ug/L and a single exceedance of this value indicates a potential cause of impairment

6 Corresponding hardness values were used to calculate standards. Analytical data can be found in Appendix C.

Section 3
Quality Assurance Review

A review was conducted to assess the quality and usability of data generated from Stage 2 work activities and to review compliance with the original sampling plan and objectives developed for the QAPP. Field and laboratory methods were deemed in accordance with the QAPP. Minor deviations from the original plan occurred and all are discussed below.

3.1 Deviations from original Sampling Plan (QAPP)

The following issues and/or concerns developed during the sampling events:

- Sampling during the week of September 25th followed a heavy precipitation event which resulted in high stream flows and flooding at Bay Creek Ditch segment AJK01A and East Palzo Creek segment ATHV01.
- In-field filtering was not performed for dissolved phosphorus or dissolved metal samples. Illinois EPA requested additional information on this procedure. CDM along with ARDL, Inc drafted text for Illinois EPA to validate this sampling practice. Total versus dissolved samples are discussed further in section 3.2.2.
- All locations on Chicken Creek (OIO09) were dry during both sample periods; therefore no samples were collected for this segment.
- The following sites had no water during either sampling event: Maxwell Creek IIKSPA1 and IIKSPE1A, and Cattle Creek OIP10A. Alternate locations were not found.
- Access was not available to the following sites during either sampling event: Shoal Creek OIO5A, South Fork Saline River sites ATH14 and ATHLEC1. Alternate locations were not found.
- Site EZVA1 on Owl Creek was moved from the location proposed in the QAPP to the intersection of Owl Creek and County Road 3100 due to better stream flow.
- Only one round of sampling was conducted at the following sites due to access or water volume issues (refer to Table 2-2 for specific dates and issues): Locust Fork OIC01, Cattle Creek OIP10, Crab Orchard Creek ND15, Little Crab Orchard Creek NDA99, Pond Creek CCFFD1A, East Palzo Creek ATHV01 and ATHV01A, and Bay Creek Ditch AJK01A.
- Due to field crew error only one round of sampling was conducted at South Fork Sangamon River EO13A and EO13B and Elm River locations CD02 and CD02A.

3.2 Data Verification and Validation

A data quality review was performed on all laboratory data. The review consisted of an evaluation of laboratory QC and field QC samples. Laboratory QC included an evaluation of method blanks, matrix spikes, matrix spike duplicates, laboratory control samples and holding times. Field QC included an evaluation of field duplicates. No decontamination rinsate blanks were collected.

No laboratory violation resulted in the qualification of CDM collected data. While some matrix spikes had percent recoveries outside of the established limits, all other QC associated with the samples were acceptable. When a matrix spike was reported outside of the control limits, the laboratory control samples had percent recoveries within the established control limits, indicating a matrix effect on the sample analysis and no need to qualify the data. All samples were analyzed within the control limits.

An evaluation of the phosphorus data (total versus dissolved) was performed to determine the effects of filtering the samples immediately versus waiting up to 48 to 64 hours. All samples were received by the laboratories on ice and at 4^0C (+/-). A total of 161 samples have been analyzed for both total and dissolved phosphorus by method 365.2. Of the 161 samples, a total of 10 samples sets had a phosphorus concentration of greater than 1 mg/L (100 times higher than the reporting limit and considered significant when controlling based on RPDs). One of these samples had relative percent difference (RPD) between the total and dissolved fraction of the sample of greater than 100. Precision values of less that 25 % RPD are considered acceptable for sample results reported significantly above the reporting limit. Sample EO13C had total phosphorus measured at 2.09 mg/L and dissolved phosphorus measured at 0.52 mg/L. The TSS measured in this sample was 159 mg/L. The suspended solids contained in this sample may have absorbed the available phosphorus, but all other results in samples with phosphorus concentrations above 1mg/L show that this reaction is not taking place. Sampling or analytical variations may explain the elevated RPD between the sample and the duplicate. Total phosphorus and dissolved phosphorus results for samples with phosphorus concentrations above 1 mg/L are not significantly different.

Looking at all other results, there does not appear to be a correlation between the difference of total and dissolved phosphorus and the TSS concentration. Suspended solids absorbing dissolved phosphorus would be the likely mechanism for lowering the dissolved phosphorus concentrations. Based on the lack of this correlation, dissolved phosphorus concentration would not be significantly different if the samples were filtered immediately versus filtering at the laboratory 48-hours after collection.

Finally, field and laboratory quality control data were collected to assess bias associated between field and laboratory methods. Positive sample results and relative percent difference (RPD) are presented in Table 3-1.

3.3 Data Quality Objectives

The data generated during the Stage 2 investigation conformed to the data quality objectives established in the QAPP. A completeness criterion of 90% was established and easily achieved. No data have been qualified that were collected by CDM personnel and analyzed by ARDL, Inc or Prairie Analytical laboratories. Data qualifiers were applied to some of the data collected by Illinois EPA personnel. All qualifiers are included with the laboratory data contained in Appendix C.

Table 3-1: Duplicate Pair Sample Results

SampleLocation	Parameter	Result	Units	Collection Date	RPD(%)
AJK01-DUP	Solids, total suspended	24.2	MG/L	9/25/2006	
AJK01	Solids, total suspended	25	MG/L	9/25/2006	3.252033
ATHS01A-DUP	Hardness (CA/MG)	435.1	MG CACO3/L	11/2/2006	
ATHS01A	Hardness (CA/MG)	445	MG CACO3/L	11/2/2006	2.249744
ATHS01A-DUP	Solids, total dissolved	604	MG/L	11/2/2006	
ATHS01A	Solids, total dissolved	597	MG/L	11/2/2006	-1.1657
ATHS01A-DUP	Chloride	5.13	MG/L	9/27/2006	
ATHS01A	Chloride	5.1	MG/L	9/27/2006	-0.64556
ATHS01A-DUP	Solids, total dissolved	675	MG/L	9/27/2006	
ATHS01A	Solids, total dissolved	678	MG/L	9/27/2006	0.443459
ATHS01A-DUP	Sulfate	290.63	MG/L	9/27/2006	
ATHS01A	Sulfate	294	MG/L	9/27/2006	1.154242
ATHS01C-DUP	Chloride	5.38	MG/L	9/11/2006	
ATHS01C	Chloride	5.4	MG/L	9/11/2006	0.388903
ATHS01C-DUP	Sulfate	1297.83	MG/L	9/11/2006	
ATHS01C	Sulfate	1290	MG/L	9/11/2006	-0.60514
ATHS01-FIELDDUP	Alkalinity	113	MG/L	10/30/2006	
ATHS01	Alkalinity	108	MG/L	10/30/2006	-4.52489
ATHS01-FIELDDUP	Chloride	4.9	MG/L	10/30/2006	
ATHS01	Chloride	4.9	MG/L	10/30/2006	0
ATHS01-FIELDDUP	Hardness (CA/MG)	673	MG CACO3/L	10/30/2006	
ATHS01	Hardness (CA/MG)	668	MG CACO3/L	10/30/2006	-0.74571
ATHS01-FIELDDUP	Iron	68200	MG/KG	10/30/2006	
ATHS01	Iron	93800	MG/KG	10/30/2006	31.60494
ATHS01-FIELDDUP	Manganese	1130	MG/KG	10/30/2006	
ATHS01	Manganese	1480	MG/KG	10/30/2006	26.81992
ATHS01-FIELDDUP	Manganese	1.5	MG/L	10/30/2006	
ATHS01	Manganese	1.5	MG/L	10/30/2006	0
ATHS01-FIELDDUP	Nitrate-Nitrite	0.06	MG/L	10/30/2006	
ATHS01	Nitrate-Nitrite	0.06	MG/L	10/30/2006	-11.9658
ATHS01-FIELDDUP	Phosphorus, diss	0.05	MG/L	10/30/2006	
ATHS01	Phosphorus, diss	0.05	MG/L	10/30/2006	8.163265
ATHS01-FIELDDUP	Phosphorus, total	0.04	MG/L	10/30/2006	
ATHS01	Phosphorus, total	0.03	MG/L	10/30/2006	-26.8657
ATHS01-FIELDDUP	Solids, total	69.7	%	10/30/2006	
ATHS01	Solids, total	74.5	%	10/30/2006	6.65742
ATHS01-FIELDDUP	Solids, total dissolved	1040	MG/L	10/30/2006	
ATHS01	Solids, total dissolved	1070	MG/L	10/30/2006	2.843602
ATHS01-FIELDDUP	Solids, total suspended	4.3	MG/L	10/30/2006	
ATHS01	Solids, total suspended	5.6	MG/L	10/30/2006	26.26263
ATHS01-FIELDDUP	Sulfate	662	MG/L	10/30/2006	
ATHS01	Sulfate	604	MG/L	10/30/2006	-9.16272
ATHS01-FIELDDUP	Zinc	106	MG/KG	10/30/2006	
ATHS01	Zinc	116	MG/KG	10/30/2006	9.009009
ATHS01-FIELDDUP	Zinc, diss	0.02	MG/L	10/30/2006	
ATHS01	Zinc, diss	0.03	MG/L	10/30/2006	8.333333
ATHS01-DUP	Alkalinity	60.9	MG/L	11/15/2006	
ATHS01	Alkalinity	56.8	MG/L	11/15/2006	-6.96686
ATHS01-DUP	Hardness (CA/MG)	340.14	MG CACO3/L	11/15/2006	
ATHS01	Hardness (CA/MG)	337	MG CACO3/L	11/15/2006	-0.92743
ATHS01-DUP	Solids, total dissolved	481	MG/L	11/15/2006	

Table 3-1: Duplicate Pair Sample Results (continued)

SampleLocation	Parameter	Result	Units	Collection Date	RPD(%)
ATHS01	Solids, total suspended	151	MG/L	11/15/2006	-104.43
ATHS01-DUP	Hardness (CA/MG)	1035.17	MG CACO3/L	9/27/2006	
ATHS01	Hardness (CA/MG)	1030	MG CACO3/L	9/27/2006	-0.50069
ATHV01B-DUP	Alkalinity	15.3	MG/L	9/26/2006	
ATHV01B	Alkalinity	15.3	MG/L	9/26/2006	0
ATHV01B-DUP	Solids, total	72.5	%	9/26/2006	
ATHV01B	Solids, total	71.9	%	9/26/2006	-0.83102
CCFFD1-DUP	Chlorophyll	5.5	MG/CU.M.	9/9/2006	
CCFFD1	Chlorophyll	5	MG/CU.M.	9/9/2006	-9.52381
CE01A-DUP	Solids, total suspended	134	MG/L	9/12/2006	
CE01A	Solids, total suspended	137	MG/L	9/12/2006	2.214022
CJA02-DUP	Biological Oxygen Demand	4	MG/L	11/8/2006	
CJA02	Biological Oxygen Demand	3.7	MG/L	11/8/2006	-7.79221
EO13-DUP	Biological Oxygen Demand	6.3	MG/L	11/2/2006	
EO13	Biological Oxygen Demand	6.3	MG/L	11/2/2006	0
EO13-DUP	Solids, total suspended	8.4	MG/L	11/2/2006	
EO13	Solids, total suspended	7.6	MG/L	11/2/2006	-10
IIAA01-DUP	Chloride	21.71	MG/L	9/9/2006	
IIAA01	Chloride	21.7	MG/L	9/9/2006	-0.0258
IIAA01-DUP	Sulfate	1832.11	MG/L	9/9/2006	
IIAA01	Sulfate	1850	MG/L	9/9/2006	0.971725
IIHA01-DUP	Chloride	21.71	MG/L	9/9/2006	
IIHA01	Chloride	21.7	MG/L	9/9/2006	-0.0258
IIHA01-DUP	Sulfate	1832.11	MG/L	9/9/2006	
IIHA01	Sulfate	1850	MG/L	9/9/2006	0.971725
IIHA31-DUP	Hardness (CA/MG)	1290.87	MG CACO3/L	9/9/2006	
IIHA31	Hardness (CA/MG)	1300	MG CACO3/L	9/9/2006	0.704783
IIHA31-DUP	Hardness (CA/MG)	1306.27	MG CACO3/L	10/18/2006	
IIHA31	Hardness (CA/MG)	1280	MG CACO3/L	10/18/2006	-2.0315
IIHA31-DUP	Chloride	19.5	MG/L	10/18/2006	
IIHA31	Chloride	19.4	MG/L	10/18/2006	-0.51363
IIHA31-DUP	Solids, total dissolved	2850	MG/L	10/18/2006	
IIHA31	Solids, total dissolved	2830	MG/L	10/18/2006	-0.70423
IIHA31-DUP	Sulfate	1783.35	MG/L	10/18/2006	
IIHA31	Sulfate	1830	MG/L	10/18/2006	2.582091
IIHA-STE1-DUP	Solids, total dissolved	3100	MG/L	9/9/2006	
IIHA-STE1	Solids, total dissolved	3090	MG/L	9/9/2006	-0.3231
IIKSPC3A-DUP	Biological Oxygen Demand	11	MG/L	9/7/2006	
IIKSPC3A	Biological Oxygen Demand	11	MG/L	9/7/2006	0
JQ01-DUP	Chlorophyll	11.8	MG/CU.M.	8/31/2006	
JQ-01	Chlorophyll	13.2	MG/CU.M.	8/31/2006	11.2
JQ01-DUP	Hardness (CA/MG)	221.3	MG CACO3/L	8/31/2006	
JQ-01	Hardness (CA/MG)	221	MG CACO3/L	8/31/2006	-0.13565
ND11-DUP	Solids, total suspended	16.2	MG/L	11/1/2006	
ND11	Solids, total suspended	15	MG/L	11/1/2006	-7.69231
ND11-DUP	Alkalinity	90.2	MG/L	9/6/2006	
ND11	Alkalinity	90.2	MG/L	9/6/2006	0
NDA01-DUP	Solids, total suspended	18.2	MG/L	9/6/2006	
NDA01	Solids, total suspended	16.6	MG/L	9/6/2006	-9.1954
NDB04-DUP	Chlorophyll	26.9	MG/CU.M.	11/2/2006	
NDB04	Chlorophyll	25.7	MG/CU.M.	11/2/2006	-4.56274
OI05C-DUP	Biological Oxygen Demand	4.6	MG/L	9/1/2006	
OI05C	Biological Oxygen Demand	5.1	MG/L	9/1/2006	10.30928
OIC02-DUP	Solids, total suspended	14	MG/L	8/31/2006	
OIC02	Solids, total suspended	13.7	MG/L	8/31/2006	-2.16606
OIC02-DUP	Solids, total suspended	18.5	MG/L	10/17/2006	

Table 3-1: Duplicate Pair Sample Results (continued)

SampleLocation	Parameter	Result	Units	Collection Date	RPD(%)
OIC02	Solids, total suspended	16.8	MG/L	10/17/2006	-9.63173
OIP10-DUP	Hardness (CA/MG)	278.52	MG CACO3/L	10/17/2006	
OIP10	Hardness (CA/MG)	286	MG CACO3/L	10/17/2006	2.650039
OZH-OK-A2A-DUP	Chlorophyll	155.4	MG/CU.M.	9/8/2006	
OZH-OK-A2A	Chlorophyll	126	MG/CU.M.	9/8/2006	-20.8955

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Section 4
Conclusions

Data collected during Stage 2 have been deemed adequate and usable for Stage 3 TMDL development (see discussion in Section 3). Table 4-1 contains information for each segment sampled during Stage 2 with regards to its impairment status. The table contains information on the number of historic samples available prior to Stage 2 data collection, the number of historic violations as well as the date of the last recorded violation. The intention of this table is to assist any future determination on the impairment status of the Stage 2 stream segments.

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Table 4-1: Impairment Status

Watershed	Stream Name	Segment	Parameter of Concern	Historic Data Count	Number of Historic Violations	Date of Last Recorded Violation	Stage 2 Data Count	Number of Violations	Suggested Status
Bay Creek	Cedar Creek	AJF16	Dissolved Oxygen	1	1	2000	Continuous	0	Delist
			Manganese	1	0	-	4	0	Delist
	Bay Creek Ditch	AJK01	Dissolved Oxygen	3	3	1987	Continuous	Multiple	Impaired
			Manganese	3	3	1987	3	0	Delist
Cahokia Creek/ Holiday Shores Lake	Cahokia Diversion Ditch	JQ07	Dissolved Oxygen	147	130	2005	Continuous	Multiple	Impaired
			Copper	5	1	1998	4	0	Delist
Cedar Creek	Big Muddy River	N99	Dissolved Oxygen	3	1	2002	Continuous	*	Impaired
			Sulfates	3	0	-	4	0	Delist
	Cave Creek	NAC01	Dissolved Oxygen	2	1	1995	Continuous	1	Impaired
Crab Orchard Lake	Crab Orchard Creek	ND11	Dissolved Oxygen	2	1	2000	Continuous	Multiple	Impaired
			Manganese	2	2	2000	2	0	Delist
			pH	3	2	2004	Continuous	Multiple	Impaired
	Crab Orchard Creek	ND12	pH	3	1	2004	Continuous	0	Delist
			Manganese	2	1	2000	2	0	Delist
	Crab Orchard Creek	ND13	Dissolved Oxygen	4	4	2000	Continuous	Multiple	Impaired
	Little Crab Orchard Creek	NDA01	Dissolved Oxygen	2	1	1995	Continuous	Multiple	Impaired
			Manganese	2	1	1995	3	1	Impaired
	Piles Fork	NDB03	Dissolved Oxygen	2	1	1995	Continuous	Multiple	Impaired
Crooked Creek	Plum Creek	OZH-OK-A2	Dissolved Oxygen	1	1	2002	Continuous	Multiple	Impaired
	Plum Creek		Manganese	1	1	2002	4	0	Delist
	Plum Creek	OZH-OK-C2	Dissolved Oxygen	1	1	2002	Continuous	Multiple	Impaired
	Plum Creek	OZH-OK-C3	Dissolved Oxygen	1	1	2002	Continuous	Multiple	Impaired
	Plum Creek		Manganese	1	1	2002	2	0	Delist
	Little Crooked Creek	OJA-01	Dissolved Oxygen	5	4	2002	Continuous	Multiple	Impaired
			Manganese	5	2	2002	4	0	Delist

Table 4-1: Impairment Status

Watershed	Stream Name	Segment	Parameter of Concern	Historic Data Count	Number of Historic Violations	Date of Last Recorded Violation	Stage 2 Data Count	Number of Violations	Suggested Status
Little Wabash	Little Wabash River	C09	Dissolved Oxygen	43	7	2003	Continuous	Multiple	Impaired
			Silver	43	1	2002	18	0	Delist
			Atrazine	2	1	1991	16	2	Impaired
		C33	Dissolved Oxygen	5	3	2002	Continuous	Multiple	Impaired
			Manganese	5	5	2002	10	10	Impaired
			Atrazine	NA	NA	NA	16	2	Impaired
	Village Creek	CE01	Dissolved Oxygen	1	0	NA	Continuous	Multiple	Impaired
			Manganese	1	1	2002	6	0	Delist
	Johnson Creek	CCAFFA1	Dissolved Oxygen	1	1	1997	Continuous	Multiple	Impaired
	Pond Creek	CCFFD1	Dissolved Oxygen	1	1	1997	Continuous	Multiple	Impaired
	Elm River	CD01	Atrazine	8	3	2002	16	2	Impaired
		CD02	Dissolved Oxygen	3	2	2003	Continuous	Multiple	Impaired
	Seminary Creek	CDGFLA1	Dissolved Oxygen	1	1	1998	Continuous	Multiple	Impaired
	Seminary Creek	CDFGLC6	Dissolved Oxygen	1	1	1998	Continuous	Multiple	Impaired
	Big Muddy Creek	CJ06	Dissolved Oxygen	3	1	2002	Continuous	Multiple	Impaired
			Manganese	2	1	2002	6	0	Delist
	Little Muddy Creek	CJA02	Dissolved Oxygen	4	3	2002	Continuous	Multiple	Impaired
			Manganese	4	3	2002	4	2	Impaired
	Big Muddy Diversion Ditch	CJAE01	Dissolved Oxygen	1	0	2000	Continuous	Multiple	Impaired
Mary's River/ North Fork Cox Creek	North Fork Cox Creek	IIHA31	Sulfates	2	2	1995	4	4	Impaired
			TDS	2	2	1995	4	4	Impaired
	North Fork Cox Creek	IIHA-STC1	TDS	1	1	1995	4	2	Impaired
	Maxwell Creek	IIKSPC1A	Dissolved Oxygen	2	2	19999	Continuous	Multiple	Impaired
	Randolph County Lake	RIB	Total Phosphorus	11	3	1993	6	2	Impaired
Sangamon River/ Lake Decatur	Owl Creek	EZV	Dissolved Oxygen	3	1	1998	Continuous	Multiple	Impaired

Table 4-1: Impairment Status

Watershed	Stream Name	Segment	Parameter of Concern	Historic Data Count	Number of Historic Violations	Date of Last Recorded Violation	Stage 2 Data Count	Number of Violations	Suggested Status
Shoal Creek	Shoal Creek	OI05	Dissolved Oxygen	3	1	2002	Continuous	0	Delist
	Locust Fork	OIC01	Dissolved Oxygen	3	1	1991	Continuous	Multiple	Impaired
			Manganese	3	1	1991	2	0	Delist
	Chicken Creek	OIO09	Dissolved Oxygen	2	1	1991	0	0	No Water
	Cattle Creek	OIP10	Dissolved Oxygen	3	2	1991	Continuous	Multiple	Impaired
			Ammonia	3	1	1991	1	0	Delist
			TDS	3	1	1991	1	0	Delist
South Fork Saline River/ Lake of Egypt	Briers Creek	ATHS01	Zinc	2	2	1993	13	0	Delist
			Iron	3	3	1993	16	3	Impaired
			Manganese	3	3	1993	8	4	Impaired
			Silver	3	1	1993	12	0	Delist
			Sulfates	3	3	1993	16	6	Impaired
			TDS	2	1	1993	16	9	Impaired
			pH	3	3	1993	Continuous	0	Delist
			Dissolved Oxygen	2	1	1993	Continuous	1	Impaired
	East Palzo Creek	ATHV01	Copper	3	2	1993	5	0	Delist
			Iron	3	3	1993	7	1	Impaired
			Manganese	3	3	1993	7	3	Impaired
			TDS	0		-	7	1	Impaired
			pH	3	3	1993	Continuous	Multiple	Impaired
	South Fork Saline River	ATH14	Dissolved Oxygen	8	1	2000	Continuous	0	Delist
South Fork Sangamon/ Lake Taylorville	South Fork Sangamon River	EO13	Dissolved Oxygen	1	1	1989	Continuous	Multiple	Impaired
			Boron	1	1	1989	6	0	Delist
			Manganese	1	1	1989	6	2	Impaired

* Continuous data did not violate the 5.0 mg/L instantaneous DO standard, however, continuous data collected at site N13 experienced more than 16 hours below 6.0 mg/L in a 24 hour period

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For Appendices, please contact Jennifer Clarke at the Illinois EPA for information.

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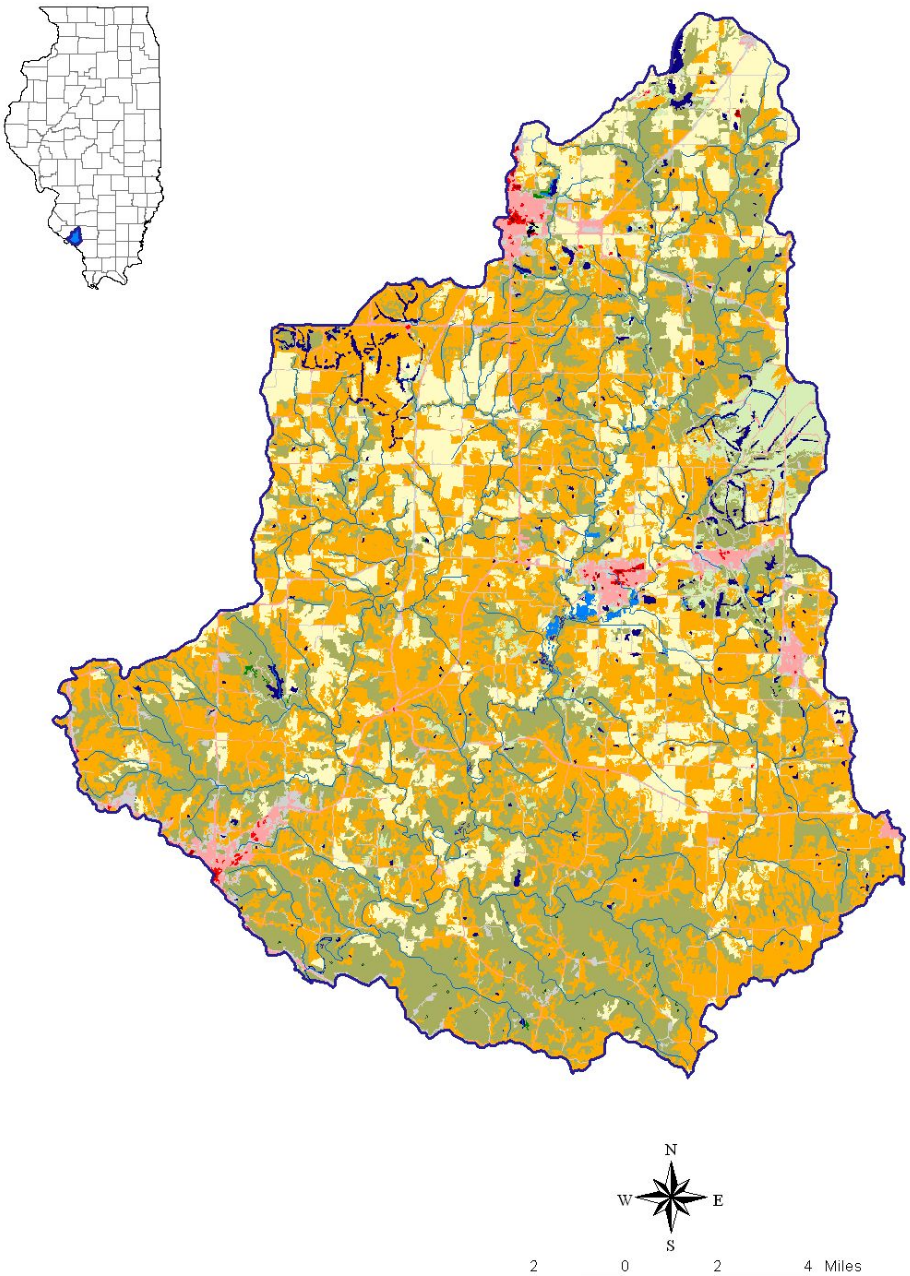
TMDL Development for the Mary's River/North Fork Cox Creek Watershed, Illinois

FINAL REPORT
September 6, 2007



TETRA TECH

Illinois Environmental Protection Agency

TMDL Development for the Mary's River/North Fork Cox Creek Watershed, Illinois

FINAL REPORT

September 6, 2007

Submitted to:
Illinois Environmental Protection Agency
1021 N. Grand Avenue East
Springfield, IL 62702

Submitted by:
Tetra Tech, Inc.
Water Resources TMDL Center

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1.0 INTRODUCTION

A TMDL is defined as "the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background" such that the capacity of the waterbody to assimilate pollutant loadings is not exceeded. A TMDL is also required to be developed with seasonal variations and must include a margin of safety that addresses the uncertainty in the analysis. The overall goals and objectives in developing TMDLs include:

- Assess the water quality of the impaired waterbodies and identify key issues associated with the impairments and potential pollutant sources.
- Use the best available science and available data to determine the maximum load the waterbodies can receive and fully support all of their designated uses.
- Use the best available science and available data to determine current loads of pollutants to the impaired waterbodies.
- If current loads exceed the maximum allowable load, determine the load reduction that is needed.
- Identify feasible and cost-effective actions that can be taken to reduce loads.
- Inform and involve the public throughout the project to ensure that key concerns are addressed and the best available information is used.
- Submit a final TMDL report to USEPA for review and approval.

The Mary's River/North Fork Cox Creek watershed has been assessed and analyzed in three stages as part of the Illinois Environmental Protection Agency's (IEPA) TMDL development process. Stage 1 (IEPA, 2006) was completed in June 2006 by the Camp Dresser and McKee (CDM) consulting firm and focused on watershed characterization, analysis of available data, and recommendations for additional sampling. Stage 2 (IEPA, 2007) involved collecting additional chemical water quality data, continuous dissolved oxygen measurements, channel morphology, and discharge measurements and was also conducted by CDM (Appendix E). Stage 2 data were collected at twelve monitoring locations within the Mary's River/North Fork Cox Creek watershed (Figure 1) and the sampling data confirmed all of the original listings of impaired waters. This report addresses Stage 3 of the TMDL process which involves modeling and TMDL analysis of the parameters of concern for the impaired segments of the Mary's River/North Fork Cox Creek watershed.

2.0 BACKGROUND

The Mary's River/North Fork Cox Creek watershed covers a drainage area of approximately 244 square miles (156,000 acres) and is a portion of the Upper Mississippi-Cape Girardeau 8-digit hydrologic unit (07140105-02). Located in southern Illinois, the Mary's River/North Fork Cox Creek watershed drains portions of Randolph (35%), Jackson (3%), and Perry (3%) counties in the Interior River Valleys and Hills (IRVH) ecoregion (Figure 1). The Mary's River originates in northeast Randolph County and flows towards the southwest until its confluence with the Mississippi River near Chester, IL. Major tributaries to Mary's River include Maxwell Creek, North Fork Cox Creek, Cox Creek, Little Mary's River, and Mill Creek. Population centers include Willisville, Chester, Steeleville, Percy, and Sparta. There are no designated/permitted Municipal Separate Storm Sewer Systems (MS4s) within the Mary's River/North Fork Cox Creek watershed. The dominant land cover is agricultural land use (Figure 2).

Table 1 lists the Mary's River/North Fork Cox Creek Section 303(d) listing information along with an identification of the TMDLs presented in this report. IEPA is currently developing TMDLs only for pollutants that have numeric water quality standards.

Table 1. 2006 303(d) List Information for the Mary's River/North Fork Cox Creek Watershed

Waterbody Name/Segment	Segment Size	Cause of Impairment*	Impaired Designated Use	Potential Sources
North Fork Cox Creek (IIHA-31)	4.76 miles	**Sulfates**	Aquatic Life	Surface Mining
		Total Dissolved Solids (TDS)	Aquatic Life	Surface Mining, Urban Runoff/Storm Sewers
		Endrin	Aquatic Life	Crop Production (Crop Land or Dry Land), Urban Runoff/Storm Sewers
		Sedimentation/ Siltation	Aquatic Life	Crop Production (Crop Land or Dry Land), Urban Runoff/Storm Sewers, Surface Mining
North Fork Cox Creek (IIHA-STC1)	0.51 miles	**Total Dissolved Solids (TDS)**	Aquatic Life	Surface Mining, Urban Runoff/Storm Sewers
		Sedimentation/ Siltation	Aquatic Life	Urban Runoff/Storm Sewers, Municipal Point Source Discharges, Crop Production (Crop Land or Dry Land), Surface Mining
Maxwell Creek (IIK-SPC1A)	2.25 miles	**Dissolved Oxygen**	Aquatic Life	Municipal Point Source Discharges, Urban Runoff/Storm Sewers
		Nitrogen (Total)	Aquatic Life	Urban Runoff/Storm Sewers, Municipal Point Source Discharges
		Phosphorus (Total)	Aquatic Life	Municipal Point Source Discharges, Urban Runoff/Storm Sewers
Randolph County Lake (RIB)	65 acres	**Total Phosphorus (TP)**	Aesthetic Quality	Livestock (Grazing or Feeding Operations), Crop Production (Crop Land or Dry Land), Runoff from Forest/Grassland/Parkland, Lake Fertilization
		Total Suspended Solids	Aesthetic Quality	Crop Production (Crop Land or Dry Land), Lake Fertilization, Livestock (Grazing or Feeding Operations), Littoral/shore Area Modifications (Non-riverine)
Sparta Old Reservoir (RIJ)	26.3 acres	**Manganese**	Public Water Supply	Source Unknown
		Total Phosphorus (TP)	Aquatic Life	Crop Production (Crop Land or Dry Land)

*Parameters in bold are addressed in this TMDL report.

Figure 1. Location of the Mary's River/North Fork Cox Creek Watershed

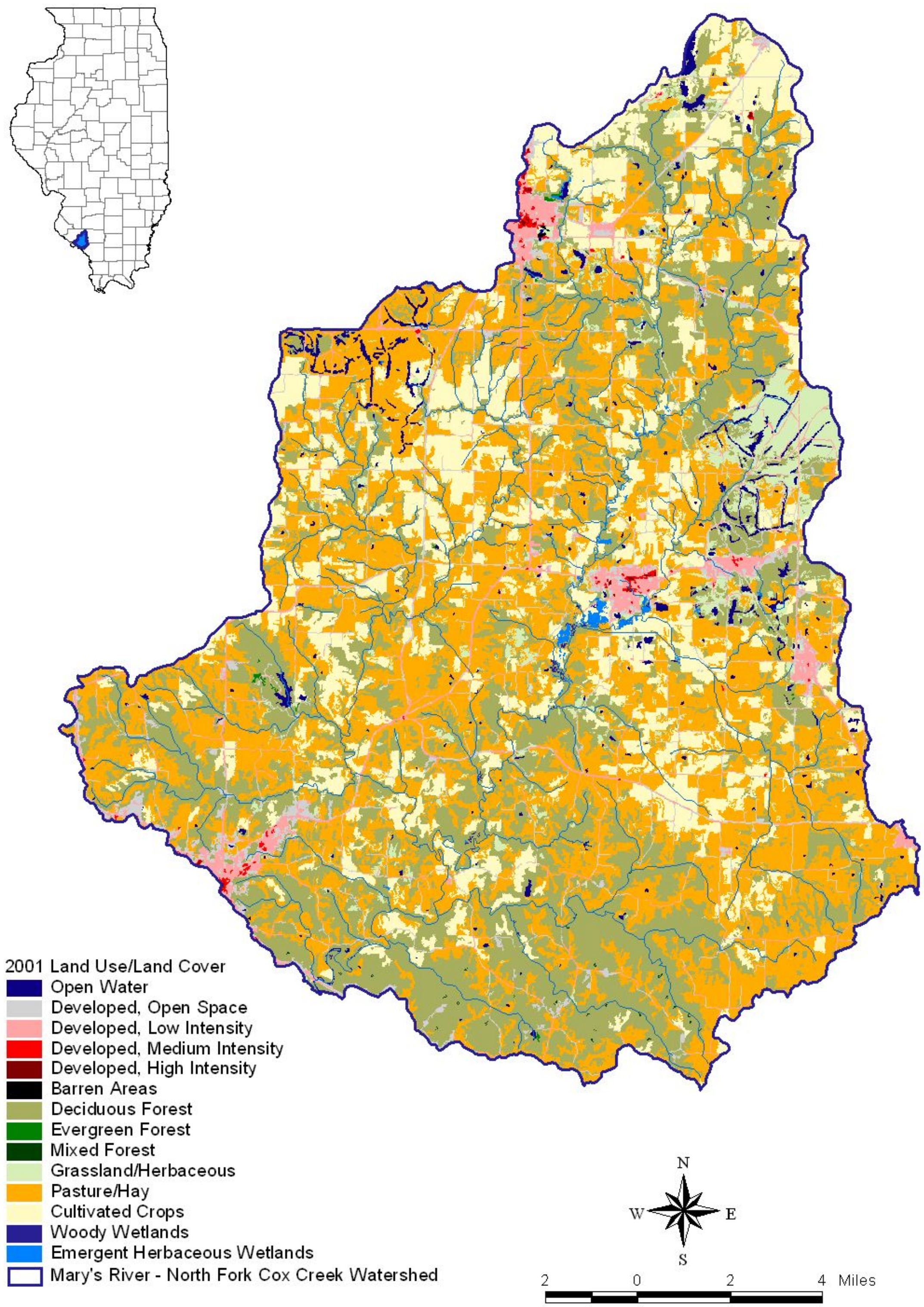

Figure 2. Land Use in the Mary's River/North Fork Cox Creek Watershed

3.0 APPLICABLE WATER QUALITY STANDARDS

The purpose of developing a TMDL is to identify the pollutant loading that a waterbody can receive and still achieve water quality standards. Under the Clean Water Act, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the Clean Water Act's goal of "swimmable/fishable" waters. Water quality standards consist of three components: designated uses, numeric or narrative criteria, and an antidegradation policy. A description of the water quality standards that apply to this TMDL is presented below.

3.1 Use Support Guidelines

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 designations provided by the IPCB that apply to water bodies in the Mary's River/North Fork Cox Creek watershed:

General Use Standards - These standards protect for aquatic life, wildlife, agricultural, 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.

Water quality standards used for TMDL development in the Mary's River/North Fork Cox Creek watershed are listed below for lakes (Table 2) and streams (Table 3).

Table 2. Summary of Water Quality Standards for the Mary's River/N. Cox Creek Watershed Lake Impairments.

Parameter	Units	General Use Water Quality Standard	Public and Food Processing Water Supplies	Section for Regulatory Citation[b]
Manganese	µg/L	1,000	150	General use: 302.208 Public Water Supply: 302.304
Total Phosphorus	mg/L	0.05[a]	No numeric standard	302.205

[a] Standard only applies in lakes/reservoirs that are greater than 20 acres in surface area and in any stream at the point where it enters such a lake/reservoir.
[b]All IEPA water quality standards are published by the Illinois Pollution Control Board under Title 35: Environmental Protection Subtitle C: Water Pollution Chapter I: Pollution Control Board. Part 302. Water Quality Standards. Subpart A: General Water Quality Provisions.

Table 3. Summary of Water Quality Standards for the Mary's River/N. Cox Creek Watershed Stream Impairments.

Parameter	Units	General Use Water Quality Standard	Public and Food Processing Water Supplies	Section for Regulatory Citation[a]
Dissolved Oxygen	mg/L	5.0 instantaneous minimum	No numeric standard	302.206
		6.0 minimum during at least 16 hours of any 24 hour period		
Sulfates	mg/L	500	250	General use: 302.208 Public Water Supply: 302.304
Total Dissolved Solids (TDS)	mg/L	1,000	500	General use: 302.208 Public Water Supply: 302.304

[a]All IEPA water quality standards are published by the Illinois Pollution Control Board under Title 35: Environmental Protection Subtitle C: Water Pollution Chapter I: Pollution Control Board. Part 302. Water Quality Standards. Subpart A: General Water Quality Provisions.
[b] Fecal coliform standards are 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

4.0 TECHNICAL ANALYSIS

This section of the report describes the technical approaches used to calculate TMDLs in the Mary's River/North Fork Cox Creek watershed. Load duration curves were used to estimate the current and allowable loads of sulfates and total dissolved solids for two impaired stream segments in the Mary's River/North Fork Cox Creek watershed. The QUAL2K model was used to simulate instream dissolved oxygen concentrations in Maxwell Creek. BATHTUB was used to model total phosphorus and manganese in the impaired lakes within the Mary's River/North Fork Cox Creek watershed. Table 4 presents the listed water bodies and the corresponding modeling approach used to address each TMDL.

Table 4. 303(d) List Information and Modeling Approaches for the Mary's River/North Fork Cox Creek Watershed

Waterbody Name	Segment	Cause of Impairment	Modeling Approach
North Fork Cox Creek	IIHA-31	Sulfates	Load Duration Curve
		Total Dissolved Solids	Load Duration Curve
North Fork Cox Creek	IIHA-ST-C1	Total Dissolved Solids	Load Duration Curve
Maxwell Creek	IIK-SP-C1A	Dissolved Oxygen	QUAL2K
Randolph County Lake	RIB	Total Phosphorus	BATHTUB
Sparta Old Reservoir	RIJ	Manganese	BATHTUB
		Total Phosphorus	BATHTUB

4.1 Load Duration Curves

Load reductions for fecal coliform and manganese were determined through the use of load duration curves. The load duration curve demonstrates the allowable loadings of a pollutant at different flow regimes expected to occur in the impaired segment and still maintain the water quality standard. The following steps are taken:

1. A flow duration curve for the stream is developed by generating a flow frequency table and plotting the data points.

2. The flow curve is translated into a load duration (or TMDL) curve. To accomplish this, each flow value is multiplied by the water quality standard and by a conversion factor. The resulting points are graphed.

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 and a conversion factor. Then, the individual loads are plotted on the TMDL graph.

4. Points plotting above the curve represent deviations from the water quality standard and the daily allowable load. Those plotting below the curve represent compliance with standards and the daily allowable load.

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.

Sulfates and total dissolved solids loadings were calculated for stream segment IIHA-31 and total dissolved solids loadings were also calculated for stream segment IIHA-ST-C1. Segment IIHA-ST-C1 is a short stream reach (0.51 miles) that begins on North Fork Cox Creek just upstream of the confluence with Cox Creek. Just upstream is segment IIHA-31 that starts in the headwaters of North Fork Cox Creek and flows for 4.76 miles to where it connects with the IIHA-ST-C1 segment (Figure 1).

Data collected at IEPA stations IIHA-31 and IIHA-ST-C1 (Figure 1) were used to assess sulfates and total dissolved solids loadings to stream segments IIHA-31 and IIHA-ST-C1 respectively as data for these stations are representative of sulfate and total dissolved solids loadings to the respective segments. Though sulfates and total dissolved solids data are limited at these stations, TMDLs were developed for each parameter and the necessary reductions for the limited samples are presented in Section 5.1.

The stream flows displayed on a load duration curve may be grouped into various flow regimes to aid with interpretation of the load duration curves. The flow regimes are typically divided into 10 groups, which can be further categorized into the following five "hydrologic zones" (Cleland, 2005):

- 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 50 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 load duration approach helps to identify the issues surrounding the impairment and to roughly differentiate between sources. Table 5 summarizes the relationship between the five hydrologic zones and potentially contributing source areas.

The load reduction approach also considers critical conditions and seasonal variation in the TMDL development as required by the Clean Water Act and EPA's implementing regulations. Because the approach establishes loads based on a representative flow regime, it inherently considers seasonal variations and critical conditions attributed to flow conditions.

Table 5. Relationship Between Load 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
Riparian areas		H	H	M	
Stormwater: Impervious		H	H	H	
Combined sewer overflow (CSO)	H	H	H		
Stormwater: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	
Bank erosion	H	M			

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

4.1.1 Stream Flow Estimates

Daily stream flows are needed to apply the load duration curve. As noted in the Stage 1 report, there are no USGS gage stations within the Mary's River/North Fork Cox Creek with current, or even recent, streamflow data. Therefore, a nearby gage (USGS gage 03612000, the Cache River near Forman, IL) was selected to estimate continuous flows in the Mary's River/North Fork Cox Creek watershed using the drainage area ratio method. This station on the Cache River was selected due to its close proximity to the Mary's River/North Fork Cox Creek watershed in Johnson County, because of the gage station's similar drainage area of 244 square miles, and because the land uses in the two watersheds are similar.

Daily average stream flows from 1/1/1987 through 12/31/2006 for the two monitoring stations (IIHA-31 and IIHA-ST-C1) were extrapolated from the USGS station 03612000, using the drainage area ratio method. This method is based upon comparing the load duration analysis sampling station and USGS gage station drainage areas. For example, the drainage area upstream of the IIHA-ST-C1 sampling station is 11.04 square miles, and the drainage area of the USGS gage station is 244 square miles. The drainage area ratio therefore equals 0.0452 and the daily flows at the flow gage were multiplied by 0.0452 to estimate the daily flows at station IIHA-ST-C1.

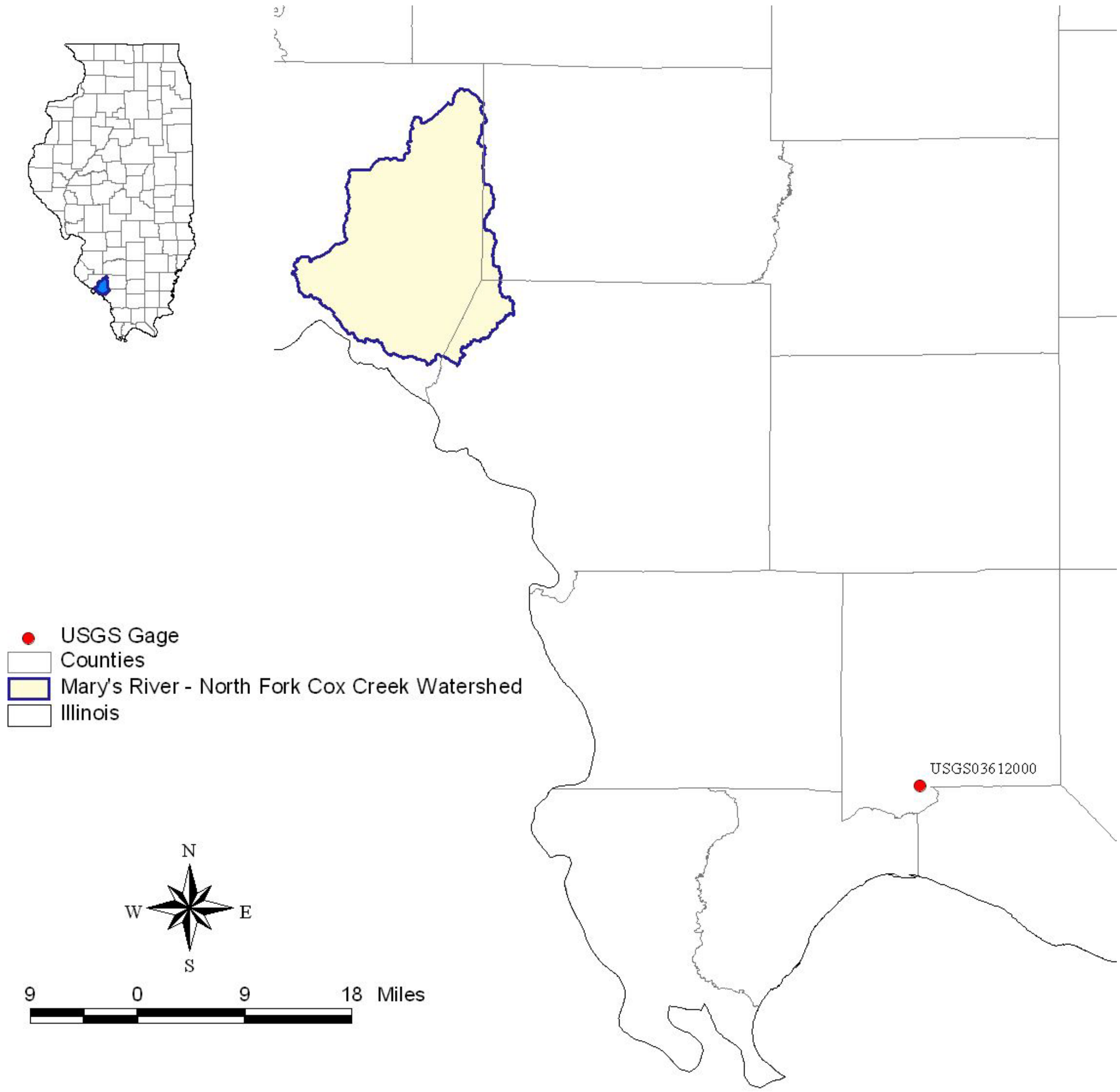

Figure 3. Location of USGS Gage 03612000 in comparison to the Mary's River – North Fork Cox Creek watershed.

4.2 QUAL2K Model

The QUAL2K water quality model was used to assess dissolved oxygen concentrations in Maxwell Creek. QUAL2K is supported by U.S. EPA and has been used extensively for TMDL development and point source permitting issues across the country, especially for issues related to dissolved oxygen concentrations. The QUAL2K model is suitable for simulating hydraulics and water quality conditions of a small river. It is a one-dimensional model with the assumption of a completely mixed system for each computational cell. QUAL2K assumes that the major pollutant transport mechanisms, advection and dispersion, are significant only along the longitudinal direction of flow. The model allows for multiple waste discharges, water withdrawals, tributary flows, and incremental inflows and outflows. The processes employed in QUAL2K address nutrient cycles, algal growth, and dissolved oxygen dynamics.

4.3 BATHTUB Model

BATHTUB was selected for modeling water quality in the Randolph County Lake (Figure 4) and Sparta Old Reservoir (Figure 5). BATHTUB performs steady-state water and phosphorus balance calculations in a spatially segmented hydraulic network, which accounts for pollutant transport and sedimentation. In addition, the BATHTUB model automatically incorporates internal phosphorus loadings into its calculations. Eutrophication-related water quality conditions (e.g., phosphorus, nitrogen, chlorophyll a, and transparency) are predicted using empirical relationships previously developed and tested for reservoir applications (Walker, 1987). BATHTUB was determined to be appropriate because it addresses the parameter of concern (phosphorus) and has been used previously for reservoir TMDLs in Illinois and elsewhere. USEPA also recommends the use of BATHTUB for lake phosphorus TMDLs (USEPA, 1999).

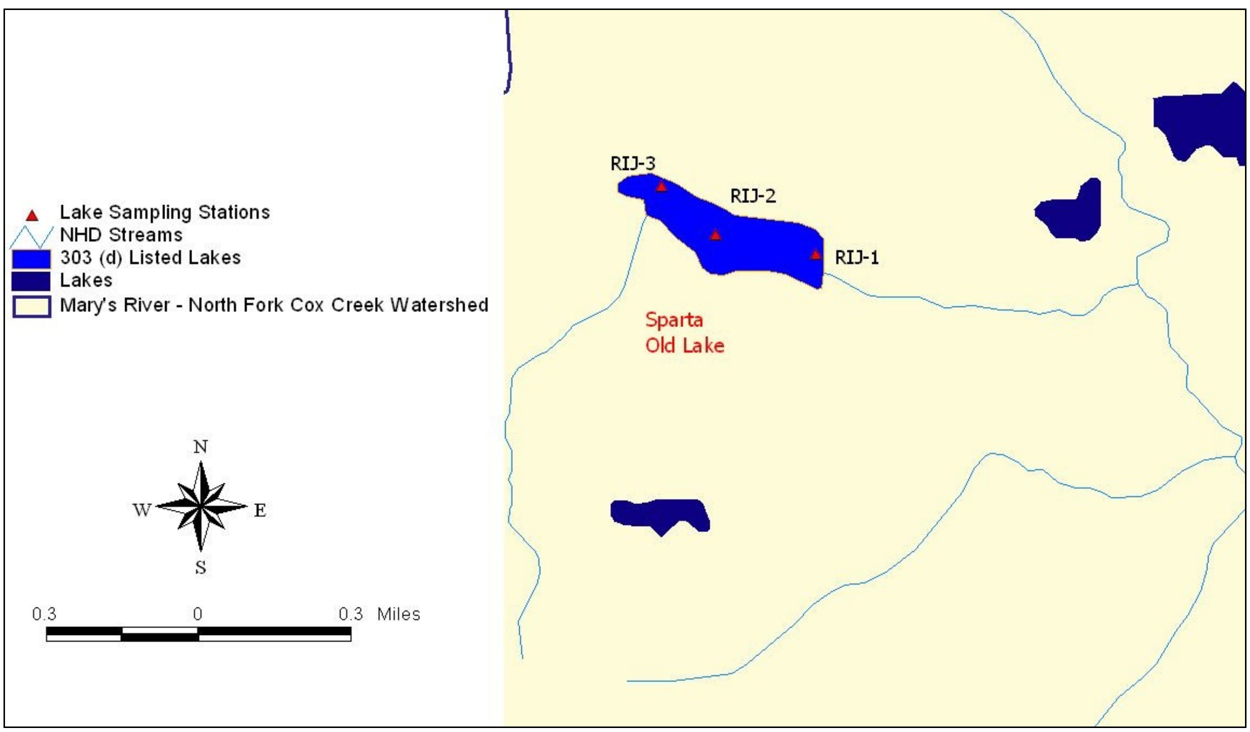

Figure 4. Randolph County Lake Monitoring Stations

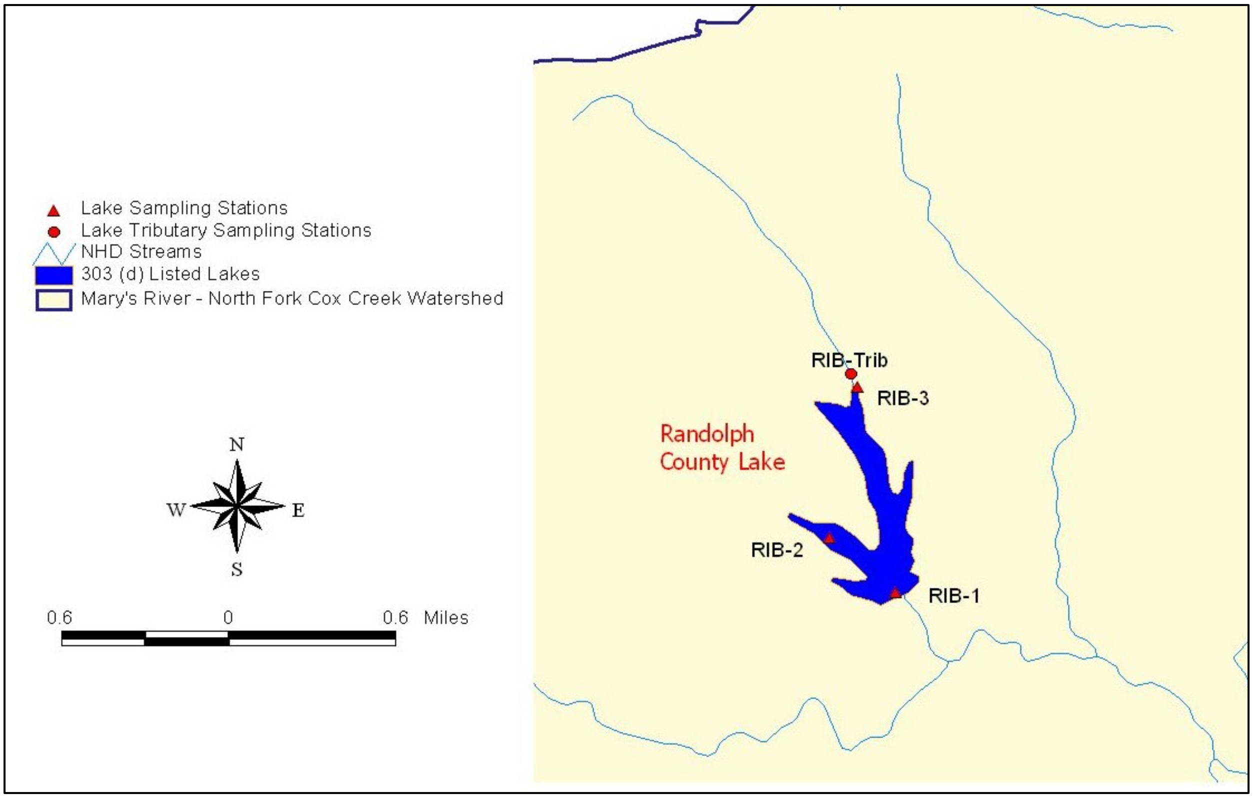

Figure 5. Sparta Old Reservoir Monitoring Stations

The BATHTUB model requires the following data to configure and calibrate: tributary flows and concentrations, reservoir bathymetry, in-lake water quality concentrations, and global parameters such as evaporation rates and annual average precipitation. Lake bathymetry data were available from IEPA's Stage 1 and 2 sampling data and maps of the lake and are summarized in Table 6.

Table 6. Bathymetry Data for the Mary's River/North Fork Cox Creek Watershed Lakes.

Lake	Parameter	Value
Randolph County Lake	Normal Pool Volume (ac-ft)	946
	Normal Pool Surface Area (ac)	65
	Maximum Depth (ft)	35
	Mean Depth (ft)	14.5
Sparta Old Reservoir	Normal Pool Volume (ac-ft)	198
	Normal Pool Surface Area (ac)	26
	Maximum Depth (ft)	17
	Mean Depth (ft)	7.5

In a typical BATHTUB model application, tributary flows and corresponding phosphorus concentrations are input to the model, and simulated inlake concentrations are compared to a limited set of water quality samples. For both Randolph County Lake and Sparta Old Reservoir, however, watershed and tributary data are not available to estimate loads to the lake. As a result, a "reverse" BATHTUB application was applied with average inlake concentrations used to derive estimates of tributary loads given the annual flow volumes and lake bathymetry data. Flows were estimated by area weighting observed flow data obtained at USGS gage 03612000 on the Cache River at Forman, IL. Randolph County Lake has a drainage area of approximately 3.5 square miles and Sparta Old Reservoir drains approximately 1 square mile. No adjustment of the phosphorus calibration factor was needed with this simulation because the loads were set by year to match average observed concentrations. Watershed loads and total flow volumes to the Mary's River/North Fork Cox Creek watershed lakes are summarized for the annual and summer season periods in Table 7 and Table 8.

Table 7. Annual Watershed Loading to Randolph County Lake.

Lake	Year	Stream Flow (MG)	TP Load (ton)
Randolph County Lake	1984	1,450	0.58
	1992	413	0.06
	1993	1,217	0.35
	2006	1,491	1.01

Table 8. Summer Season Watershed Loading to Sparta Old Reservoir.

Lake	Year	Stream Flow (MG)*	TP Load (ton)
Sparta Old Reservoir	1991	31	0.63
	1992	9	1.16
	1999	31	0.44
	2003	170	2.45
	2005	34	1.57

The BATHTUB model requires input of the fraction of inorganic nutrient load. Inorganic fractions for nitrogen were estimated from the ratio of ammonia plus nitrite plus nitrate to total nitrogen. Phosphate data were not available to estimate the inorganic phosphorus fraction, so a value of 0.3 was assumed based on similar lakes modeled previously in Illinois.

The USACOE BATHTUB model (Walker, 1987) was set up to simulate nutrient responses in Randolph County Lake for the years 1984, 1992, 1993, and 2006 and in Sparta Old Reservoir for 1991, 1992, 1999, 2003, and 2005 to correspond with available water quality data. Second order, available nutrient models were used to simulate total phosphorus. No adjustment of the phosphorus calibration factor was needed because the loads were set by year to match the average observed concentrations.

The BATHTUB model includes rates of direct deposition to the lake surface for total phosphorus. However, direct atmospheric deposition of phosphorus to a lake surface is generally considered insignificant compared to watershed loading rates. In studying phosphorus inputs to Lake Michigan, USGS determined that atmospheric deposition rates in agricultural areas were approximately 0.18 lb/ac/yr (Robertson, 1996). This rate was used for all simulation years in Randolph County Lake and Sparta Old Reservoir.

5.0 TMDL

A TMDL is the total amount of a pollutant that can be assimilated by the receiving water while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources (including 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. An additional portion of the TMDL can be reserved for future growth if significant development is anticipated; however, no significant growth is anticipated in this primarily rural watershed and therefore no future growth reserve was included in the TMDL calculations. Conceptually, the TMDL allocations can be defined by the equation:

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

A summary of the TMDL allocations for the Mary's River/North Fork Cox Creek watershed is presented in this section of the report, organized according to pollutants and modeling analysis.

5.1 Loading Capacity for Sulfates and TDS in North Fork Cox Creek

A TMDL must identify the loading capacity of a waterbody for the applicable pollutant. USEPA regulations define loading capacity as the greatest amount of a pollutant that a waterbody can receive without violating water quality standards. The loading capacity is often referred to as the "allowable" load. The following sections provide information on the allowable loads for segments IIHA-31 and IIHA-ST-C1 of North Fork Cox Creek. Table 9 and Table 10 list the sulfates and TDS load reductions required at the sample stations (one station per segment) within the two stream segments.

The not-to-exceed general use components of Illinois's water quality standards were evaluated using load duration analysis as part of this study. The results of the load duration analysis based on the not-to-exceed target values of 1,000 mg/L for TDS and 500 mg/L for sulfates are presented in the sections below. Observed loads noted in the TMDL tables are based on the median observed load obtained for each flow category. Detailed load duration reports are presented in Appendix A.

5.1.1 Loading Capacity of Stream Segment IIHA-31

Existing and allowable loads were calculated for North Fork Cox Creek, segment IIHA-31, at sampling station IIHA-31. This station is located on North Fork Cox Creek upstream of Steeleville, just northwest of Percy. This location drains 4.9 square miles and land use/land cover is primarily agricultural (pasture/hay 26% and cultivated crops 21%). Surface and underground coal mining has occurred in the headwaters and south-central portions of North Fork Cox Creek. A total of 4 TDS samples and 4 sulfates samples were available for load duration analysis (Appendix B). The Percy STP discharges to segment IIHA-31, however it is downstream of the IIHA-31 sampling station. No other permitted facilities discharge upstream of the IIHA-31 sampling station.

Due to a lack of available data, load duration analyses for TDS and sulfates were completed using all available data for the IIHA-31 sampling station, which included two samples from 2006 and one sample from both 1995 and 1996 (Appendix B). It is recommended that future TDS and sulfates monitoring be conducted to allow for a more thorough water quality assessment in the IIHA-31 segment of North Fork

Cox Creek. Available TDS and sulfates data represent only two of the five flow conditions (moist and dry).

Table 9 presents the TMDL summary for the IIHA-31 sampling station. Results of the load duration analysis indicate that all TDS and sulfates loads in this segment are well above the allowable loading limits for North Fork Cox Creek. The needed load reductions for TDS ranged from 68 (moist flow conditions) to 73 percent (dry flow conditions). Similarly, sulfates displayed needed reductions of 69 and 74 percent at moist and dry flow conditions, respectively.

As listed in the Stage 1 report, potential sources of the excessive TDS and sulfites loads may be agriculture/crop related sources, urban runoff/storm sewers, and/or resource extraction/surface mining. Though there are coal mines within and surrounding the watershed, there are no permitted mine discharges within the North Fork Cox Creek watershed. No other permitted discharges exist within the watershed upstream of the IIHA-31 sampling station.

Table 9. TDS and Sulfates TMDL Summary for Stream Segment IIHA-31

IIHA31 TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
TDS (kg/day)	Current Load	No Data	37,910	No Data	1,467	No Data
	TMDL= LA+WLA+MOS	**66,328**	**13,462**	**2,702**	**432**	**74**
	LA	59,695	12,116	2,432	389	66
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	6,633	1,346	270	43	7
	TMDL Reduction (%)	No Data	68%	No Data	73%	No Data
Sulfates (kg/day)	Current Load	No Data	19,587	No Data	759	No Data
	TMDL= LA+WLA+MOS	**33,164**	**6,731**	**1,351**	**216**	**37**
	LA	29,848	6,058	1,216	195	33
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	3,316	673	135	22	4
	TMDL Reduction (%)	No Data	69%	No Data	74%	No Data

5.1.2 Loading Capacity of Stream Segment IIHA-ST-C1

Existing and allowable loads were calculated for the North Fork Cox Creek sampling station IIHA-ST-C1 on the IIHA-ST-C1 segment. Located directly downstream of segment IIHA-31 in the southeastern corner of the Steeleville municipal boundary, this sampling station drains 11.04 square miles and the upstream land use/land cover consists of primarily grassland/herbaceous (27%), deciduous forest (23%), and pasture/hay (20%). Three TDS samples were available for load duration analysis, two from 2006 and one from a 1995 sampling event (Appendix B). There are two NPDES facilities that are permitted to discharge upstream of sampling station IIHA-ST-C1:

- Percy Sewage Treatment Plant (STP) (permit number ILG580109)
- Steeleville STP (permit number IL0031241)

TDS loads for these facilities were not calculated because sampling for TDS is not required by the discharge permits for these facilities and they are not expected to be significant sources of TDS. As such no WLAs were specified for these facilities as part of the TMDL.

The general use water quality standard of 1,000 mg/L for TDS was applied to develop TMDLs for the IIHA-ST-C1 segment. Only 3 samples were available for load duration analysis at this site, two from sampling in 2006 and one from 1995, and all three were included in analysis to utilize all available data. Available TDS data were collected during two of the five flow conditions (moist and dry).

Table 10 presents the TMDL summary for this assessment location. Results of the load duration analysis indicate that TDS observations exceed the loading limit during all sampled flows. Needed load reductions are displayed at both moist (71 percent) and dry flow conditions (67 percent). Because there are only 3 samples available for TDS, it is recommended that future monitoring be conducted to allow for a more thorough water quality assessment in the IIHA-ST-C1 segment of North Fork Cox Creek.

As noted in the Stage 1 TMDL report, possible sources of TDS loads in the North Fork Cox Creek watershed include municipal point sources, agricultural practices, urban runoff/storm sewers, resource extraction, and surface mining.

Table 10. TDS TMDL Summary for Stream Segment IIHA-ST-C1

IIHASTC1 TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
TDS (kg/day)	Current Load	No Data	94,646	No Data	2,689	No Data
	TMDL= LA+WLA+MOS	149,442	30,331	6,088	974	166
	LA	134,497	27,298	5,480	877	149
	WLA: Percy STP/ Steeleville STP	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	14,944	3,033	609	97	17
	TMDL Reduction (%)	No Data	71%	No Data	67%	No Data

5.1.3 Waste Load Allocations

No TDS WLAs are presented in this TMDL for the two sewage treatment plants because they are not required to sample for this parameter and because they are not expected to be significant sources of TDS.

5.1.4 Load Allocation

The load allocations are based on subtracting the allocations MOS from the allowable loads and are presented in Table 9 and Table 10. The control of TDS loadings from non point sources will be explored during the development of the implementation plan.

5.1.5 Margin of Safety

The Clean Water Act requires that a TMDL include a margin of safety (MOS) to account for uncertainties in the relationship between pollutants loads and receiving water quality. USEPA 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 percent explicit MOS has been applied as part of this TMDL as shown in Table 9 and Table 10. A moderate MOS was specified because the use of the 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 due to the lack of flow data within the watershed.

5.1.6 Critical Conditions and Seasonality

TMDLs should also take into account critical conditions and seasonal variations. Critical conditions refer to the periods when greatest reductions of pollutants are needed. The Clean Water Act requires that TMDLs take into account critical conditions for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. It is difficult to identify critical conditions for TDS and sulfate in the watershed due to the lack of observed data. However, the load duration approach addresses critical conditions by specifying allowable loads that vary by flow.

The Clean Water Act also requires that TMDLs be established with consideration of seasonal variations. The load duration approach also accounts for seasonality by evaluating allowable loads on a daily basis over the entire range of observed flows and presenting daily allowable loads that vary by flow.

5.2 Dissolved Oxygen Analysis in Maxwell Creek

Segment IIK-SPC1A of Maxwell Creek is listed as impaired due to low dissolved oxygen. The original listing was made based on two samples collected in 1999, both of which were below 3 mg/L, and the impairment was confirmed based on the Stage 2 sampling in September 2006 which resulted in two additional samples below 3 mg/L (refer to Stage 1 and Stage 2 reports for details). The QUAL2K model was setup and calibrated to the 2006 sampling data in Maxwell Creek to further investigate the dissolved oxygen issues as explained in Section 4.2. Details of the QUAL2K modeling are provided in Appendix C. There is one point source discharging to Maxwell Creek: the Sparta Southeast STP (permit ID IL0031160).

Based upon the results of the Stage 1 study, the Stage 2 sampling, and the QUAL2K modeling the low dissolved oxygen conditions in Maxwell Creek appear to be strongly related a lack of aeration caused by low flows and stagnant pools as well as high sediment oxygen demand. For example, the most upstream station on Maxwell Creek could not be sampled in either September or October 2006 due to a lack of flow. To further investigate this issue two separate model scenarios were made to evaluate the potential for meeting the dissolved oxygen water quality standard in Maxwell Creek:

1. Point and nonpoint source loads of carbonaceous biochemical oxygen demand (CBOD) and total ammonia were reduced until both components of the dissolved oxygen water were met.
2. The average dissolved oxygen re-aeration coefficient derived from the QUAL2K calibration was increased until both components of the dissolved oxygen water quality standard were met.

Table 11 indicates that significant load reductions of CBOD and total ammonia from both the Sparta Southeast STP and nonpoint sources in the watershed would be needed to achieve the dissolved oxygen water quality standard. CBOD measures the rate of oxygen uptake by micro-organisms in a sample of water and is an indication of the amount of biodegradable carbon in organic matter. Total ammonia is the sum of ammonia (NH_3) and ammonium (NH_4+) and is significant because the conversion of ammonium to nitrate by bacteria consumes dissolved oxygen. Natural sources of CBOD and total ammonia include leaf fall from vegetation near the water's edge, aquatic plants, and drainage from organically rich areas like swamps and bogs are all natural sources of material that consume oxygen. Human related sources of CBOD and ammonia include wastewater treatment plants, failing onsite (septic) systems, livestock operations, and manured crops. Currently very limited information is available with which to evaluate how much of the Maxwell Creek CBOD and total ammonia loads are due to natural conditions versus human activity.

The modeling analysis also indicated that the average re-aeration rate would need to be significantly increased from 5.48/day to 28/day to meet the water quality standards. However, increasing aeration in the stream is not a parameter for which a TMDL can be developed. Therefore, based on these considerations, no TMDL will be developed at this time.

Table 11. CBOD and total ammonia reductions needed for Maxwell Creek to achieve dissolved oxygen criteria.

Pollutant	Existing Nonpoint Sources (lbs/day)	Reduced Nonpoint Sources (lbs/day)	Nonpoint Source Percent Reduction	Existing Sparta Southeast STP (lbs/day)	Reduced Sparta Southeast STP (lbs/day)	Sparta Southeast STP Percent Reduction
CBOD	194.2	60.1	69	18.6	5.6	70
NH3+NH4	8.67	2.68	69	2.37	0.73	69

5.3 Loading Capacity for Randolph County Lake and Old Sparta Lake

The BATHTUB model was used to identify the load reductions necessary to achieve the target concentration of 0.05 mg/L total phosphorus in the Mary's River/North Fork Cox Creek watershed Lakes. The following sections summarize this analysis for Randolph County Lake and Sparta Old Reservoir. Table 12 and Table 12 detail the reductions necessary for each lake to meet the TMDL target.

5.3.1 Randolph County Lake Loading Capacity

The total phosphorus target for Randolph County Lake is 0.05 mg/L. To meet the target during all years, a 37 percent reduction of phosphorus load is required. Table 12 shows the annual average total phosphorus concentrations if a 37 percent reduction is implemented.

Table 12. Average Total Phosphorus Concentration in Randolph County Lake with 37 Percent Reduction in Loading

Year	Observed Historic TP (mg/L)	Simulated Post-TMDL TP (mg/L)
1984	0.048	0.035
1992	0.022	0.017
1993	0.037	0.027
2006	0.067	0.049
Average	0.044	0.032

5.3.2 Sparta Old Reservoir Loading Capacity

The total phosphorus target for Sparta Old Reservoir is 0.05 mg/L. To meet the target during all years, a 98 percent reduction of phosphorus load is required. Table 12 shows the annual average total phosphorus concentrations if a 98 percent reduction is implemented.

Table 13. Average Total Phosphorus Concentration in Sparta Old Reservoir with 98 Percent Reduction in Loading

Year	Observed Historic TP (mg/L)	Simulated Post-TMDL TP (mg/L)
1991	0.240	0.034
1992	0.330	0.047
1999	0.200	0.029
2003	0.390	0.038
2005	0.380	0.049
Average	0.308	0.039

5.3.3 Waste Load Allocations

There are no permitted facilities that discharge phosphorus loads to or upstream of Randolph County Lake or Sparta Old Reservoir, therefore no WLAs have developed as part of these TMDLs.

5.3.4 Load Allocation

The allocation of loads for the Mary's River/North Fork Cox Creek watershed lake TMDLs are summarized in Table 14. The existing loads for Randolph County Lake are the average annual loads to the lake for the period 1984 to 2006 and the existing loads for Sparta Old Reservoir are the average summer loads from 1991 to 2005. The loading capacity was calculated based on the percent reduction from existing loads determined to be necessary from the modeling analysis, 37 percent for Randolph County Lake and 98 percent for Sparta Old Reservoir. Five percent of the loading capacity is reserved for a margin of safety (as required by the Clean Water Act; see Section 5.3.5 for more information on the margin of safety).

Table 14. TMDL Summary for the Mary's River/North Fork Cox Creek Watershed Lakes.

Lake	Category	Phosphorus (kg/day)
Randolph County Lake	Existing Load	1.37
	Loading Capacity	0.86
	Wasteload Allocation	0.00
	Margin of Safety	0.04
	Load Allocation	0.82
Sparta Old Reservoir	Existing Load	8.17
	Loading Capacity	0.16
	Wasteload Allocation	0.0
	Margin of Safety	0.01
	Load Allocation	0.15

5.3.5 Margin of Safety

Section 303(d) of the Clean Water Act and USEPA's regulations at 40 CFR 130.7 require that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." The margin of safety can either be implicitly incorporated into conservative assumptions used to develop the TMDL or added as a separate explicit component of the TMDL (USEPA, 1991).

A five percent explicit margin of safety has been incorporated into the Mary's River/North Fork Cox Creek watershed lake TMDLs by reserving a portion of the loading capacity (refer to Table 14). A relatively low explicit margin of safety was selected because an implicit MOS is also associated with the TMDL reductions resulting in lake water quality being significantly better than the water quality standard in all but the most critical years (refer to Table 12 and Table 13).

5.3.6 Critical Conditions and Seasonality

Section 303(d)(1)(C) of the Clean Water Act and USEPA's regulations at 40 CFR 130.7(c)(1) require that a TMDL be established that addresses seasonal variations normally found in natural systems. Lake nutrients are typically highest during the summer. The TMDL for Sparta Old Reservoir is therefore expressed in terms of the summer average load. If the loading capacity identified for the summer months is achieved the beneficial use of the lakes are expected to be supported year-round. Randolph County Lake was evaluated using the summer season, however the turnover ratio using only May through September data did not fit the application so all data were used in an annual application.

REFERENCES

Cleland, B. 2005. TMDL Development Using Duration Curves. Update & Habitat TMDL Applications. Presentation made at Region 5 TMDL Practitioners' Workshop
Hickory Corners, MI. November 15, 2005.

Illinois EPA, 2006. Final Stage 1 Progress Report. Mary's River/North Fork Cox Creek Watershed. September 2006. Available at: http//www.epa.state.il.us/water/tmdl/report-status.html

Illinois EPA, 2007. Final Stage 2 Progress Report. Mary's River/North Fork Cox Creek Watershed. March 2007. Available at: http//www.epa.state.il.us/water/tmdl/report-status.html

Robertson, D.M. 1996. Sources and Transport of Phosphorus in the Western Lake Michigan Drainages. USGS Fact Sheet FS-208-96.

Walker, W.W., Jr. 1987. Empirical Methods for Predicting Eutrophication in Impoundments. Report 4– Phase III: Applications Manual. Technical Report E-81-9. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Appendix A : Load Duration Analysis Reports

Appendix B : TDS and Sulfates Data for Load Duration Analysis

Table B-1. Available TDS Data for Segment IIHA-31

Date	TDS at station IIHA-31 (mg/L)
12/21/1995	3,215
4/3/1996	1,640
9/9/2006	3,110
10/18/2006	2,840

Table B-2. Available Sulfates Data for Segment IIHA-31

Date	Sulfates at Station IIHA-31 (mg/L)
12/21/1995	680
4/3/1996	1,370
9/9/2006	1,610
10/18/2006	1,806

Table B-3. Available TDS data for Segment IIHA-ST-C1

Date	TDS Data at Station IIHA-ST-C1 (mg/L)
12/21/1995	1,974
9/9/2006	2,530
10/18/2006	1,530

Appendix C : QUAL2K Model

Appendix D : Stage 1 Report

Appendix E : Stage 2 Report

Mary’s River/North Fork Cox Creek TMDL Implementation Plan

FINAL REPORT

April 3, 2008

Submitted to:
Illinois Environmental Protection Agency
1021 N. Grand Avenue East
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Submitted by:
Tetra Tech

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KEY FINDINGS

The TMDLs developed for the impaired waterbodies in the Mary's River/North Fork Cox Creek watershed were approved by USEPA in September 2007. The results indicate that significant reductions of phosphorus, TDS, and sulfate are required. Because no dissolved oxygen TMDL was developed for Maxwell Creek, implementation measures to abate low dissolved oxygen in the Maxwell Creek are not included in this report. Similarly, because a manganese TMDL was not developed for Sparta Old Lake, specific implementation measures for manganese load abatement are not included in this report. However, due to the interrelated nature and sources of the pollutants causing impairment in the Mary's River/North Fork Cox Creek watershed, the recommended BMPs are expected to improve overall water quality in the impaired segments.

The largest potential sources of phosphorus in Randolph County Lake and Sparta Old Reservoir are associated with crop production and failing septic systems. Crop production in the watershed has resulted in increased loadings of nutrients, sediment, and manganese to the watershed. Fertilizer application results in additional phosphorus loading when rain events wash pollutants into adjacent waterbodies through over-land flow or through underlying tile drainage systems. Increased erosion rates associated with agricultural practices result in excessive sediment loads. The most cost-effective management strategy that addresses the nutrient and sediment issues in Mary's River/North Fork Cox Creek watershed is conservation tillage. Other effective practices include grass waterways, filter strips, fertilizer and pesticide management, and restoration of riparian buffers.

Failing onsite systems may cause localized water quality impacts as well as serious risks to human health. Identifying these systems through a routine inspection program and encouraging proper maintenance and upkeep will help to minimize these impacts.

Manure from animal operations is also a significant source of phosphorus in the Mary's River/North Fork Cox Creek watershed. The BMPs most likely to control loading from animal operations are 1) proper handling, storage, and final disposal practices for manure, 2) vegetative controls such as grassed waterways, filter strips, and constructed wetlands, 3) manure composting, and 4) restoration of riparian buffers. Since watershed specific data on animal operations was not available, the extent of phosphorus loadings to Randolph County Lake and Sparta Old Reservoir could not be estimated from this source.

Abandoned surface and underground mines are potential significant sources of TDS and sulfates in the Mary's River/North Fork Cox Creek watershed. Various BMPs that are effective in reducing the impacts from acid mine drainage such as sulfate-reducing bioreactors could potentially reduce TDS and sulfates loadings to North Fork Cox Creek.

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1.0 INTRODUCTION

The Clean Water Act and U.S. Environmental Protection Agency (USEPA) regulations require that states develop Total Maximum Daily Loads (TMDLs) for waters identified as impaired on the Section 303(d) lists. Several waterbodies in the Mary's River/North Fork Cox Creek watershed are listed on the State of Illinois' 2006 303(d) list as described in Table 1-1 and displayed in Figure 1-1. The causes of impairment highlighted in bold font in Table 1-1 are addressed in this report.

Table 1-1. 2006 303(d) Listing Information for Mary's River/North Fork Cox Creek Watershed.

Waterbody Name/Segment	Segment Size	Cause of Impairment*	Impaired Designated Use	Potential Sources
North Fork Cox Creek (IIHA-31)	4.76 miles	**Sulfates**	Aquatic Life	Surface Mining
		Total Dissolved Solids (TDS)	Aquatic Life	Surface Mining, Urban Runoff/Storm Sewers
		Endrin	Aquatic Life	Crop Production (Crop Land or Dry Land), Urban Runoff/Storm Sewers
		Sedimentation/ Siltation	Aquatic Life	Crop Production (Crop Land or Dry Land), Urban Runoff/Storm Sewers, Surface Mining
North Fork Cox Creek (IIHA-STC1)	0.51 miles	**Total Dissolved Solids (TDS)**	Aquatic Life	Surface Mining, Urban Runoff/Storm Sewers
		Sedimentation/ Siltation	Aquatic Life	Urban Runoff/Storm Sewers, Municipal Point Source Discharges, Crop Production (Crop Land or Dry Land), Surface Mining
Maxwell Creek (IIK-SPC1A)	2.25 miles	**Dissolved Oxygen** [a]	Aquatic Life	Municipal Point Source Discharges, Urban Runoff/Storm Sewers
		Nitrogen (Total)	Aquatic Life	Urban Runoff/Storm Sewers, Municipal Point Source Discharges
		Total Phosphorus (TP)	Aquatic Life	Municipal Point Source Discharges, Urban Runoff/Storm Sewers
Randolph County Lake (RIB)	65 acres	**Total Phosphorus (TP)**	Aesthetic Quality	Livestock (Grazing or Feeding Operations), Crop Production (Crop Land or Dry Land), Runoff from Forest/Grassland/Parkland, Lake Fertilization
		Total Suspended Solids	Aesthetic Quality	Crop Production (Crop Land or Dry Land), Lake Fertilization, Livestock (Grazing or Feeding Operations), Littoral/shore Area Modifications (Non-riverine)
Sparta Old Reservoir (RIJ)	26.3 acres	**Manganese**[b]	Public Water Supply	Source Unknown
		Total Phosphorus (TP)	Aquatic Life	Crop Production (Crop Land or Dry Land)

[a] QUAL 2K model indicated that the average re-aeration rate would need to significantly increased to improve dissolved oxygen levels in Maxwell Creek. Since increasing aeration in the stream is not a parameter for which TMDL can be developed, a dissolved oxygen TMDL was not developed.
[b] Sparta Old Reservoir manganese impairment is believed to be related to eutrophication issues caused by phosphorus loadings. Therefore, implementation measures suggested to control phosphorus will also abate manganese loadings to the lake.

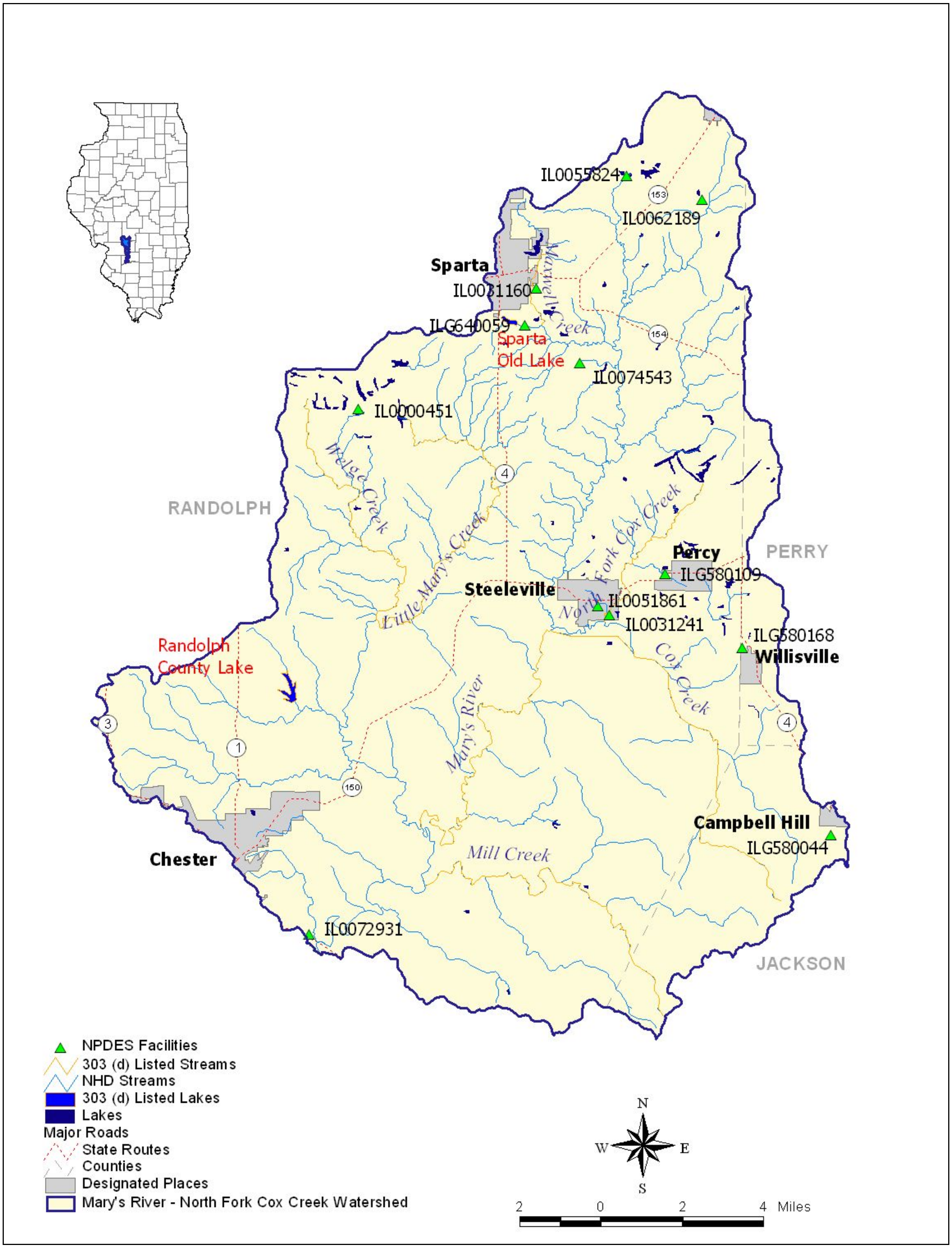

Figure 1-1. 303(d) Listed Reaches in Mary's River/North Fork Cox Creek Watershed.

IEPA is currently developing TMDLs for pollutants that have numeric water quality standards. Of the pollutants impairing waterbodies in the Mary's River/North Fork Cox Creek watershed, total phosphorus, dissolved oxygen, manganese, sulfates and total dissolved solids have numeric water quality standards. IEPA believes that addressing these impairments should lead to an overall improvement in water quality due to the interrelated nature of the other listed pollutants. For example, reducing loads of phosphorus should result in less algal growth and some of the management measures taken to reduce phosphorus loads (e.g., reducing agricultural erosion) should also reduce loads of suspended solids/sediment and other associated nutrients.

The Mary's River/North Fork Cox Creek TMDL project is being initiated in three stages. Stage One was completed in June 2006 and involved the characterization of the watershed, an assessment of the available water quality data, and identification of potential technical approaches. Stage Two involved additional data collection for waters where a TMDL could not yet be developed due to data limitations. The first portion of Stage Three was completed and approved by USEPA on September 6, 2007 and involved modeling and TMDL analyses for Mary's River/North Fork Cox Creek watershed impairments. The final component of Stage Three involves the completion of this implementation plan, outlining how the recommended TMDL reductions could be achieved.

The TMDLs for the waterbodies in Mary's River/North Fork Cox Creek watershed were developed using a load duration approach, QUAL2K modeling, or BATHTUB modeling depending on the pollutant(s) causing the impairment and the impaired water body type (lake or stream). Due to the number of listed segments in the watershed, this report will not detail the TMDL process. Readers interested in the details of each TMDL may refer to the TMDL report for the Mary's River/North Fork Cox Creek watershed which is available online at:

http://www.epa.state.il.us/water/tmdl/report-status.html

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2.0 DESCRIPTION OF WATERBODY AND WATERSHED CHARACTERISTICS

The purpose of this section of the report is to provide a brief background of the St. Mary’s River/North Fork Cox Creek watershed. More detailed information on the soils, topography, land use/land cover, climate, and population are available in the Stage One Watershed Characterization Report.

The Mary’s River/North Fork Cox Creek watershed encompasses a drainage area of approximately 244 square miles (156,000 acres) and is a portion of the Upper Mississippi-Cape Girardeau 8-digit hydrologic unit (07140105-02). Located in southern Illinois, the Mary’s River/North Fork Cox Creek watershed drains parts of Randolph (35%), Jackson (3%), and Perry (3%) counties in the Interior River Valleys and Hills (IRVH) ecoregion (Figure 1-1). The Mary’s River originates in northeast Randolph County and flows towards the southwest until its confluence with the Mississippi River near Chester, IL. Major tributaries to Mary’s River include Maxwell Creek, North Fork Cox Creek, Cox Creek, Little Mary’s River, and Mill Creek. Population centers include Willisville, Chester, Steeleville, Percy, and Sparta. There are no designated/permitted Municipal Separate Storm Sewer Systems (MS4s) within the Mary’s River/North Fork Cox Creek watershed. The dominant land cover is agricultural land use (Figure 2-1).

Soil erodibility factors reported for soils in the watershed range from 0.2 to 0.64, indicating moderate soil erodibility. Hydrologic soil groups B, C, and D are found within the Mary's River/North Fork Cox Creek watershed with the majority of the watershed falling into category B. Category B soils are defined as “soils having a moderate infiltration rate when thoroughly wet” that ”consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture.” Figure 2-2 displays the highly erodible soils in the Mary’s River/North Fork Cox Creek watershed.

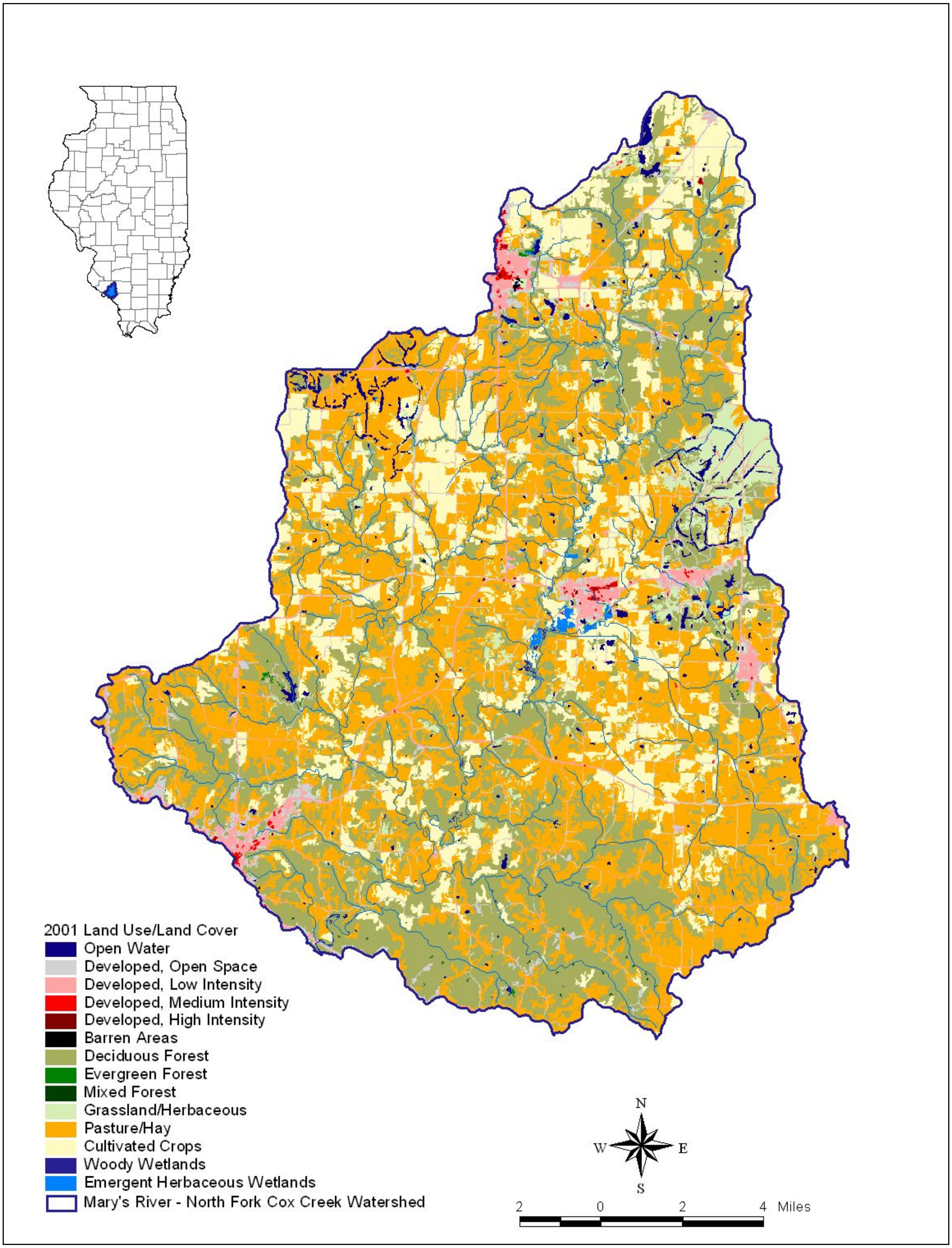

Figure 2-1. Land Use in the Mary's River/North Fork Cox Creek Watershed.

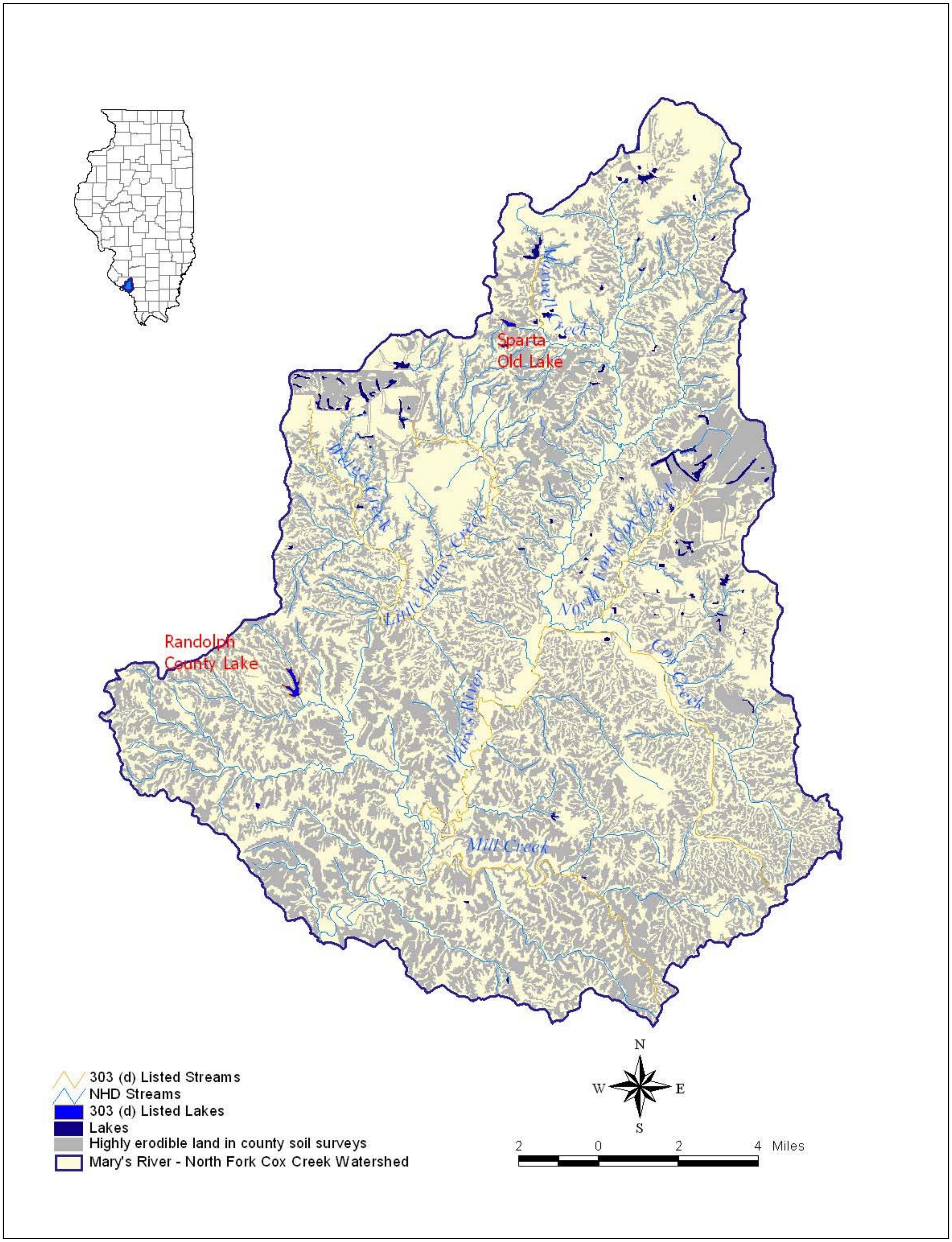

Figure 2-2. Highly Erodible Soils in the Mary's River/North Fork Cox Creek Watershed

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3.0 WATER QUALITY STANDARDS, IMPAIRMENTS, AND TMDL ALLOCATIONS

Waterbodies in the Mary's River/North Fork Cox Creek watershed are currently listed for several impairments. Those parameters that carry numeric water quality standards (total phosphorus, manganese, sulfates and total dissolved solids) are addressed in this implementation plan. This section presents the applicable water quality standards for each parameter and TMDL allocations in the watershed. More detailed discussions of the available water quality data and TMDL development are presented in the Stage One Watershed Characterization Report and Stage Three TMDL Development Report, respectively.

To assess the designated use support for Illinois waterbodies, the IEPA uses rules and regulations adopted by the Illinois Pollution Control Board (IPCB). The following are the use support designations applicable in the Mary's River/North Fork Cox Creek watershed:

General Use Standards - These standards protect for aquatic life, wildlife, agricultural use, primary contact recreation (where physical configuration of the waterbody permits it), secondary contact recreation, and most industrial uses. Primary contact recreation includes 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 recreation includes 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. 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.

3.1 Total Phosphorus

3.1.1 Water Quality Standards

The numeric water quality standard for total phosphorus requires that concentrations at one foot from the water surface remain at or below 0.05 mg/L in lakes with a surface area of at least 20 acres. This standard also applies to streams at the point that they enter a lake or reservoir.

3.1.2 TMDL Allocations

The BATHTUB model was used to derive phosphorus load reductions for both Randolph County Lake and Sparta Old Reservoir. Phosphorus reductions of 37 percent and 98 percent are required for Randolph County Lake and Sparta Old Reservoir, respectively. The TMDL allocations are summarized in Table3-1.

Table 3-1. TMDL Summary for the Mary's River /North Fork Cox Creek Watershed Lakes

Lake	Category	Phosphorus (kg/day)
Randolph County Lake	Existing Load	1.37
	Loading Capacity	0.86
	Wasteload Allocation	0.00
	Margin of Safety	0.04
	Load Allocation	0.82
Sparta Old Reservoir	Existing Load	8.17
	Loading Capacity	0.16
	Wasteload Allocation	0.0
	Margin of Safety	0.01
	Load Allocation	0.15

3.2 Manganese

3.2.1 Water Quality Standards

The water quality standard for manganese is 1,000 µg/L in the streams and lakes designated for general use in the Mary's River/North Fork Cox Creek watershed. An additional manganese water quality standard of 150 µg/L is applied to lakes that are used for public and food processing water supply.

3.2.2 Impairments in the Crab Orchard Creek Watershed

The only segment/water body in the watershed impaired for manganese is the Sparta Old Reservoir which is a public water supply; the 150 µg/L water quality standard therefore applies. Only three total manganese samples have been obtained in the Sparta Old Reservoir and the three samples (collected in 1999) had manganese concentrations ranging from 180 to 340 µg/L.

3.2.3 TMDL Allocations

Limited manganese data for Sparta Old Reservoir prevented any modeling from being completed for this waterbody and therefore the TMDL is based upon the total phosphorus allocations. Additional data collection is recommended in Sparta Old Reservoir to allow for future modeling efforts and to track the effectiveness of various BMPs recommended for the watershed. Due to the nature of manganese impairments, it is anticipated that projects oriented towards reducing phosphorus loading will also have positive impacts on manganese loading.

3.3 Total Dissolved Solids (TDS)

3.3.1 Water Quality Standard

The general use and public food processing water standards are 1, 000 mg/L and 500 mg/L, respectively.

3.3.2 TMDL Allocations

A load duration curve approach was used to develop TMDLs for TDS for two North Fork Cox Creek stream segments (IIHA31 and IIHA-STC1). The needed load reductions ranged from 68 (moist flow conditions) to 73 percent (dry flow conditions) for segment IIHA31, while load reductions of 71 percent and 76 percent are required to meet the TMDL target for segment IIHA-ST-C1 (Table 3-2).

Table 3-2. TDS TMDL Summary for North Fork Cox Creek Stream Segments

IIHA31 TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
TDS (kg/day)	Current Load	No Data	37,910	No Data	1,467	No Data
	TMDL= LA+WLA+MOS	**66,328**	**13,462**	**2,702**	**432**	**74**
	LA	59,695	12,116	2,432	389	67
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	6,633	1,346	270	43	7
	TMDL Reduction (%)	No Data	68%	No Data	73%	No Data
IIHASTC1 TMDL		**High Flows**	**Moist Conditions**	**Mid-Range Flows**	**Dry Conditions**	**Low Flows**
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
TDS (kg/day)	Current Load	No Data	94,646	No Data	2,689	No Data
	TMDL= LA+WLA+MOS	149,442	30,331	6,088	974	166
	LA	134,498	27,298	5,489	877	149
	WLA: Percy STP/ Steeleville STP	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	14,944	3,033	609	97	17
	TMDL Reduction (%)	No Data	71%	No Data	67%	No Data

3.4 Sulfates

3.4.1 Water Quality Standard

The general water quality standard for sulfates is 500 mg/L, and the standard for public and food processing water supply is 250 mg/L.

3.4.2 TMDL Allocations

Elevated sulfates are a concern in North Fork Cox Creek segment IIHA31. The load reductions for this segment were computed by applying a load duration curve approach. As illustrated in Table 3-3, sulfates display needed reductions of 69 and 74 percent at moist and dry flow conditions, respectively.

Table 3-3. Sulfates TMDL Summary for Stream Segment IIHA31

IIHA31 TMDL		High Flows	Moist Conditions	Mid-Range Flows	Dry Conditions	Low Flows
Pollutant	**TMDL Component**	**0-10**	**10-40**	**40-60**	**60-90**	**90-100**
Sulfates (kg/day)	Current Load	No Data	19,587	No Data	759	No Data
	TMDL= LA+WLA+MOS	**33,164**	**6,731**	**1,351**	**216**	**37**
	LA	29,848	6,058	1,216	194	33
	WLA: facility	n/a	n/a	n/a	n/a	n/a
	WLA: MS4	n/a	n/a	n/a	n/a	n/a
	MOS (10%)	3,316	673	135	22	4
	TMDL Reduction (%)	No Data	69%	No Data	74%	No Data

4.0 POLLUTANT SOURCES IN THE MARY'S RIVER/NORTH FORK COX CREEK WATERSHED

The Mary's River/North Fork Cox Creek watershed contains waterbodies listed for impairments due to total phosphorus, TDS, and sulfates. Both point and nonpoint sources contribute to the listed impairments. This section describes the major source categories as well as the impacts and contributions to pollutant loading in this watershed for each parameter.

4.1 Point Source Dischargers

This section discusses the National Pollutant Discharge Elimination System (NPDES) facilities that are allowed to discharge industrial or municipal wastewater to waterbodies within the Mary's River/North Fork Cox Creek watershed.

4.1.1 Phosphorus

There are no wastewater treatment facilities that contribute to phosphorus loading upstream of Sparta Old Reservoir or the Randolph County Lake.

4.1.2 TDS

North Fork Cox Creek segments IIHA31 and IIHA-ST-C1 have TDS loads that are above the allowable limits for TDS. There are two NPDES facilities that are permitted to discharge upstream of North Fork Cox Creek segments IIHA-ST-C1:

- Percy Sewage Treatment Plant (STP) (permit number ILG580109)
- Steeleville STP (permit number IL0031241)

These two facilities are not required to monitor for TDS and are not considered significant sources of TDS.

4.1.3 Sulfates

Permitted coal mine discharges and wastewater treatment plants are potential contributors of sulfate loads. However, there are no permitted mine discharges or wastewater treatment plants upstream of North Fork Cox Creek segment IIHA31 and therefore no point sources contribute to the listed sulfate impairment.

4.2 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems are not typically a significant source of pollutant loading if they are operating as designed. However, if the number of systems that are failing in this watershed is high, or if systems are placed on unsuitable soils, not maintained properly, or are connected to subsurface drainage systems, the loading rates to receiving waterbodies may be significant. At this time, no database of onsite wastewater treatment systems is available for the Mary's River/North Fork Cox Creek watershed, so it is difficult to estimate levels of performance or number of failing systems. It is recommended that systems older than 20 years and those located close to the lakes or streams should be prioritized for inspection.

4.2.1 Phosphorus

The waterbodies currently impaired for excessive total phosphorus are Sparta Old Reservoir and Randolph County Lake. Though a watershed model was not developed to determine the phosphorus loadings from septic systems, the GWLF user's manual (Haith et al., 1992) reports septic tank effluent loading rates and subsequent removal rates based on the use of phosphate detergents. Though phosphates have been banned from laundry detergents, dish detergents often contain between 4 and 8 percent phosphate by weight. The GWLF model assumes a septic tank effluent phosphorus loading rate for households using phosphate detergent of 2.5 g/capita/day. The model assumes a plant uptake rate of 0.4 g/capita/day of phosphorus during the growing season and 0.0 g/capita/day during the dormant season. Assuming a 6-month growing season (May through October), the average annual plant uptake rate is 0.2 g/capita/day.

In a properly functioning septic system, wastewater effluent leaves the septic tank and percolates through the system's drainfield. Phosphorus is removed from the wastewater by adsorption to soil particles. Plant uptake by vegetation growing over the drainfield is assumed negligible since all of the phosphorus is removed in the soil treatment zone. In the case of failing systems that either short circuit the soil adsorption field or cause effluent to pool at the ground surface, it is assumed that phosphorus removal occurs through plant uptake only (average annual uptake rate of 0.2 g/capita/day). Direct discharge systems that intentionally bypass the drainfield by connecting the septic tank effluent directly to a waterbody or other transport line (such as an agricultural tile drain) do not allow for soil zone treatment or plant uptake.

To approximate the phosphorus loading rate from onsite wastewater systems discharging to Randolph County Lake and Sparta Old Reservoir, a rough calculation based on the population density of Randolph County, the area of the watershed and, net loading rates reported in the GWLF User's manual were assumed. The population in the Mary's River/North Fork Cox Creek watershed is 19,000 (CDM, 2006) and the urban population (determined by GIS analysis) which account for the people living in Chester, Percy, Sparta, Steeleville, Willisville and Campbell Hill is 7,608. The estimated rural population of the watershed is therefore 11,392 (19,000 - 7,608 = 11,392).

Based on an average household size of 2.46 people per household, it is estimated that there are approximately 4,630 rural households served by septic systems. Since, the exact number of households around Randolph County Lake and Sparta Old Reservoir are unknown, an area weighted method was used to estimate the number of septic systems. Randolph County Lake drains 1.15 percent and Sparta Old Reservoir drains 0.27 percent of the total Mary's River/North Fork Cox Creek watershed area. Therefore, the number of septic systems is estimated to be 53 and 13 for Randolph County Lake and Sparta Old Reservoir, respectively.

The USEPA Onsite Wastewater Treatment Systems Manual (2002b) estimates that septic systems fail (do not perform as designed) at an average rate of 7 percent across the nation. Phosphorus loading rates under four scenarios were calculated to display a range of potential loading from this source. System failures were distributed evenly over the three failure types: short circuiting, ponding, and directly discharging. Table 4-1and Table 4-2 shows the phosphorus load if 0, 7, 15, 30, and 60 percent of systems are failing in the residences surrounding Randolph County Lake and Sparta Old Reservoir.

Table 4-1. Failure Rate Scenarios and Resulting Phosphorus Loads to Randolph County Lake.

Failure Rate[1] (%)	Average Annual Phosphorus Load (lb/yr)
7[2]	18
15	38
30	76
60	151

[1] Failures are assumed distributed evenly over short-circuiting, ponded, and directly discharging systems.
[2] This is the average annual failure rate across the nation.

Table 4-2. Failure Rate Scenarios and Resulting Phosphorus Loads to Sparta Old Reservoir.

Failure Rate[1] (%)	Average Annual Phosphorus Load (lb/yr)
7[2]	4
15	9
30	19
60	37

[1]Failures are assumed distributed evenly over short-circuiting, ponded, and directly discharging systems.
[2]This is the average annual failure rate across the nation.

4.3 Crop Production

The majority of land in the Mary's River/North Fork Cox Creek watershed is used for production of corn, soybeans, wheat, and other small grains. Due to application of commercial fertilizer, manure, and pesticides, as well as increased rates of erosion, pollutant loads from croplands are relatively high compared to other land uses in this watershed.

4.3.1 Phosphorus

Agricultural land use is found throughout the Mary's River/North Fork Cox Creek watershed. Phosphorus impairments, however, are only present in Randolph County Lake and Sparta Old Reservoir. Cultivated crops account for 2, 716 and 7, 940 acres in the land area draining to Randolph County Lake and Sparta Old Reservoir, respectively. Data presented by Gentry et al. (2007) suggest that phosphorus loading rates from tiled agricultural fields in east-central Illinois range from 0.5 to 1.5 lb/ac/yr. Comparable data are not available for the Mary's River/North Fork Cox Creek watershed. Based on the Gentry data, the phosphorus loads to Randolph County Lake derived from crop production areas may range from 1,358 to 4, 074 lb/yr and from 3,970 to 11,910 lb/yr in Sparta Old Reservoir, assuming that all of the fields are artificially drained.

4.4 Animal Operations

Pollutant loading from animal operations can be a problem in both confined and pasture-based systems. Though the exact location of animal operations in the watershed is not known, countywide statistics indicate that a large number of livestock, swine, and poultry may exist. Figure 4-1 shows an example of poorly managed animal wastes that may contaminate nearby surface waters.

(Photo courtesy of USDA NRCS.)

Figure 4-1. Example of Poorly Managed Animal Waste.

4.4.1 Phosphorus

Agricultural animal operations are a potentially large source of total phosphorus loading if adequate best management practices (BMPs) are not in place to protect surface waters. Livestock operations either consist of confined or pasture-based systems. If a confined operation has greater than 1,000 animal units or is determined to threaten water quality, the operation requires a federal Concentrated Animal Feeding Operation (CAFO) permit. CAFOs are required to develop a nutrient management plan (NMP) as part of the CAFO permitting process (USEPA, 2003). The CAFO NMP consists of manure management and disposal strategies that minimize the release of excess nutrients into surface and ground water. The CAFO NMPs are based on NRCS standards and technical expertise.

Table 4-3 lists the number of animals equivalent to one animal unit (IDA, 2001) for each of the livestock and poultry classes that are likely present in the Mary's River/North Fork Cox Creek watershed, as well as each associated total phosphorus loading rate (USEPA, 2002a; ASAE, 1998). In addition, the table lists the total number of animal units in Mary's River/North Fork Cox Creek watershed and the estimated total phosphorus loads.

Table 4-3. Animal Unit Data and Total Phosphorus Loading Rates for Mary's River/North Fork Cox Creek Watershed

Animal	Number of Animals in One Animal Unit	Total Number of Animals	Number of Animal Units in Watershed	Total Phosphorus Load (lb/au/d)	Total Phosphorus Load (lb/yr)
Poultry	50	17,967	359	0.32	41,931
Beef cattle	1	6,540	6,540	0.16	381,936
Dairy cattle	0.71	2,039	2,871	0.14	146,708
Other cattle: heifers, bulls, calves, etc.	1	17,967	17,967	0.16	1,049,272
Hogs and pigs	2.5	10,034	4,013	0.13	190,416
Sheep and lambs	10	660	66	0.05	1,204
Horses and ponies	0.5	708	1,416	0.16	8,2694
Total Phosphorus Load from Agricultural Animals in Mary's River/North Fork Cox Creek Watershed					**1,894,161**

Since the distribution of animal operations in Randolph County Lake and Sparta Old Reservoir subwatersheds are unknown, the extent of phosphorus loading specific to these two lakes could not be computed. However, a study done by Illinois EPA on 32 livestock facilities existing in 2000 within this watershed showed that 18 facilities had no impact on water quality, 12 were assessed to have slight impact, and 2 were assessed to have a moderate impact. Neither of the moderate impact sites are located on a listed impaired stream segment (CDM, 2006). Information on new permitted facilities (if any have been established after 2000) operating in Randolph County Lake and Sparta Old Reservoir subwatersheds is need to assess phosphorus loadings to these lakes.

4.5 Mining Operations

4.5.1 TDS

Two North Fork Cox Creek segments (IIHA31 and IIHA-ST-C1) are listed for TDS impairments. There are three permitted mine discharges within the Mary's River/North Fork Cox Creek watershed (Table 4-4) and the location map displaying the extent of these coal mines can be found in Figure 4-2. The surface and underground mines associated with Knight Hawk Coal (IL0072575) are located within the North Fork Cox Creek subwatershed and are potential contributors of TDS and sulfates to North Fork Cox Creek. However, the contributions would be from diffuse nonpoint sources (e.g. underground mine seeps, mine waste pile runoff, etc…) within the subwatershed because the facility's permitted outfall discharges to Branch Creek (a tributary to Cox Creek), not the North Fork Cox Creek segments. It is recommended that a thorough AMD source assessment be completed within the subwatershed to determine the full extent and location of the AMD sources causing impairment in North Fork Cox Creek.

Elevated TDS, metals, and acidity levels are typical of mine drainage from surface and underground coal mines in particular. However, since no TDS monitoring data were available for the mining facilities in this watershed, the TDS loads could not be estimated.

Table 4-4. Permitted Coal Mining Facilities in the Mary's River/North Fork Cox Creek Watershed

Permit #	Facility Name	Active Mining?	Permit Status	Reclamation Status	Other Notes
IL0055824	Alpena Vision Resources	No	Historic Mining	Reclamation of site and refuse disposal areas are ongoing	Outfalls 001 and 002 discharge only in response to precipitation events and discharge infrequently
IL0000451	Consolidated Coal Company	No	Historic mining	Reclamation complete- permit holders applying for final bond release	Outfall 296 is the discharge from a permanent impoundment that discharges fairly consistently due to the impoundment being fed by shallow groundwater in the area
IL0072575	Knight Hawk Coal	Yes	Active	Active mining still occurring	Relatively new facility- basin and outfall 002 constructed in 2003

4.5.2 Sulfate

Abandoned surface and underground mines are also the suspected sources of sulfates in North Fork Cox Creek segment IIHA-31. When iron disulfide (pyrite) and associated minerals react with air and water the oxidation reaction produces sulfuric acid. The sulfuric acid leaches metals from the surrounding geology as well as lowers the pH in the impacted streams. However, as with TDS, the sulfate loading from the abandoned mine areas could not be computed.

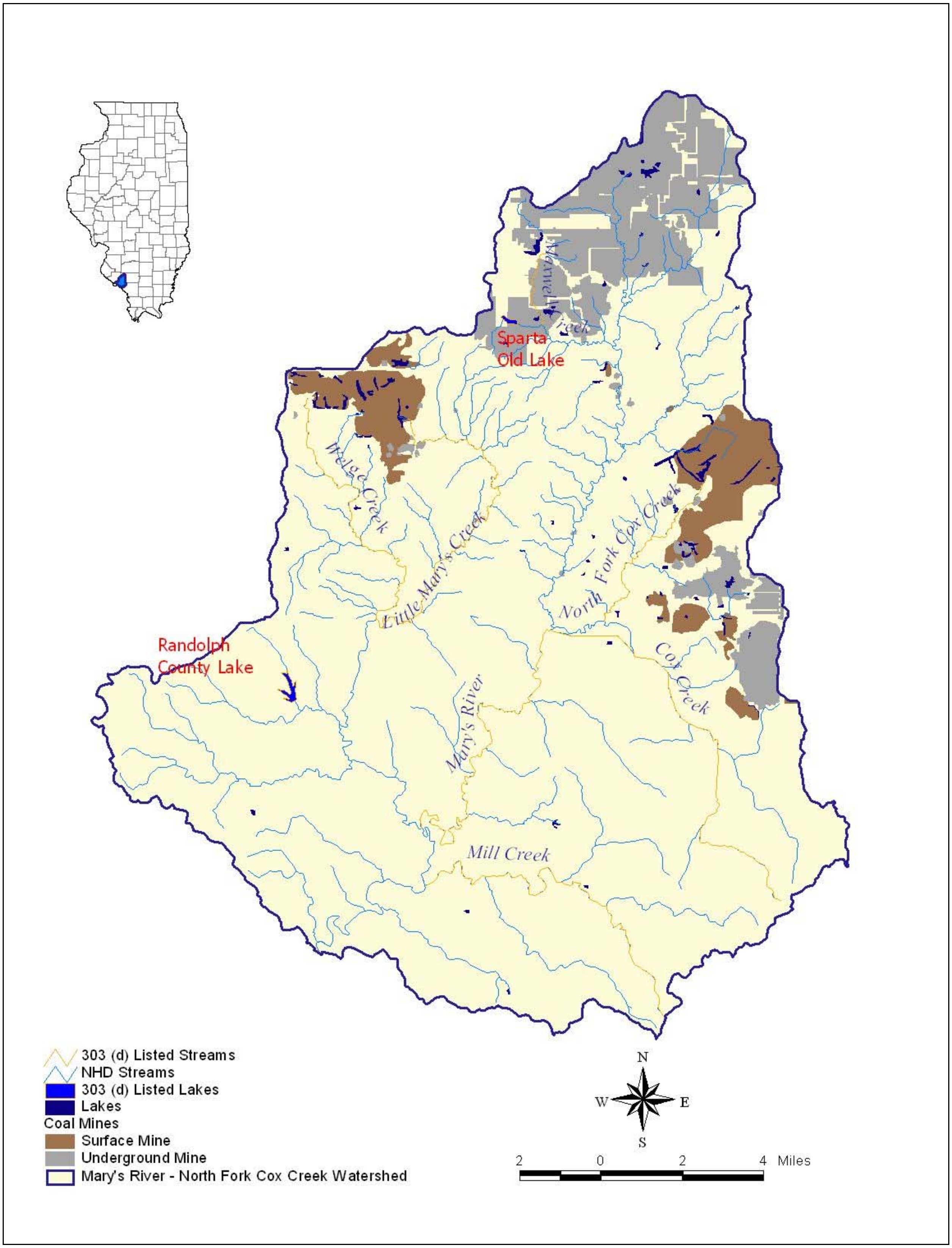


Figure 4-2. Mining Coverage in the Mary's River/North Fork Cox Creek Watershed

4.6 Lake Shore and Stream Bank Erosion

Excessive erosion can quickly degrade aquatic ecosystems and can also contribute to nutrient loads as phosphorus often attaches to fine sediment particles and is washed into water bodies during runoff events. Once sediment reaches a waterbody, the attached phosphorus may be released through biological and chemical transformations into the water column. This release may increase rates of algal and plant growth (also called eutrophication), which leads to issues with dissolved oxygen concentrations, water treatability, and overall aesthetics. Severe erosion reduces the stability of streambanks and lake shores by undercutting the roots of established vegetation and altering stream channel geometry. Loss of vegetative canopy and widening of a stream channel will allow more sunlight to reach the water column which may 1) increase rates of eutrophication, 2) increase water temperatures, and 3) decrease dissolved oxygen concentrations.

Without quantitative estimates of streambank and shoreline erosion, it is not possible to estimate the phosphorus loading from this source. Fortunately several of the BMPs described in Section 5.0 that control pollutant loads and runoff volumes will also help control streambank and lakeshore erosion.

4.7 Internal Loading from Lake Bottom Sediments

Randolph County Lake and Sparta Old Reservoir are both listed for phosphorus impairments. In addition to tributary loadings, internal loading may occur as phosphorus that is attached to fine sediment particles is released from bottom sediments in anoxic (without oxygen) lakes. Inlake management strategies are discussed in Section 5.0. In addition, BMPs that reduce phosphorus loads in the watersheds surrounding these lakes will help to mitigate phosphorus loads to the lake, and are expected to reduce the anoxic (without oxygen) dissolved oxygen conditions that stimulate phosphorus release from bottom sediments.

4.8 Atmospheric Deposition

Phosphorus loading from atmospheric deposition is not considered a significant fraction of the total loading to both Randolph County Lake and Sparta Old Reservoir. Wind erosion is usually the primary loading mechanism for atmospheric sources of phosphorus. The USGS reports atmospheric deposition rates of phosphorus from agricultural areas near Lake Michigan at 0.18 lb/ac/yr (Robertson, 1996). With a lake surface area of 65 acres, the phosphorus load due to atmospheric deposition in Randolph County Lake is estimated to be 11.7 lb/yr. Sparta Old Reservoir has a surface area of 26.3 acres and the atmospheric deposition is estimated to be 4.73 lb/yr. Both of these atmospheric deposition values account for only a small fraction of the load estimated from watershed sources.

5.0 BEST MANAGEMENT PRACTICES

Controlling pollutant loading to the impaired reaches of Mary's Rive/North Fork Cox Creek watershed will require implementation of various BMPs depending on the pollutant(s) of concern and major sources of loading. This section describes BMPs that may be used to reduce loading from onsite wastewater treatment systems, agricultural operations, inlake resuspension, lake shore erosion, and mine operations. The net costs associated with the BMPs described in this plan depend on the cost of construction (for structural BMPs), maintenance costs (seeding, grading, etc.), and operating costs (electricity, fuel, labor, etc.). In addition, some practices require that land be taken out of farm production and converted to treatment areas, which results in a loss of income from the cash crop. On the other hand, taking land out of production does save money on future seed, fertilizer, labor, etc., and this must be accounted for as well. This section describes how the various costs apply to each BMP, and presents an estimate of the annualized cost spread out over the service life. Incentive plans and cost share programs are discussed separately in Section 8.0.

The costs presented in this section are discussed in year 2004 dollars because this is the latest year for which gross income estimates for corn and soybean production are available. Market prices can fluctuate significantly from year to year based on supply and demand factors, so applying straight rates of inflation to convert crop incomes from one year to the next is not appropriate. The cost to construct, maintain, and operate the BMPs is assumed to follow a yearly inflation rate of 3 percent since these components are not as dependent on such factors as weather and consumer demand. Therefore, all prices for BMP costs have been converted to year 2004 dollars to develop a net cost for each BMP. Inflated prices are rounded to the nearest quarter of a dollar since most of the costs were reported in whole dollars per acre, not dollars and cents.

Gross 2004 income estimates for corn and soybean in Illinois are \$510/acre and \$473/acre, respectively (IASS, 2004). Accounting for operating and ownership costs results in net incomes from corn and soybean farms of \$140/acre and \$217/acre, respectively (USDA-ERS, 2005). The average net annual income of \$178/acre was therefore used to estimate the annual loss from BMPs that take a portion of land out of farm production. The average value is considered appropriate since most farms operate on a 2-year crop rotation.

5.1 Proper Maintenance of Onsite Systems

The most effective BMP for managing loads from septic systems is regular maintenance. Unfortunately, most people do not think about their wastewater systems until a major malfunction occurs (e.g., sewage backs up into the house or onto the lawn). When not maintained properly, septic systems can cause the release of pathogens and excess nutrients into nearby surface waters. Good housekeeping measures relating to septic systems are listed below (Goo, 2004; CWP, 2004):

- Inspect system annually and pump system every 3 to 5 years, depending on the tank size and number of residents per household.
- Refrain from trampling the ground or using heavy equipment above a septic system (to prevent collapse of pipes).
- Prevent septic system overflow by conserving water, not diverting storm drains or basement pumps into septic systems, and not disposing of trash through drains or toilets.

Education is a crucial component of reducing pollution from septic systems. Many owners are not familiar with USEPA recommendations concerning maintenance schedules. Education can occur through public meetings, mass mailings, and radio and television advertisements.

The USEPA recommends that septic tanks be pumped every 3 to 5 years depending on the tank size and number of residents in the household. Annual inspections, in addition to regular maintenance, ensure that systems are functioning properly. An inspection program would also help identify those systems that are currently connected to tile drain systems. All tanks discharging to tile drainage systems should be disconnected immediately.

Some communities choose to formally regulate septic systems by creating a database of all the systems in the area. This database usually contains information on the size, age, and type of each system within the community. All inspections and maintenance records are maintained in the database through cooperation with licensed maintenance and repair companies. These databases allow the communities to detect problem areas and ensure proper maintenance.

At this time, there is not a formal inspection and maintenance program in Randolph County for onsite wastewater treatment systems. The County Health Department does issue permits for new onsite systems and major repairs and investigates complaints as they arise.

5.1.1 Effectiveness

The reductions in pollutant loading resulting from improved operation and maintenance of all systems in the watershed depends on the wastewater characteristics and the level of onsite system failures present in the watershed. Reducing the level of failure to 0 percent may result in the following load reductions (refer to Table 4-1 and Table 4-2 for details):

- Phosphorus loads to Randolph County Lake may be reduced by 18 to 151 lb/d.
- Phosphorus loads to Sparta Old Reservoir may be reduced by 4 to 37 lb/d.

5.1.2 Costs

Septic tanks are designed to accumulate sludge in the bottom portion of the tank while allowing water to pass into the drain field. If the tank is not pumped out regularly, the sludge can accumulate and eventually become deep enough to enter the drain field. Pumping the tank every three to five years prolongs the life of the system by protecting the drain field from solid material that may cause clogs and system backups.

The cost to pump a septic tank ranges from $250 to $350 depending on how many gallons are pumped out and the disposal fee for the area. If a system is pumped once every three to five years, this expense averages out to less than $100 per year. Septic tanks that are not maintained will likely require replacement which may cost between $2,000 and $10,000.

The cost of developing and maintaining a watershed-wide database of the onsite wastewater treatment systems in the watershed depends on the number of systems that need to be inspected. Based on Census data collected in 2000, there are approximately 3,720 households in the Mary's River/North Fork Cox Creek watershed. After the initial inspection of each system and creation of the database, only systems with no subsequent maintenance records would need to be inspected. A recent inspection program in South Carolina found that inspections cost approximately $160 per system (Hajjar, 2000).

Education of home and business owners that use onsite wastewater treatment systems should occur periodically. Public meetings, mass mailings, and radio, newspaper, and TV announcements can all be used to remind and inform owners of their responsibility to maintain their systems (Table 5-1).

The costs associated with education and inspection programs will vary depending on the level of effort required to communicate the importance of proper maintenance and the number of systems in the area.

Table 5-1. Costs Associated with Maintaining and Replacing an Onsite Wastewater Treatment System.

Action	Cost per System	Frequency	Annual Cost per System
Pumping	$250 to $350	Once every 3 to 5 years	$70 to $85
Inspection	$160	Initially all systems should be inspected, followed by 5 year inspections for systems not on record as being maintained	Up to $32, assuming all systems have to be inspected once every five years, which is not likely
Replacement	$2,000 to $10,000	With proper maintenance, system life should be 30 years	$67 to $333
Education	$1	Public reminders should occur once per year	$1

5.2 Nutrient Management Plans

The majority of nutrient loading from farmland occurs from fertilization with commercial and manure fertilizers (USEPA, 2003). In heavily fertilized areas, soil phosphorus content has increased significantly above natural levels. Parties responsible for reducing loads due to excessive fertilization include farmers and local agricultural service agencies that provide fertilization guidelines.

The primary BMP for reducing phosphorus loading from excessive fertilization is the development of a nutrient management plan. The plan should address fertilizer application rates, methods, and application timing. Initial soil phosphorus concentrations are determined by onsite soil testing, which is available from local vendors. Losses through plant uptake are subtracted and gains from organic sources such as manure application or industrial/municipal wastewater are added. The resulting phosphorus content is then compared to local guidelines to determine if fertilizer should be added to support crop growth and maintain current phosphorus levels. In some cases, the soil phosphorus content is too high, and no fertilizer should be added until stores are reduced by crop uptake to target levels.

Soil phosphorus tests are used to measure the phosphorus available for crop growth. Test results reported in parts per million (ppm) can be converted to lb/ac by multiplying by 2 (USDA, 2003). Based on a survey of state soil testing laboratories in 1997, 64 percent of soils in Illinois had high soil phosphorus test concentrations (> 50 ppm). By 2000, the percentage of soils testing high decreased to 58 percent (USDA, 2003). Guidelines in the Illinois Agronomy Handbook (IAH) recommend maintaining soil test phosphorus content in southeastern Illinois at 25 ppm (50 lb/ac). Soils that test at or above 35 ppm (70 lb/ac) should not be fertilized until subsequent crop uptake decreases the test to 25 ppm (50 lb/ac) (IAH, 2002). Soil phosphorus tests should be conducted once every three or four years to monitor accumulation or depletion of phosphorus concentrations (USDA, 2003).

Table 5-2 and Table 5-3 show buildup, maintenance, and total application rates for various starting soil test concentrations for sample corn and soybean yields, respectively. For a complete listing of buildup and maintenance rates for the three inherent availability zones and varying yields of corn, soybeans, oats, wheat, and grasses, see Chapter 11 of the IAH.

Starting Soil Test Phosphorus	***Fertilization Guidelines***
Less than 25 ppm:	*Buildup plus maintenance*
Between 25 and 35 ppm:	*Maintenance only*
Greater than 35 ppm:	*None*

Table 5-2. Suggested Buildup and Maintenance Application Rates of P_2O_5 for Corn Production in the Low Inherent Phosphorus Availability Zone (IAH, 2002).

Starting Soil Test P ppm (lb/ac)	Buildup P_2O_5 (lb/ac)[1]	Maintenance P_2O_5 (lb/ac)[2]	Total P_2O_5 (lb/ac)
10 (20)	68	71	139
15 (30)	45	71	116
20 (40)	22	71	93
25 (50)	0	71	71
30 (60)	0	71	71
35 (70) or higher	0	0	0

[1] Rates based on buildup for four years to achieve target soil test phosphorus of 25 ppm (50 lb/ac).
[2] Maintenance rates assume a corn yield of 165 bushels per acre. The IAH lists maintenance rates discretely for yields of 90 to 200 bushels per acre.

Table 5-3. Suggested Buildup and Maintenance Application Rates of P_2O_5 for Soybean Production in the Low Inherent Phosphorus Availability Zone (IAH, 2002).

Starting Soil Test P ppm (lb/ac)	Buildup P_2O_5 (lb/ac)[1]	Maintenance P_2O_5 (lb/ac)[2]	Total P_2O_5 (lb/ac)
10 (20)	68	51	119
15 (30)	45	51	96
20 (40)	22	51	73
25 (50)	0	51	51
30 (60)	0	51	51
35 (70) or higher	0	0	0

[1] Rates based on buildup for four years to achieve target soil test phosphorus of 25 ppm (50 lb/ac).
[2] Maintenance rates assume a soybean yield of 60 bushels per acre. The IAH lists maintenance rates discretely for yields of 30 to 100 bushels per acre.

Nutrient management plans also address different methods of application. Fertilizer may be applied directly to the surface, placed in bands below and to the side of seeds, or incorporated into the top several inches of the soil profile through drilled holes, injection, or tillage. Surface applications that are not followed by incorporation may result in accumulation of phosphorus at the soil surface and increased dissolved phosphorus concentrations in surface runoff (Mallarino, 2004).

Methods of phosphorus application have shown no impact on crop yield (Mallarino, 2004). The Champaign County Soil and Water Conservation District (CCSWCD) reports that deep placement of phosphorus in bands next to the seed zone requires only one-third to one-half the amount of phosphorus fertilizer to achieve the same yields and that on average, fertilizer application rates were decreased by 13 lb/ac (Stikkers, 2007). Thus, deep placement will not only reduce the amount of phosphorus available for transport, but will also result in lower fertilizer costs. Figure 5-1 shows the deep placement attachment used by the CCSWCD.

The NRCS provides additional information on nutrient management planning at:
http://efotg.nrcs.usda.gov/references/public/IL/590.pdf

The Illinois Agronomy Handbook may be found online at:
http://iah.aces.uiuc.edu/

(Photo Courtesy of CCSWCD)

Figure 5-1. Deep Placement Phosphorus Attachment Unit for Strip-till Toolbar.

For corn-soybean rotations, it is recommended that phosphorus fertilizer be applied once every two years, following harvest of the corn crop if application consists of broadcast followed by incorporation (UME, 1996). Band placement should occur prior to or during corn planting, depending on the type of field equipment available. In this watershed, most fertilizer is applied after bean harvest and before corn planting (Sample, 2007). Fertilizer should be applied when the chance of a large precipitation event is low. 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 percent of the total annual phosphorus load (Gentry et al., 2007).

Recent technological developments in field equipment allow for fertilizer to be applied at varying rates across a field. Crop yield and net profits are optimized with this variable rate technology (IAH, 2002). Precision farming typically divides fields into 1- to 3-acre plots that are specifically managed for seed, chemical, and water requirements. Operating costs are reduced and crop yields typically increase, though upfront equipment costs may be high.

5.2.1 Effectiveness

The effectiveness of nutrient management plans (application rates, methods, and timing) in reducing phosphorus loading from agricultural land will be site specific. The following reductions are reported in the literature:

- 35 percent average reduction of total phosphorus load reported in Pennsylvania (USEPA, 2003).
- 20 to 50 percent total phosphorus load reductions with subsurface application at agronomic rates (HWRCI, 2005).
- 60 to 70 percent reduction in dissolved phosphorus concentrations and 20 percent reduction in total phosphorus concentrations when fertilizer is incorporated to a minimum depth of two inches prior to planting (HWRCI, 2005).
- 60 to 70 percent reduction in dissolved phosphorus concentrations and 20 to 50 percent reduction in total phosphorus with subsurface application, such as deep placement (HWRCI, 2005).
- 60 percent reduction in runoff concentrations of phosphorus when the following precipitation event occurred 10 days after fertilizer application, as opposed to 24 hours after application (HWRCI, 2005).
- Nutrient management plans will also reduce the dissolved oxygen impairments in the watershed by reducing the nutrients available to stimulate eutrophication.

5.2.2 Costs

A good nutrient management plan should address the rates, methods, and timing of fertilizer application. To determine the appropriate fertilizer rates, consultants in Illinois typically charge $6 to $18 per acre, which includes soil testing, manure analysis, scaled maps, and site specific recommendations for fertilizer management (USEPA, 2003). The Champaign County Soil and Water Conservation District (CCSWCD, 2003) estimates savings of approximately $10/ac during each plan cycle (4 years) by applying fertilizer at recommended rates. Actual savings (or costs) depend on the reduction (or increase) in fertilizer application rates required by the nutrient management plan as well as other farm management recommendations.

Placing the fertilizer below and to the side of the seed bed (referred to as banding) reduces the required application by one third to one half to achieve the same crop yields. In Champaign County, phosphorus application rates were reduced by approximately 13 lb/ac with this method. The equipment needed for deep placement costs up to $113,000 (Stikkers, 2007). Alternatively, the equipment can be rented or the entire process can be hired out. The Heartland Regional Water Coordination Initiative lists the cost for deep placement of phosphorus fertilizer at $3.50/ac per application (HRWCI, 2005).

Table 5-4 summarizes the assumptions used to develop the annualized cost for this BMP.

Table 5-4. Costs Calculations for Nutrient Management Plans.

Item	Costs and Frequency	Annualized Costs (Savings)
Soil Testing and Determination of Rates	Costs $6/ac to $18/ac Every four years	$1.50/ac/yr to $4.50/ac/yr
Savings on Fertilizer	Saves $10/ac Every four years	($2.50/ac/yr)
Deep Placement of Phosphorus	Costs $3.50/ac Every two years	$1.75/ac/yr
Average Annual Costs		**$0.75/ac/yr to $3.75/ac/yr**

5.3 Conservation Tillage

Conservation tillage practices and residue management are commonly used to control erosion and surface transport of pollutants from fields used for crop production. The residuals not only provide erosion control, but also provide a nutrient source to growing plants, and continued use of conservation tillage results in a more productive soil with higher organic and nutrient content. Increasing the organic content of soil has the added benefit of reducing the amount of carbon in the atmosphere by storing it in the soil. Researchers estimate that croplands and pasturelands could be managed to trap 5 to 17 percent of the greenhouse gases produced in the United States (Lewandrowski et al., 2004).

Several practices are commonly used to maintain the suggested 30 percent 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 percent residual surface cover, excluding no-till and ridge till systems.

The NRCS provides additional information on these conservation tillage practices:

no-till and strip till:	http://efotg.nrcs.usda.gov/references/public/IL/329a.pdf
ridge till:	http://efotg.nrcs.usda.gov/references/public/IL/329b.pdf
mulch till:	http://efotg.nrcs.usda.gov/references/public/IL/329c.pdf

Tillage system practices are not available specifically for the Mary's River/North Fork Cox Creek watershed; however, countywide tillage system surveys are performed by the Illinois Department of Agriculture every two years. It is assumed that the general tillage practice trends measured in Randolph County is applicable to the Mary's River/North Fork Cox Creek watershed and the results of the 2006 surveys are presented in Table 5-5. Mulch till and no-till are considered conservation tillage practices: reduced till practices do not maintain 30 percent ground cover.

In 2006, the use of conservation tillage practices on corn fields typically occurred on less than 50 percent of the fields surveyed. It is more common for soybean fields to use conservation practices. At least 61 percent of soybean fields in use some form of conservation tillage. About 33 percent of small grain fields use conservation tillage practices.

Table 5-5. Percentage of Agricultural Fields Surveyed with Indicated Tillage System in 2006

Crop Field Type	Tillage Practice				Conservation Tillage
	Conventional Till	Reduced-till	Mulch Till	No Till	
Randolph County					
Corn	76	9	8	7	**15**
Soybean	28	11	15	46	**61**
Small Grain	46	20	22	11	**33**

Source: IDA, 2006.

Corn residues are more durable and capable of sustaining the required 30 percent cover required for conservation tillage. Soybeans generate less residue, the residue that is generated degrades more quickly, and supplemental measures or special care may be necessary to meet the 30 percent cover requirement (UME, 1996). Figure 5-2 shows a comparison of ground cover under conventional and conservation tillage practices.

Figure 5-2. Comparison of Conventional (left) and Conservation (right) Tillage Practices.

Though no-till systems are more effective in reducing sediment loading from crop fields, they tend to concentrate phosphorus in the upper two inches of the soil profile due to surface application of fertilizer and decomposition of plant material (IAH, 2002; UME, 1996). This pool of phosphorus readily mixes with precipitation and can lead to increased concentrations of dissolved phosphorus in surface runoff. Chisel plowing may be required once every several years to reduce stratification of phosphorus in the soil profile.

5.3.1 Effectiveness

Czapar et al. (2006) summarize past and present tillage practices and their impacts on erosion control and nutrient delivery. Historically, the mold board plow was used to prepare the field for planting. This practice disturbed 100 percent of the soil surface and resulted in basically no residual material. Today, conventional tillage typically employs the chisel plow, which is not as disruptive to the soil surface and tends to leave a small amount of residue on the field (0 to 15 percent). Mulch till systems were classified as leaving 30 percent residue; percent cover was not quantified for the no-till systems in this study. The researchers used WEPP modeling to simulate changes in sediment and nutrient loading for these tillage practices. Relative to mold board plowing, chisel plowing reduced phosphorus loads leaving the field by 38 percent, strip tilling reduced loads by 80 percent, and no-till reduced loads by 85 percent. If chisel plowing is now considered conventional, then the strip till and no-till practices are capable of reducing phosphorus loads by 68 percent and 76 percent, respectively (Czapar et al., 2006).

The IAH (2002) defines conservation tillage as any tillage practice that results in at least 30 percent coverage of the soil surface by crop residuals after planting. Tillage practices leaving 20 to 30 percent residual cover after planting reduce erosion by approximately 50 percent compared to bare soil. Practices that result in 70 percent residual cover reduce erosion by approximately 90 percent (IAH, 2002). Manganese reductions will be similar since this pollutant is primarily sediment bound.

The reductions achieved by conservation tillage reported in these studies are summarized below:

- 68 to 76 percent reduction in total phosphorus.
- 50 percent reduction in sediment for practices leaving 20 to 30 percent residual cover.
- 90 percent reduction in sediment for practices leaving 70 percent residual cover.
- 69 percent reduction in runoff losses for no-till practices.

5.3.2 Costs

Conservation tillage practices generally require fewer trips to the field, saving on labor, fuel, and equipment repair costs, though increased weed production may result in higher pesticide costs relative to conventional till (USDA, 1999). In general, conservation tillage results in increased profits relative to conventional tillage (Olson and Senjem, 2002; Buman et al., 2004; Czapar, 2006). The HRWCI (2005) lists no additional costs for conservation tillage.

Hydrologic inputs are often the limiting factor for crop yields and farm profits. Conservation practices reduce evaporative losses by covering the soil surface. USDA (1999) reports a 30 percent reduction in evaporative losses when 30 percent ground cover is maintained. Harman et al. (2003) and the Southwest Farm Press (2001) report substantial yield increases during dry years on farms managed with conservation or no-till systems compared to conventional till systems.

Depending on the type of equipment currently used, replacing conventional till equipment with no-till equipment can either result in a net savings or slight cost to the producer. Al-Kaisi et al. (2000) estimate that converting conventional equipment to no-till equipment costs approximately $1.25 to $2.25/ac/yr, but that for new equipment, purchasing no-till equipment is less expensive than conventional equipment. Other researchers report a net gain when conventional equipment is sold to purchase no-till equipment (Harman et al., 2003).

Table 5-6 summarizes the available information for determining average annual cost for this BMP.

Table 5-6. Costs Calculations for Conservation Tillage

Item	Costs and Frequency	Annualized Costs (Savings)
Conversion of Conventional Equipment to Conservation Equipment	Costs presented in literature were already averaged out to yearly per acre costs: $1.25/ac/yr to $2.25/ac/yr	$1.25/ac/yr to $2.25/ac/yr
Operating Costs of Conservation Tillage Relative to Conventional Costs	$0/ac/yr	$0/ac/yr
Average Annual Costs		**$1.25/ac/yr to $2.25/ac/yr**

5.4 Cover Crops

Grasses and legumes may be used as winter cover crops to reduce soil erosion and improve soil quality (IAH, 2002). These crops also contribute nitrogen to the following crop, reducing fertilizer requirements. Grasses tend to have low seed costs and establish relatively quickly, but can impede cash crop development by drying out the soil surface or releasing chemicals during decomposition that may inhibit the growth of a following cash crop. Legumes take longer to establish, but are capable of fixing nitrogen from the atmosphere, thus reducing nitrogen fertilization required for the next cash crop. Legumes, however, are more susceptible to harsh winter environments and may not have adequate survival to offer sufficient erosion protection. Planting the cash crop in wet soil that is covered by heavy surface residue from the cover crop may impede emergence by prolonging wet, cool soil conditions. Cover crops should be killed off two or three weeks prior to planting the cash crop either by application of herbicide or mowing and incorporation, depending on the tillage practices used. Use of cover crops is illustrated in Figure 5-3.

(Photo Courtesy of NRCS)

Figure 5-3. Use of Cover Crops.

The NRCS provides additional information on cover crops at:
http://efotg.nrcs.usda.gov/references/public/IL/340.pdf

5.4.1 Effectiveness

The effectiveness of cover crops in reducing pollutant loading has been reported by several agencies. In addition to these benefits, the reduction in runoff losses will reduce erosion from streambanks, further reducing sediment-bound phosphorus and manganese and allowing for the establishment of vegetation and canopy cover. The reported reductions are listed below:

- 50 percent reduction in soil and runoff losses with cover crops alone. When combined with no-till systems, may reduce soil loss by more than 90 percent (IAH, 2002).
- 70 to 85 percent reduction in phosphorus loading on naturally drained fields (HRWCI, 2005).
- Useful in conservation tillage systems following low-residue crops such as soybeans (USDA, 1999).

5.4.2 Costs

The National Sustainable Agriculture Information Service recommends planting ryegrass after corn harvest and hairy vetch after soybeans (Sullivan, 2003). Both seeds can be planted at a depth of ¼ to ½ inch at a rate of 20 lb/ac or broadcast at a rate of 25 to 30 lb/ac (Ebelhar and Plumer, 2007; OSUE, 1990).

Researchers at Purdue University estimate the seed cost of ryegrass and hairy vetch at $12 and $30/ac, respectively. Savings in nitrogen fertilizer (assuming nitrogen fertilizer cost of $0.30/lb (Sample, 2007)) are $3.75/ac for ryegrass and $28.50/ac for hairy vetch. Yield increases in the following crop, particularly during droughts, are reported at 10 percent and are expected to offset the cost of this practice (Mannering et al., 1998). Herbicide application is estimated to cost $14.25/ac.

Accounting for the seed cost, herbicide cost, and fertilizer offset results in an average net cost of approximately $19.25/ac assuming that cover crop planting recommendations for a typical 2-year corn/soybean rotation are followed (Mannering et al., 1998). These costs do not account for yield increases which may offset the costs completely. Table 5-7 summarizes the costs and savings associated with ryegrass and hairy vetch.

Table 5-7. Costs Calculations for Cover Crops.

Item	Ryegrass	Hairy Vetch
Seed Costs	$12/ac	$30/ac
Nitrogen Fertilizer Savings	($3.75/ac)	($28.50/ac)
Herbicide Costs	$14.25/ac	$14.25/ac
Annual Costs	$22.50/ac	$15.75/ac
Average Annual Cost Assuming Ryegrass Follows Corn and Hairy Vetch Follows Soybeans: $19.25/ac		

5.5 Filter Strips

Filter strips are used in agricultural and urban areas to intercept and treat runoff before it enters the adjacent waterbody. If topography allows, filter strips may also be used to treat effluent from tile drain outlets. For small dairy operations, filter strips may also be used to treat milk house washings and runoff from the open lot (NRCS, 2003).

Filter strips will require maintenance, including grading and seeding, to ensure distributed flow across the filter and protection from erosion. Periodic removal of vegetation will encourage plant growth and uptake and remove nutrients stored in the plant material. Filter strips are most effective on sites with mild slopes of generally less than 5 percent, and to prevent concentrated flow, the upstream edge of a filter strip should follow one elevation contour (NCDENR, 2005). A grass filter strip is shown in Figure 5-4.

(Photo Courtesy of NRCS)

Figure 5-4. Grass Filter Strip Protecting Stream from Adjacent Agriculture.

The NRCS provides additional information on filter strips at:
http://efotg.nrcs.usda.gov/references/public/IL/393.pdf

Filter strips also serve to reduce the quantity and velocity of runoff. Filter strip sizing is dependent on site specific features such as climate and topography, but at a minimum the area of a filter strip should be no less than 2 percent of the drainage area for agricultural land (OSUE, 1994). The minimum filter strip width suggested by NRCS (2002a) is 30 ft. The strips are assumed to function properly with annual maintenance for 30 years before requiring replacement of soil and vegetation.

5.5.1 Effectiveness

Filter strips have been found to effectively remove pollutants from agricultural runoff. The following reductions are reported in the literature (USEPA, 2003; Kalita, 2000; Woerner et al., 2006):

- 65 percent reduction in total phosphorus
- Slows runoff velocities and may reduce runoff volumes via infiltration

5.5.2 Costs

Filter strips cost approximately $0.30 per sq ft to construct and the system life is typically assumed to be 20 years (Weiss et al., 2007). Assuming that the required filter strip area is 2 percent of the area drained (OSUE, 1994), 870 square feet of filter strip are required for each acre of agricultural land treated. The construction cost to treat one acre of land is therefore $261/ac. The annualized construction costs are $13/ac/yr. Annual maintenance of filter strips is estimated at $0.01 per sq ft (USEPA, 2002c), for an additional cost of $8.70/ac/yr of agricultural land treated. In addition, the area converted from agricultural production to filter strip will result in a net annual income loss of $3.50. Table 5-8 summarizes the costs assumptions used to estimate the annualized cost to treat one acre of agricultural drainage with a filter strip.

Table 5-8. Costs Calculations for Filter Strips Used in Crop Production.

Item	Costs Required to Treat One Acre of Agricultural Land with Filter Strip
Construction Costs	$0.30
Annual Maintenance Costs	$0.01
Construction Costs	$261
System Life (years)	20
Annualized Construction Costs	$13
Annual Maintenance Costs	$8.70
Annual Income Loss	$3.50
Average Annual Costs	**$25/ac treated**

Filter strips used in animal operations typically treat contaminated runoff from pastures or feedlot areas or washings from the milk houses of small dairy operations (NRCS, 2003). The NRCS (2003) estimated costs for small dairy operations (75 milk cows) assume a filter strip area of 12,000 sq ft is required. For the pasture operations, it is assumed that a filter strip area of 12,000 sq ft (30 ft wide and 400 ft long) would be required to treat runoff from a herd of 50 cattle (NRCS, 2003). The document does not explain why more animals can be treated by the same area of filter strip at the dairy operation compared to the pasture operation.

For animal operations, it is not likely that land used for growing crops would be taken out of production for conversion to a filter strip. Table 5-9 summarizes the capital, maintenance, and annualized costs for filter strips per head of animal.

Table 5-9. Costs Calculations for Filter Strips Used at Animal Operations.

Operation	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Small dairy (75 milking cows)	$48 per head of cattle	$1.50 per head of cattle	$4 per head of cattle
Beef or other (50 cattle)	$72 per head of cattle	$2.50 per head of cattle	$6 per head of cattle

5.6 Grassed Waterways

Grassed waterways are stormwater conveyances lined with grass that prevent erosion of the transport channel. They are often used to divert clean up-grade runoff around contaminated feedlots and manure storage areas (NRCS, 2003). In addition, the grassed channel reduces runoff velocities, allows for some infiltration, and filters out some particulate pollutants. A grassed waterway providing surface drainage for a corn field is shown in Figure 5-5.

(Photo Courtesy of NRCS)

Figure 5-5. Grassed Waterway.

The NRCS provides additional information on grassed waterways at:
http://efotg.nrcs.usda.gov/references/public/IL/412.pdf

5.6.1 Effectiveness

The effectiveness of grass swales for treating agricultural runoff has not been quantified. The Center for Watershed Protection reports a 30 percent reduction in total phosphorus in urban settings (Winer, 2000):

5.6.2 Costs

Grassed waterways cost approximately $0.50 per sq ft to construct (USEPA, 2002c). These stormwater conveyances are best constructed where existing bare ditches transport stormwater, so no income loss from land conversion is expected with this practice. It is assumed that the average area required for a grassed waterway is approximately 0.1 to 0.3 percent of the drainage area, or between 44 and 131 sq ft per acre. The range is based on examples in the Illinois Drainage Guide, information from the NRCS Engineering Field Handbook, and a range of waterway lengths (100 to 300 feet). Waterways are assumed to remove phosphorus effectively for 20 years before soil, vegetation, and drainage material need to be replaced (Weiss et al., 2007). The construction cost spread out over the life of the waterway is thus $2.25/yr for each acre of agriculture draining to a grassed waterway. Annual maintenance of grassed waterways is estimated at $0.02 per sq ft (Rouge River, 2001) for an additional cost of $1.75/ac/yr of agricultural land treated. Table 5-10 summarizes the annual costs assumptions for grassed waterways.

Table 5-10. Costs Calculations for Grassed Waterways Draining Cropland.

Item	Costs Required to Treat One Acre of Agricultural Land
Costs per Square Foot	
Construction Costs	$0.50
Annual Maintenance Costs	$0.02
Costs to Treat One Acre of Agricultural Land (assuming 44 to 131 sq ft of filter strip)	
Construction Costs	$22 to $65.50
System Life (years)	20
Annualized Construction Costs	$1 to $3.25
Annual Maintenance Costs	$1 to $2.75
Annual Income Loss	$0
Average Annual Costs	**$2 to 6/ac treated**

Grassed waterways are primarily used in animal operations to divert clean water away from pastures, feedlots, and manure storage areas. Table 5-11 summarizes the capital, maintenance, and annualized costs of this practice per head of cattle as summarized by NRCS (2003).

Table 5-11. Costs Calculations for Grassed Waterways Used in Cattle Operations.

Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
$0.50 to $1.50	$0.02 to $0.04	$0.05 to $0.12

5.7 Riparian Buffers

Riparian corridors, including both the stream channel and adjacent land areas, are important components of watershed ecology. The streamside forest slowly releases nutrients as twigs and leaves decompose. These nutrients are valuable to the fungi, bacteria, and invertebrates that form the basis of a stream's food chain. Tree canopies of riparian forests also cool the water in streams which can affect the composition of the fish species in the stream, the rate of biological reactions, and the amount of dissolved oxygen the water can hold. Channelization or widening of streams moves the canopy farther apart, decreasing the amount of shaded water surface, increasing water temperatures, and decreasing dissolved oxygen concentrations.

Preserving natural vegetation along stream corridors can effectively reduce water quality degradation associated with human disturbances. The root structure of the vegetation in a buffer enhances infiltration of runoff and subsequent trapping of nonpoint source pollutants. However, the 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 will quickly pass through the buffer offering minimal opportunity for retention and uptake of pollutants.

Even more important than the filtering capacity of the buffers is the protection they provide for streambanks. The rooting systems of the vegetation serve as reinforcements in streambank soils, which help to hold streambank material in place and minimize erosion. Riparian buffers also prevent cattle access to streams, reducing streambank trampling and defecation in the stream. Due to the increase in stormwater runoff volume and peak rates of runoff associated with agriculture and development such as mining operations, stream channels are subject to greater erosional forces during stormflow events. Thus, preserving natural vegetation along stream channels minimizes the potential for water quality and habitat degradation caused by streambank erosion and enhances the pollutant removal of sheet flow runoff from developed areas that pass through the buffer. A riparian buffer protecting the stream corridor from adjacent agricultural areas is shown in Figure 5-6.

(Photo Courtesy of NRCS)

Figure 5-6. Riparian Buffer Between Stream Channel and Agricultural Areas.

The NRCS provides additional information on riparian buffers at:
http://efotg.nrcs.usda.gov/references/public/IL/390.pdf *and*
http://efotg.nrcs.usda.gov/references/public/IL/391.pdf

5.7.1 Effectiveness

Riparian buffers should consist of native plant species and may include grasses, grass-like plants, forbs, shrubs, and trees. Minimum buffer widths of 25 feet are required for optimal water quality benefits. Higher pollutant removal rates are provided with greater buffer widths. Riparian corridors typically treat a maximum of 300 ft of adjacent land before runoff forms small channels that short circuit treatment. Buffer widths based on slope measurements and recommended plant species should conform to NRCS Field Office Technical Guidelines. The following reductions are reported in the literature:

- 25 to 30 percent reduction of total phosphorus for 30 ft wide buffers (NCSU, 2002)
- 70 to 80 percent reduction of total phosphorus for 60 to 90 ft wide buffers (NCSU, 2002)
- Increased canopy cover provides shading which may reduce water temperatures and improve dissolved oxygen concentrations (NCSU, 2002). Wenger (1999) suggests buffer width of at least 30 ft to maintain stream temperatures.

- Increased channel stability will reduce streambank erosion

5.7.2 Costs

Restoration of riparian areas costs approximately $100/ac to construct and $475/ac to maintain over the life of the buffer (Wossink and Osmond, 2001; NCEEP, 2004). Maintenance of a riparian buffer should be minimal, but may include items such as period inspection of the buffer, minor grading to prevent short circuiting, and replanting/reseeding dead vegetation following premature death or heavy storms. Assuming a buffer width of 90 ft on either side of the stream channel and an adjacent treated width of 300 ft of agricultural land, one acre of buffer will treat approximately 3.3 acres of adjacent agricultural land. The cost per treated area is therefore $30/ac to construct and $142.50/ac to maintain over the life of the buffer. Assuming a system life of 30 years results in an annualized cost of $59.25/yr for each acre of agriculture land treated (Table 5-12).

Table 5-12. Costs Calculations for Riparian Buffers.

Item	Costs Required to Treat One Acre of Agricultural Land
Costs per Acre of Riparian Buffer	
Construction Costs	$100
Maintenance Costs Over System Life	$475
Costs to Treat One Acre of Agricultural Land (assuming 0.3 ac of buffer)	
Construction Costs	$30
Maintenance Costs Over System Life	$142.50
System Life (Years)	30
Annualized Construction Costs	$1
Annualized Maintenance Costs	$4.75
Annual Income Loss	$53.50
Average Annual Costs	**$59.25/ac treated**

5.8 Constructed Wetlands

Constructed wetlands used to treat animal wastes are typically surface flowing systems comprised of cattails, bulrush, and reed plants. Prior to treating animal waste in a constructed wetland, storage in a lagoon or pond is required to protect the wetland from high pollutant loads that may kill the vegetation or clog pore spaces. After treatment in the wetland, the effluent is typically held in another storage lagoon and then land applied (USEPA, 2002a). Alternatively, the stored effluent can be used to supplement flows to the wetland during dry periods. Constructed wetlands that ultimately discharge to a surface waterbody will require a permit, and the receiving stream must be capable of assimilating the effluent during low flow conditions (NRCS, 2002b). Figure 5-7 shows an example of a lagoon-wetland system.

(Photo courtesy of USDA NRCS.)

Figure 5-7. Constructed Wetland System for Animal Waste Treatment.

The NRCS provides additional information on constructed wetlands at
http://efotg.nrcs.usda.gov/references/public/IL/656.pdf
and
ftp://ftp.wcc.nrcs.usda.gov/downloads/wastemgmt/NEH637Ch3ConstructedWetlands.pdf

5.8.1 Effectiveness

Wetland environments treat wastewater through sedimentation, filtration, plant uptake, biochemical transformations, and volatilization. Reported pollutant reductions found in the literature are listed below:

- 42 percent reduction in total phosphorus (USEPA, 2003)

5.8.2 Costs

Researchers of the use of constructed wetlands for animal waste management generally agree that these systems are a lower cost alternative compared to conventional treatment and land application technologies. Few studies, however, actually report the costs of constructing and maintaining these systems. A Canadian study (CPAAC, 1999) evaluated the use of a constructed wetland system for treating milk house washings as well as contaminated runoff from the feedlot area and manure storage pile of a dairy operation containing 135 head of dairy cattle. The treatment system was comprised of a pond/wetland/pond/wetland/filter strip treatment train that cost $492 per head to construct. Annual operating and maintenance costs of $6.75 per head include electricity to run pumps, maintenance of pumps and berms, and dredging the wetland cells once every 10 years. Reductions in final disposal costs due to reduced phosphorus content of the final effluent were $20.75 per head and offset the costs of constructing and maintaining the wetland in seven years.

Another study evaluated the use of constructed wetlands for treatment of a 3,520-head swine operation in North Carolina. Waste removal from the swine facility occurs via slatted floors to an underlying pit that is flushed once per week. This new treatment system incorporated a settling basin, constructed wetland, and storage pond treatment system prior to land application or return to the pit for flushing.

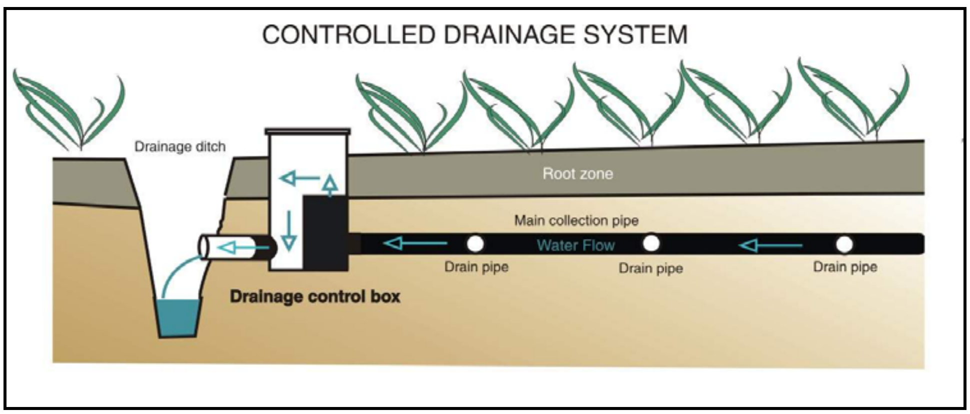
Capital and maintenance costs reported in the literature for dairy and swine operations are summarized per head in Table 5-13. No example studies including costs were available for beef cattle operations, which should generate less liquid waste than the other two operations. It would therefore be expected that constructing a wetland for beef cattle operation would cost less than for a dairy or swine operation.

Table 5-13. Costs Calculations for Constructed Wetlands.

Example	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Dairy farm	$492	-$14	$2.50
Swine operation	$103.75	$1.00	$4.50

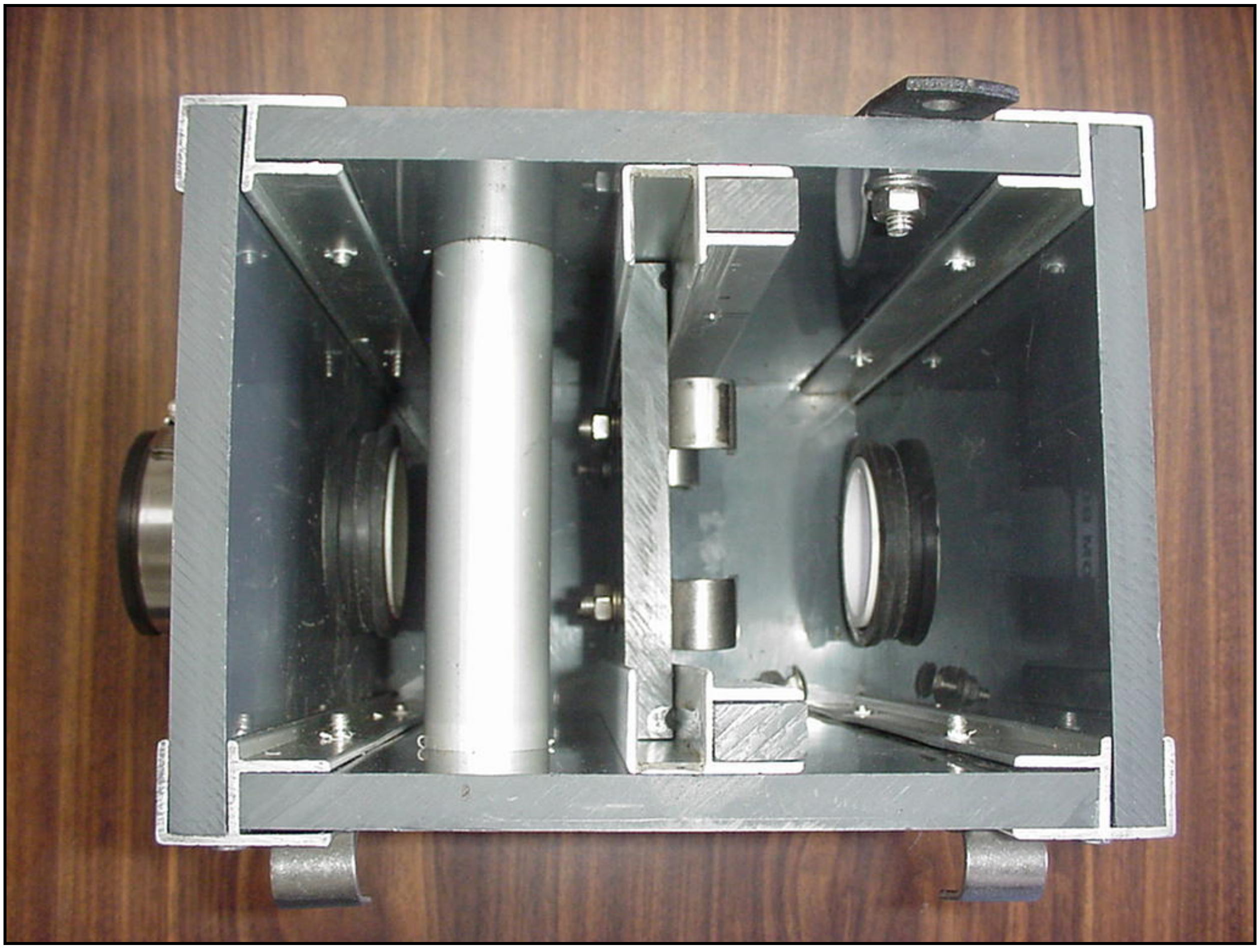
5.9 Controlled Drainage

A conventional tile drain system collects infiltrated water below the root zone and transports the water quickly to a down-gradient surface outlet. Placement of a water-level control structure at the outlet (Figure 5-8 and Figure 5-9) allows for storage of the collected water up to a predefined elevation. The stored water becomes a source of moisture for plants during dry conditions and undergoes biological, chemical, and physical processes that result in lower nutrient concentrations in the final effluent.



(Illustration Courtesy of the Agricultural Research Service Information Division)

Figure 5-8. Controlled Drainage Structure for a Tile Drain System.



(Photo Courtesy of CCSWCD)

Figure 5-9. Interior View of a Drainage Control Structure with Adjustable Baffle Height.

The NRCS provides additional information on drainage management at: http://efotg.nrcs.usda.gov/references/public/IL/554.pdf.

5.9.1 Effectiveness

Use of control structures on conventional tile drain systems in the coastal plains has resulted in reductions of total phosphorus loading of 35 percent (Gilliam et al., 1997). Researchers at the University of Illinois also report reductions in phosphorus loading with tile drainage control structures. Concentrations of phosphate were reduced by 82 percent, although total phosphorus reductions were not quantified in this study (Cooke, 2005). Changing from a surface draining system to a tile drain system with outlet control reduces phosphorus loading by 65 percent (Gilliam et al., 1997).

Storage of tiled drained water for later use via subsurface irrigation has shown decreases in dissolved phosphorus loading of approximately 50 percent (Tan et al., 2003). However, accumulated salts in reuse water may eventually exceed plant tolerance and result in reduced crop yields. Mixing stored drain water with fresh water or alternating irrigation with natural precipitation events will reduce the negative impacts of reuse. Salinity thresholds for each crop should be considered and compared to irrigation water concentrations.

5.9.2 Costs

The Champaign County Soil and Water Conservation District currently offers tile mapping services for approximately $2.25/ac using color infrared photography to assist farmers in identifying the exact location of their tile drain lines. Similar services are likely available through local vendors in the Mary's River/North Fork Cox Creek watershed. Cooke (2005) estimates that the cost of retrofitting tile drain systems with outlet control structures ranges from $20 to $40 per acre. Construction of new tile drain systems with outlet control is approximately $75/ac. The yield increases associated with installation of tile drain systems are expected to offset the cost of installation (Cooke, 2005). It is assumed that outlet control structures have a system life of 30 years. Cost assumptions for retrofitting and installation of new tile drain systems with outlet control devices are summarized in Table 5-14.

Table 5-14. Costs Calculations for Outlet Control Devices on Tile Drain Systems.

Item	Costs to Retrofit Existing Systems	Costs to Install a New System
Mapping Costs per Acre	$2.25	$0
Construction Costs	$20 to $40/ac	$75/ac
System Life (years)	30	30
Average Annual Costs	**$0.75 to $1.50/ac treated**	**$2.50/ac treated**

5.10 Feeding Strategies

Use of dietary supplements, genetically enhanced feed, and specialized diets has been shown to reduce the nitrogen and phosphorus content of manure either by reducing the quantity of nutrients consumed or by increasing the digestibility of the nutrients. Manure with a lower nutrient content can be applied at higher rates to crop land, thus reducing transportation and disposal costs for excess manure.

Manure typically has high phosphorus content relative to plant requirements compared to its nitrogen content. Nitrogen losses due to ammonia volatilization begin immediately following waste excretion and continue throughout the stabilization process, whereas phosphorus remains conserved. In addition, most livestock animals are not capable of efficiently digesting phosphorus, so a large percentage passes through the animal undigested. Compounding the problem is over-supplementation of phosphorus additives relative to nutritional guidelines, particularly for dairy cattle (USEPA, 2002a).

5.10.1 Effectiveness

Most feeding strategies work to reduce the phosphorus content of manure such that the end product has a more balanced ratio of nitrogen and phosphorus. Reducing the phosphorus content of manure will result in lower phosphorus concentrations in runoff and stream systems. Feeding strategies will indirectly impact dissolved oxygen concentrations by reducing eutrophication in streams and lakes. The USEPA (2002a) reports the following reductions in phosphorus manure content:

- 40 percent reduction in the phosphorus content of swine manure if the animals are fed low-phytate corn or maize-soybean diets or given a phytase enzyme to increase assimilation by the animal.
- 30 to 50 percent reduction in the phosphorus content of poultry manure by supplementing feed with the phytase enzyme.

5.10.2 Costs

Several feeding strategies are available to reduce the phosphorus content of manure. Supplementing feed with the phytase enzyme increases the digestibility of phytate, which is difficult for animals to digest and is the form of phosphorus found in conventional feed products. Supplementing with phytase used to be expensive, but now is basically equivalent to the cost of the dietary phosphorus supplements that are required when animals are fed traditional grains (Wenzel, 2002).

Another strategy is to feed animals low-phytate corn or barley which contains more phosphorus in forms available to the animal. Most animals fed low-phytate feed do not require additional phosphorus supplementation; the additional cost of the feed is expected to offset the cost of supplements. The third strategy is to stop over-supplementing animals with phosphorus. Reducing intake to dietary requirements established by the USDA may save dairy farmers $25 per year per cow (USEPA, 2002a). Final disposal costs for manure will likely also decrease since less land will be required during the application process.

5.11 Alternative Watering Systems

A primary management tool for pasture-based systems is supplying cattle with watering systems away from streams and riparian areas. Livestock producers who currently rely on streams to provide water for their animals must develop alternative watering systems, or controlled access systems, before they can exclude cattle from streams and riparian areas. One method of providing an alternative water source is the development of off-stream watering using wells with tank or trough systems. These systems are often highly successful, as cattle often prefer spring or well water to surface water sources.

Landowners should work with an agricultural extension agent to properly design and locate watering facilities. One option is to collect rainwater from building roofs (with gutters feeding into cisterns) and use this water for the animal watering system to reduce runoff and conserve water use (Tetra Tech, 2006). Whether or not animals are allowed access to streams, the landowner should provide an alternative shady location and water source so that animals are encouraged to stay away from riparian areas.

Figure 5-10 shows a centralized watering tank allowing access from rotated grazing plots and a barn area.

(Photo courtesy of USDA NRCS.)

Figure 5-10. Centralized Watering Tank.

The NRCS provides additional information on these alternative watering components:
Spring development:
http://efotg.nrcs.usda.gov/references/public/IL/IL-574.pdf,
Well development:
http://efotg.nrcs.usda.gov/references/public/IL/IL-642.pdf,
Pipeline:
http://efotg.nrcs.usda.gov/references/public/IL/516.pdf,
Watering facilities (trough, barrel, etc.):
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 614

5.11.1 Effectiveness

The USEPA (2003) reports the following pollutant load reductions achieved by supplying cattle with alternative watering locations and excluding cattle from the stream channel by structural or vegetative barrier:

- 15 to 49 percent reductions in total phosphorus loading

Some researchers have studied the impacts of providing alternative watering sites without structural exclusions and found that cattle spend 90 percent less time in the stream when alternative drinking water is furnished (USEPA, 2003). Prohibiting access to the stream channels will also prevent streambank trampling, decrease bank erosion, protect bank vegetation, and reduce the loading of organic material to the streams. As a result, dissolved oxygen concentrations will likely increase and manganese loads associated with bank erosion will decrease.

5.11.2 Costs

Alternative drinking water can be supplied by installing a well in the pasture area, pumping water from a nearby stream to a storage tank, developing springs away from the stream corridor, or piping water from an existing water supply. For pasture areas without access to an existing water supply, the most reliable alternative is installation of a well, which ensures continuous flow and water quality for the cattle (NRCS, 2003). Assuming a well depth of 250 ft and a cost of installation of $22.50 per ft, the cost to install a well is approximately, $5,625 per well. The well pump would be sized to deliver adequate water supply for the existing herd size. For a herd of 150 cattle, the price per head for installation was estimated at $37.50.

After installation of the well or extension of the existing water supply, a water storage device is required to provide the cattle access to the water. Storage devices include troughs or tanks. NRCS (2003) lists the costs of storage devices at $23 per head.

Annual operating costs to run the well pump range from $9 to $22 per year for electricity (USEPA, 2003; Marsh, 2001), or up to $0.15 per head. Table 5-15 lists the capital, maintenance, and annualized costs for a well, pump, and storage system assuming a system life of 20 years.

Table 5-15. Costs Calculations for Alternative Watering Facilities.

Item	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Installation of well	$37.50	$0	$2
Storage container	$23	$0	$1
Electricity for well pump	$0	$0.15	$0.15
Total system costs	**$60.50**	**$0.15**	**$3.15**

5.12 Cattle Exclusion from Streams

Cattle manure is a substantial source of nutrient and fecal coliform loading to streams, particularly where direct access is not restricted and/or where cattle feeding structures are located adjacent to riparian areas. Direct deposition of feces into streams may be a primary mechanism of pollutant loading during baseflow periods. During storm events, overbank and overland flow may entrain manure accumulated in riparian areas resulting in pulsed loads of nutrients, total organic carbon (TOC), biochemical oxygen demand (BOD), and fecal coliform bacteria into streams. In addition, cattle with unrestrained stream access typically cause severe streambank erosion. The impacts of cattle on stream ecosystems are shown in Figure 5-11 and Figure 5-12.

Figure 5-11. Typical Stream Bank Erosion in Pastures with Cattle Access to Stream.

Figure 5-12. Cattle-Induced Streambank Mass Wasting and Deposition of Manure into Stream.

An example of proper exclusion and the positive impacts it has on the stream channel are shown in Figure 5-13.

(Photo courtesy of USDA NRCS.)

Figure 5-13. Stream Protected from Sheep by Fencing.

The NRCS provides additional information on fencing at:
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 382

Allowing limited or no animal access to streams will provide the greatest water quality protection. On properties where cattle need to cross streams to have access to pasture, stream crossings should be built so that cattle can travel across streams without degrading streambanks and contaminating streams with manure. Figure 5-14 shows an example of a reinforced cattle access point to minimize time spent in the stream and mass wasting of streambanks.

(Photo courtesy of USDA NRCS.)

Figure 5-14. Restricted Cattle Access Point with Reinforced Banks.

The NRCS provides additional information on use exclusion and controlled access at:
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 472

5.12.1 Effectiveness

Fencing cattle from streams and riparian areas using vegetative or fencing materials will reduce streambank trampling and direct deposition of fecal material in the streams. The USEPA (2003) reports the following reduction in phosphorus loading as a result of cattle exclusion practices:

- 15 to 49 percent reductions in total phosphorus loading

5.12.2 Costs

The costs of excluding cattle from streams depends more on the length of channel that needs to be protected than the number of animals on site. Fencing may also be used in a grazing land protection operation to control cattle access to individual plots. The system life of wire fences is reported as 20 years; the high tensile fence materials have a reported system life of 25 years (Iowa State University, 2005). NRCS reports that the average operation needs approximately 35 ft of additional fencing per head to protect grazing lands and streams. Table 5-16 presents the capital, maintenance, and annualized costs for four fencing materials based on the NRCS assumptions.

Table 5-16. Installation and Maintenance Costs of Fencing Material.

Material	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Woven Wire	$43.50	$3.50	$5.75
Barbed Wire	$33.50	$2.75	$4.50
High Tensile (non-electric) 8-strand	$30.75	$1.75	$3.00
High Tensile (electric) 5-strand	$23.00	$1.50	$2.50

5.13 Grazing Land Management

While erosion rates from pasture areas are generally lower than those from row-crop areas, a poorly managed pasture can approach or exceed a well-managed row-crop area in terms of erosion rates. Grazing land protection is intended to maximize ground cover on pasture, reduce soil compaction resulting from overuse, reduce runoff concentrations of nutrients and fecal coliform, and protect streambanks and riparian areas from erosion and fecal deposition. Figure 5-15 shows an example of a pasture managed for land protection. Cows graze the left lot while the right lot is allowed a resting period to revegetate.

(Photo courtesy of USDA NRCS.)

Figure 5-15. Example of a Well Managed Grazing System.

The NRCS provides additional information on prescribed grazing at:
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 528A

And on grazing practices in general at:
http://www.glti.nrcs.usda.gov/technical/publications/nrph.html

5.13.1 Effectiveness

Maintaining sufficient ground cover on pasture lands requires a proper density of grazing animals and/or a rotational feeding pattern among grazing plots. Increased ground cover will also reduce transport of sediment-bound manganese.

The following reductions in loading are reported in the literature:

- 49 to 60 percent reduction in total phosphorus loading

5.13.2 Costs

The costs associated with grazing land protection include acquiring additional land if current animal densities are too high (or reducing the number of animals maintained), fencing and seeding costs, and developing alternative water sources. Establishment of vegetation for pasture areas costs from $39/ac to $69/ac based on data presented in the EPA nonpoint source guidance for agriculture (USEPA, 2003). Annual costs for maintaining vegetative cover will likely range from $6/ac to $11/ac (USEPA, 2003). If cattle are not allowed to graze plots to the point of requiring revegetation, the cost of grazing land protection may be covered by the fencing and alternative watering strategies discussed above.

5.14 Inlake Controls

For lakes experiencing high rates of phosphorus inputs from bottom sediments, several management measures are available to control internal loading. Hypolimnetic (bottom water) aeration involves an aerator air-release that can be positioned at a selected depth or at multiple depths to increase oxygen transfer efficiencies in the water column and reduce internal loading by establishing aerobic (with oxygen) conditions at the sediment-water interface.

Hypolimnetic aeration effectiveness in reducing phosphorus concentration depends in part on the presence of sufficient iron to bind with phosphorus in the oxygenated waters. A mean hypolimnetic iron:phosphorus ratio greater than 3.0 is optimal to promote iron phosphate precipitation (Stauffer, 1981). The iron:phosphorus ratio in the sediments should be greater than 15 to bind phosphorus (Welch, 1992). Aeration of bottom waters will also likely inhibit the release of manganese from bottom sediments in lakes.

Phosphorus inactivation by aluminum addition (specifically aluminum sulfate or alum) to lakes has been the most widely-used technique to control internal phosphorus loading. Alum forms a polymer that binds phosphorus and organic matter. The aluminum hydroxide-phosphate complex (commonly called alum floc) is insoluble and settles to the bottom, carrying suspended and colloidal particles with it. Once on the sediment surface, alum floc retards phosphate diffusion from the sediment to the water (Cooke et al., 1993).

Artificial circulation is the induced mixing of the lake, usually through the input of compressed air, which forms bubbles that act as airlift pumps. The increased circulation raises the temperature of the whole lake (Cooke et al., 1993) and chemically oxidizes substances throughout the water column (Pastorak et al., 1981 and 1982), reducing the release of phosphorus and manganese from the sediments to the overlying water, and enlarging the suitable habitat for aerobic animals.

5.14.1 Effectiveness

If lake sediments are a significant source of phosphorus in Mary's River/North Fork Cox Creek watershed, inlake controls would likely reduce the internal loading significantly. Without field measured data to quantify the internal load for each lake, it is difficult to estimate the reduction in loading that may be seen with these controls.

5.14.2 Costs

In general, inlake controls are expensive. For comparison with the agricultural cost estimates, the inlake controls have been converted to year 2004 dollars assuming an average annual inflation rate of 3 percent.

Hypolimnetic aerators may decrease internal loading of both phosphorus and manganese. The number and size of hypolimnetic aerators used in a waterbody depend on lake morphology, bathymetry, and hypolimnetic oxygen demand. Total cost for successful systems has ranged from $170,000 to $1.7 million (Tetra Tech, 2002). USEPA (1993) reports initial costs ranging from $340,000 to $830,000 plus annual operating costs of $60,000. System life is assumed to be 20 years.

Alum treatments are effective on average for approximately 8 years per application and can reduce internal phosphorus loading by 80 percent. Treatment cost ranges from $290/ac to $720/ac (WIDNR, 2003).

Dierberg and Williams (1989) cite mean initial and annual costs for 13 artificial circulation projects in Florida of $440/ac and $190/ac/yr, respectively. The system life is assumed to be 20 years.

Table 5-17 summarizes the cost analyses for the three inlake management measures. The final column lists the annualized cost per lake surface area treated. The costs of alum treatment for Fairfield Reservoir are not included because this lake is not listed for phosphorus.

Table 5-17. Cost Comparison of Inlake Controls.

Control	Construction or Application Cost	Annual Maintenance Cost	Annualized Costs $/ac/yr
Newton Lake (1,750 acres)			
Hypolimnetic Aeration	$340,000 to $830,000	$60,000	$45 to $58
Alum Treatment	$508,000 to $1,260,000	$0	$36 to $90
Artificial Circulation	$770,000	$333,000	$212
Fairfield Reservoir (16 acres)			
Hypolimnetic Aeration	$340,000 to $830,000	$60,000	$4,810 to $6,340
Artificial Circulation	$7,000	$3,000	$209

5.15 Stream Bank and Shoreline Erosion BMPs

Reducing stream bank and lake shore erosion will reduce sediment-bound phosphorus as well as manganese loading and improve temperature and dissolved oxygen conditions by allowing vegetation to establish. The filter strips and riparian area BMPs discussed in Sections 5.5 and 5.7, and the agricultural BMPs that reduce the quantity and volume of runoff (Sections 5.2, 5.4, 5.6 and 5.7) or prevent cattle access (Section 5.12) will all provide some level of stream bank and lake shore erosion protection.

In addition, the streambanks and lake shores throughout the watershed should be inspected for signs of erosion. Banks showing moderate to high erosion rates (indicated by poorly vegetated reaches, exposed tree roots, steep banks, etc.) can be stabilized by engineering controls, vegetative stabilization, and restoration of riparian areas. Peak flows and velocities from runoff areas can be mitigated by infiltration in grassed waterways and passage of runoff through filter strips.

5.15.1 Effectiveness

Because the extent of stream bank and lake shore erosion has not yet been quantified, the effectiveness of erosion control BMPs is difficult to estimate. The benefits of BMPs that offer stream bank protection and runoff control are therefore underestimated in this report.

5.15.2 Costs

Costs associated with the BMPs that offer secondary benefits lake erosion are discussed separately for each BMP in Sections 5.4, 5.5, 5.6, and 5.7.

5.16 Stream Restoration

Stream restoration activities usually focus on improving aquatic habitat, but can also be used to increase the amount of reaeration from the atmosphere to the water. A proper restoration effort will involve an upfront design specific to the conditions of the reach being restored. Stagnant, slow moving, and deep waters typically have relatively low rates of reaeration. Restorations aimed at increasing reaeration must balance habitat needs (which include pools of deeper water) with sections of more shallow, faster flowing water. Adding structures to increase turbulence and removing excessive tree fall may also be incorporated in the restoration plan.

Stream restoration differs from riparian buffer restoration in that the shape or features within the stream channel are altered, not the land adjacent to the stream channel (although a stream restoration plan may also include restoration of the riparian corridor in addition to the features within the stream channel itself).

The effectiveness and costs of stream restorations are site specific and highly variable. Watershed planners and water resource engineers should be included in the decision making process to help determine the reaches where restoration will result in the most benefit for the watershed as a whole.

5.17 Wet Ponds

Wet ponds which are also known as stormwater ponds, wet retention ponds, or wet extended detention ponds are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season). Their main purpose is to trap sediments at the source thereby reducing sediment and nutrients loadings to the streams. Ponds treat incoming runoff by allowing particles to settle and algae to take up nutrients. The primary removal mechanism is settling as runoff resides in this pool, and pollutant uptake, particularly of nutrients, also occurs through biological activity in the pond. Wet ponds can be used to treat runoff in almost all soils and geology. The limiting factor for wet ponds is that they need sufficient drainage area to maintain a permanent pool. In humid regions, this is typically about 25 acres, but a greater area may be needed in regions with less rainfall (USEPA, 2007). Figure 5-15 shows an example of a wet pond.

Figure 5-16. Wet Pond

5.17.1 Effectiveness

Wet ponds are among the most effective practices in removing stromwater pollutants. It also very effective in reducing nutrient loads. Schueler (1997) reports phosphorus removal rate to be:

- 48 percent reduction in phosphorus

5.17.2 Cost

The cost associated with wet ponds varies considerably and are shown in Table 5-18. The annual cost of routine maintenance is typically estimated at about 3 to 5 percent of the construction cost.

Table 5-18. Cost Calculation for Wet Pond

Size of the Pond	Construction Cost	Annual Operation and Maintenance Costs per Head
1 acre –foot facility	$45, 700	$1,371 to 2,285
10 acre-foot facility	$232, 000	$6,960 to 11,600

5.17.3 Aerobic and Anaerobic Wetlands

Aerobic and anaerobic wetlands are constructed wetlands design to passively treat drainage from mine reclamation projects. Aerobic (with oxygen) wetlands precipitate metals through oxidation whereas anaerobic (without oxygen) wetlands remove heavy metals using sulfate-reducing bacteria. Due to the sulfates impairments and the capacity of anaerobic wetlands to reduce sulfate loads, the anaerobic wetlands are recommended.

Anaerobic Wetlands
Compost wetlands, or anaerobic wetlands, consist of a large pond with a lower layer of organic substrate. The flow is horizontal within the substrate layer of the basin and piling the compost slightly higher than the free water surface can increase the flow within the substrate. Anaerobic wetlands rely on organic rich substrate to create the reducing condition. The compost layer typically consists of spent mushroom

compost that contains about 10 percent calcium carbonate. Other compost materials include peat moss, wood chips, sawdust, or hay. A typical compost wetland will have 12 to 24 inches of organic substrate that is planted with cattails or other emergent vegetation (PDEP, 2007). Limestone dissolution and the metabolic products of sulfate-reducing bacteria increases pH and also precipitates metals as sulfides, hydroxides and carbonates (Henrot and Wieder, 1990).

A study conducted in the Tara Mines in Ireland successfully demonstrated the capacity to treat metal and sulfate contaminated wastewater using natural ecosystem processes (Otte and O'Sullivan, 2006). The substrates used in the anaerobic wetlands at Tara Mines contained indigenous populations of sulfate-reducing bacteria (Otte and O'Sullivan, 2006). The systems were permanently flooded and this provided net anaerobic substrate conditions conducive to the chemical reduction of sulfate (SO4) to sulfide (S2-). This reaction occurred as the microorganisms assimilated sulfate in the absence of oxygen, thus reducing it to sulfide through the transfer of electrons produced by the simultaneous oxidation of the organic substrate. The sulfide ion is very unstable and it either reacts with other metals forming metal sulfides or with hydrogen forming hydrogen sulfide.

5.17.3.1 Effectiveness

Analysis of 73 sites in Pennsylvania indicated that aerobic and anaerobic wetlands are the best available technology for many post-mining ground water seeps with moderate pH. However, the treatment efficiency decreases for sites with net acidic discharges.

Some of the major improvements noted in previous studies include:

- In the Tara Mines case study, a constructed anaerobic wetland treatment reduced up to 69% of the influent concentration of sulfate (Otte and O'Sullivan, 2006).
- No study was available to determine the reduction of TDS using anaerobic wetlands.

5.17.3.2 Cost

The average cost of creating a constructed wetland ranges from $1,250/ac/yr to $1,763/ac/yr. A study conducted in West Virginia evaluated the performance of six aerobic wetlands. The wetlands removed between 220.5 to 59,525 lb/year of acidity at the cost of $0.01/lb/yr to $3.51/lb/yr (Skousen and Ziemkiewicz, 2005).

5.17.4 Open Limestone Channels

This passive treatment method uses open ditches that are filled with cobble to small boulder sized limestone fragments. The water flows over and through the limestone which consists largely of the mineral calcite, or calcium carbonate ($CaCO_3$). Open limestone channels (OLC) may be the simplest passive treatment method and can be constructed in two ways. In the first method, a drainage ditch constructed of limestone collects acid mine drainage. The other method consists of placing limestone fragments directly in a contaminated stream. Dissolution of the limestone adds alkalinity (in the form of $CaCO_3$) and raises the pH in the water. This treatment method requires large quantities of limestone for long-term success (PDEP, 2007).

The length of the channel and the channel gradient are varied for optimum performance, as they affect turbulence and the buildup of coatings (Skousan et. al., 1989). Optimum performance is observed on slopes exceeding 20 percent, where flow velocities keep precipitates in suspension while cleaning the limestone surface (Skousan et. al., 1998). A study indicated that the fewest problems occur in OLCs containing a 12 inch minimum size for the limestone (Ziemkiewizz and Brant, 1996).

5.17.4.1 Effectiveness

Long term use of OLC can maximize acidity treatment and metals removal. Three OLCs were installed in the Casselman River located between Boynton and Meyersdale, PA for restoring an AMD impaired river (Ziemkiewicz and Brant 1996). The mine seal at the headwaters of the tributary where the OLC was located discharged up to 6.1 tons of acid per day. The OLC established was a trapezoidal channel 1,500 feet long, 6 feet wide, and 2 feet deep installed on an 8 percent slope with 12 inch diameter limestone fragments. Over the two year period, the effluent acidity decreased by 47 percent, manganese decreased by 100 percent and sulfate by 28 percent (Ziemkiewicz and Brant 1996).

5.17.4.2 Cost

The average cost of treatment ranges between $0.012/lb/yr to $3.4/lb/yr for treating acidity (Skousen and Ziemkiewicz, 2005).

5.17.5 Vertical Flow Reactors

Vertical flow reactors were conceived as a way to overcome the alkalinity producing limitations of anoxic limestone drains and the large area requirements of compost wetlands. The vertical flow reactor consists of a treatment cell with an underdrained limestone base topped with a layer of organic substrate and standing water. The water flows vertically downward, usually from a pond, and through organic matter and limestone and is collected and discharged through a drainage system. The vertical flow reactor increases alkalinity by limestone dissolution and bacterial sulfate reduction (PDEP, 2007)

Compared to horizontal flow anaerobic wetlands, vertical flow systems greatly increase the interaction of water with organic matter and limestone. Acid water is allowed to settle 1 to 3 meters over 0.1 to 0.3 meters of organic compost, which is underlain by 0.5 to 1 meters of limestone (Skousen et al. 1998). Below the limestone is a series of drainage pipes that convey the treated water into an aerobic pond where metals are precipitated. Sulfate reduction and iron sulfide precipitation occur in the compost treatment (Skousen et. al, 1998).

In the vertical flow reactor, the intent is usually to optimize sulfate reduction in the organic layer by causing water to flow through the organic matter. Eger found in his study that composted municipal waste and several other types of organic material supported reasonable levels of sulfate reduction (Eger, 1994). The lower pH condition, generally created due to limestone, enhances sulfate reduction rates.

5.17.5.1 Effectiveness

At the Brandy Camp site in PA, this method was utilized and after passage through the treatment system the effluent pH increased from 4.3 to 7.1. The system effectively increased alkalinity, but did not change manganese concentration (Hellier 1996). The sulfate reduction information was not available, although many studies have found that this treatment method enhances sulfate reduction rates (Hellier 1996, Skousen et. al, 1998).

5.17.5.2 Cost

Cost information for vertical flow reactors was not available.

5.18 Sulfate-Reducing Bioreactor

A sulfate-reducing bioreactor is a passive treatment process designed to sequentially remove metals, acidity, and sulfates (a component of TDS) in a natural-looking, man-made bio-system that capitalizes on ecological and geochemical reactions. The process requires no power and no chemicals after construction and lasts for decades with minimal maintenance (Figure 5-20). Winner Global Energy and

Environmental Services, LLC is conducting a project that utilizes sulfate-reducing bacteria to decrease sulfate and other metal concentrations so as to increase pH and alkalinity of the effluent. Detailed information on the system's efficiency to remove sulfate (and therefore a portion of the TDS concentration) and the cost associated with its construction is not available as the project is still in its preliminary stage.

Figure 5-17. Sulfate-Reducing Bacteria Reactor

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6.0 PRIORITIZATION OF IMPLEMENTATION

This section summarizes the effectiveness of the BMPs discussed in Section 5.0 and identifies potential BMP strategies for each impaired waterbody.

6.1 Summary of BMPs

BMPs that are applicable to treat the concerned parameters are summarized in Table 6-1. The table also includes the reported effectiveness for each parameter (when estimated in the literature) as well as additional information concerning streambank protection and additional impacts on dissolved oxygen. If a BMP is not expected to significantly reduce loading of a specific parameter, then the reduction is labeled not applicable ("na"). If a BMP is expected to reduce pollutant loading, but no studies were found to quantify the reduction, then the reduction is labeled "unknown." It should be noted that the BMPs that have noted benefits of reducing stream bank erosion and runoff are also expected to minimize sediment, phosphorus, manganese loads that are also associated with runoff.

BMPs managing pollutant loads from other sources in the watershed are discussed individually in Section 5.0.

Table 6-1. Summary of BMPs .

BMP	Phosphorus Reduction (percent)	TDS Reduction (percent)	Sulfate Reduction (percent)	Additional Benefits for Stream Health and Dissolved Oxygen Impairments
Nutrient Management Plans	20 to 50	na	na	Reducing nutrient loads to streams may reduce algal growth and related dissolved oxygen problems.
Conservation Tillage	68 to 76	na	unknown	Reduces runoff losses by 69 percent, which may reduce rates of streambank erosion.
Cover Crops	70 to 85	na	unknown	Reduces runoff losses by 50 percent, which may reduce rates of streambank erosion.
Filter Strips	65	na	unknown	Slows rates of runoff and may reduce volume via infiltration. May reduce rates of streambank erosion.
Grassed Waterways	30	na	unknown	Slows rates of runoff and may reduce volume via infiltration. May reduce rates of streambank erosion.
Riparian Buffers (30 ft wide)	25 to 30	unknown	unknown	Slows runoff and may reduce quantity via infiltration. Protects stream channel from erosion and canopy disturbance.
Riparian Buffers (60 to 90 ft wide)	70 to 80	unknown	unknown	Slows runoff and may reduce quantity via infiltration. Protects stream channel from erosion and canopy disturbance.
Riparian Buffers (200 ft wide)	unknown	unknown	unknown	Slows runoff and may reduce quantity via infiltration. Protects stream channel from erosion and canopy disturbance.
Constructed Wetlands	42	unknown	unknown	Slows runoff and may reduce quantity via infiltration, evaporation, and transpiration.
Controlled Drainage (new tile system)	65	na	unknown	Reduces peak flow volumes and velocities by storing water; may allow for volume reduction via transpiration.
Controlled Drainage (retrofit tile system)	35	na	unknown	Reduces peak flow volumes and velocities by storing water; may allow for volume reduction via transpiration.
Feeding Strategies	30 to 50	na	na	Feeding strategies that reduce the phosphorus content of manure may improve dissolved oxygen conditions by reducing eutrophication in streams and lakes.
Alternative Watering Systems with Cattle Exclusion from Streams	15 to 49	na	na	Prevents streambank trampling Reduces direct deposition of manure into stream channel, which reduces loads of nutrients,

BMP	Phosphorus Reduction (percent)	TDS Reduction (percent)	Sulfate Reduction (percent)	Additional Benefits for Stream Health and Dissolved Oxygen Impairments
Grazing Land Management	49 to 60	na	unknown	Increased vegetative ground cover will reduce soil erosion and improve infiltration which should reduce runoff volumes. Improvements in dissolved oxygen concentrations should occur as a result of lower concentrations of BOD_5 in the runoff (reduced proportionally by the change in number of cattle per acre.)
Inlake Controls	variable	na	na	May have impacts on dissolved oxygen balances downstream of water release structures.
Wet Ponds	unknown	unknown	unknown	May have impacts on dissolved oxygen due to uptake of nutrients
Mulching	na	na	unknown	Reduce stromwater velocity and improve filtration
Sediment Traps	na	na	unknown	Prevent phosphorus bound sediments from entering into streams thus
Check Dams	na	na	unknown	Reduce stromwater velocity
Aerobic/Anaerobic Wetlands	42	53 to 81	69	Slows runoff and may reduce quantity via infiltration, evaporation, and transpiration
Open Limestone Channels	na	unknown	28	Significantly convert from net acidity to net alkalinity.
Vertical Flow Reactor	na	unknown	unknown	Produces net alkalinity, enhances sulfate reduction.
Sulfate-Reducing Bioreactor	na	na	unknown	Generate excess alkalinity in their effluent that improves the quality of receiving stream.
AMD Vale Extraction Process	na	na	unknown	High water quality produced due to removal of iron and other metal cations

6.2 Use of BMPs to Meet Water Quality Goals

The listed reaches in the Mary's River/North Fork Cox Creek require varying degrees of reductions to meet water quality standards. This section briefly summarizes the required reductions for each segment and discusses the BMPs that will likely meet the water quality goals for the waterbody. Cost comparisons for each of the suggested BMPs are included at the end of the section.

6.2.1 Randolph County Lake (RIB)

Randolph County Lake is impaired for phosphorus and requires a 37 percent reduction in loading to attain water quality standards. A large portion of the phosphorus loading likely originates from upstream crop production, failing onsite septic systems, and potentially animal operations. . Achieving load reductions from crop production areas can most easily be achieved by source reduction strategies such as conservation tillage or cover crops. Nutrient management planning would offer supplemental reductions (and possibly cost savings), but will likely not achieve the required reductions alone.

Achieving load reductions from animal operations can likely be attained by combining at least two of the following BMPs: animal feeding strategies, cattle exclusion from streams with alternative watering systems, or grazing land management.

Treatment level BMPs such as filter strips, grassed waterways, constructed wetlands, and restoration of riparian buffers can mitigate phosphorus loads from animal operations and crop production areas. These BMPs typically treat small drainage areas and are suggested as supplemental measures that should be strategically located where needed.

6.2.2 Sparta Old Reservoir (RIJ)

A 98 percent reduction in phosphorus is required at Sparta Old Reservoir. BMP implementation strategies that are similar to those recommended for Randolph County Lake are also suggested for Sparta Old Reservoir to control phosphorus loading from crop and animal operations.

6.2.3 North Fork Cox Creek (IIHA-31)

TDS and sulfate are the two parameters causing impairments in this segment. Historic mining activities are likely the major contributors of TDS and sulfate to North Fork Cox Creek. For this segment, TDS load reductions are required during moist flow (68 percent) and dry flows (73 percent). Similarly sulfate loads display needed reductions of 69 and 74 percent at moist and dry flow conditions, respectively.

BMPs that treat AMD sources for TDS and sulfates are expected to improve water quality in this impaired segment. The Sulfate-Reducing Bioreactor system is the one BMP that primarily focus on sulfate reductions. Additional BMPs such as anaerobic wetlands, open limestone channels, and vertical flow reactors should also be used to treat TDS and sulfates impairments where applicable. Additional source investigations should be completed in the watershed surrounding this segment to determine the location and nature of the AMD sources so that the appropriate BMPs can be implemented.

6.2.4 North Fork Cox Creek (IIHA-STC1A)

TDS is the only parameter that is exceeding water quality standards in this segment. Historic mining activities are believed to be the main sources of TDS in this segment. Meeting a 71 percent TDS reduction at moist flow and 67 percent at dry flow will likely require one, or a combination of, the recommended AMD treatment strategies listed in Table 6-8. The specific BMPs selected for implementation will depend on the sources of AMD impairing water quality in this segment. Additional source investigations should be completed in the watershed surrounding this segment to determine the location and nature of the AMD sources so that the appropriate BMPs can be implemented.

6.3 Implementation Strategy for Agricultural BMPs

The water quality impairments in the Mary's River/North Fork Cox Creek watershed can mainly be attributed to loading from croplands, animal operations, mining activities, and failing onsite wastewater treatment systems. This section discusses the most effective BMPs for each of these source categories in terms of effectiveness and costs. All costs are presented in 2004 dollars as explained in Section 5.0.

6.3.1 Reducing Loads from Crop Production

Lands used for crop production contribute large portions of the phosphorus loads delivered to the waterbodies in the Mary's River/North Fork Cox Creek watershed. Table 6-6 summarizes the crop production BMPs that will most efficiently reduce loads from this source.

Table 6-2. BMPs for Crop Production.

BMP	Phosphorus Reduction (percent)	AnnualizedCosts per Acre Treated
Nutrient Management Plans	20 to 50	$0.75 to $3.75
Conservation Tillage	68 to 76	$1.25 to $2.25
Cover Crops	70 to 85	$19.25
Controlled Drainage (new)	65	$2.50
Controlled Drainage (retrofit)	35	$0.75 to $1.50
Filter Strips	65	$25
Grassed Waterways	30	$2 to $6
Riparian Buffers (30 ft)	25 to 30	$20
Riparian Buffers (60 to 90 ft)	70 to 80	$40 to $60
Riparian Buffers (200 ft)	Not reported	$130

Conservation tillage practices offer the best potential reductions for phosphorus and are among the least expensive options. Other cost-effective phosphorus reduction measures include grassed waterways, cover crops, and filter strips. In addition, fertilizers and pesticides should be applied at proper rates and only applied when the chance of heavy rain is minimal. Incorporating or banding these chemicals will reduce transport off the field. Riparian buffers are highly effective but can only be used to treat a small drainage area near the stream channel.

6.3.2 Reducing Loads from Animal Operations

Managing pollutant loading from animal operations will likely be necessary to meet the TMDL reductions for reaches impaired by phosphorus. The effectiveness of BMPs in reducing phosphorus loading from animal operations is summarized in Table 6-3.

Table 6-3. BMPs for Animal Operations.

BMP	Phosphorus Reduction (percent)	Annualized Costs
Feeding Strategies	30 to 50	Variable – ranges from savings to net costs
Alternative Watering Systems with Cattle Exclusion from Streams	15 to 49	$5.50 to $9 per head of beef or other pastured cattle
Grazing Land Management	49 to 60	Variable – costs may be covered by fencing and alternative watering locations
Filter Strips	65	$4 to $6 per head of cattle
Grassed Waterways	30	$0.05 to $0.12 per head of cattle
Riparian Buffers (30 ft)	25 to 30	$0.03 per ft of channel
Riparian Buffers (60 to 90 ft)	70 to 80	$0.05 to $0.07 per ft of channel
Riparian Buffers (200 ft)	Not reported	$0.16 per ft of channel
Constructed Wetlands	42	$2.50 per head of dairy cattle $4.50 per head of swine

For operations in the Randolph County Lake and Sparta Old Reservoir, the most cost-effective phosphorus BMPs (with known costs) are grassed waterways, filter strips, and constructed wetlands.

The costs associated with grazing land management and feeding strategies are difficult to estimate, but may be covered by other costs (i.e., fencing) or result in net savings. Proper manure handling, storage, and disposal costs are highly variable depending on the waste handling system currently in place. Management practices associated with this BMP are required on large, permitted animal operations and should be strongly encouraged on smaller operations as well.

Riparian buffers offer excellent pollutant removal opportunities as well as stream/habitat protection benefits. These corridors should be restored or protected where feasible.

6.3.3 Reducing Loads from Mine Operations

Sulfate and TDS are the main pollutants discharged from mining activities. Table 6-8 list the BMPS that are expected to control TDS and sulfate loadings to the Mary's River/North Fork Cox Creek watershed.

Table 6-4. BMPs for Mine Operations

BMP	TDS	Sulfate	Annualized Costs
Anaerobic Wetlands	unknown	69	$1,250/ac/yr to $1,763/ac/yr
Open Limestone Channels	unknown	28	$0.012/lb/yr to $3.4/lb/yr for treating acidity
Vertical Flow Reactors	unknown	unknown	unknown
Sulfate-Reducing Bioreactor[1]	na	not reported	unknown

[1,2] These are on-going projects. The final results are still to be reported.

As some of the studies relating to these treatment systems have yet to be completed, it is difficult to prioritize the BMPs that need to be implemented to meet the water quality standards. Furthermore, some of these BMPs have only qualitative data presented for the anticipated TDS reductions. In addition to these limitations, many of these BMPs are very costly to build. It is suggested that treatment systems be implemented based on additional site specific data collected on the sources and nature of AMD. Once a better understanding of the AMD sources is acquired, a more thorough cost/benefit analysis can be completed. If these measures are not able to attain the required TMDL target, then the implementation measures should focus on the more costly measure.

6.3.4 Reducing Loads from Failing Onsite Wastewater Treatment Systems

Reducing the number of failing systems will require ongoing education of system owners, periodic inspections, regular maintenance, and replacing systems when needed.

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7.0 MEASURING AND DOCUMENTING PROGRESS

Managing impairments in the Mary's River/North Fork Cox Creek watershed will likely involve multiple agricultural BMPs focused on crop production, animal operations, and surface and underground mine sources. Continuing to monitor water quality in the waterbodies will determine whether or not managing the other sources of impairments, which may include failing onsite wastewater systems, and inlake re-suspension, is necessary to bring the watershed into compliance. Tracking the implementation of BMPs while continuing to monitor water quality parameters will assist the stakeholders and public agencies in determining the effectiveness of this plan. If concentrations remain above the water quality standards, further encouragement of the use of BMPs across the watershed through education and incentives should become a priority. It may also be necessary to begin funding efforts for localized BMPs such as riparian buffer restoration.

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8.0 REASONABLE ASSURANCE

USEPA requires that a TMDL provide reasonable assurance that the required load reductions will be achieved and water quality will be restored. For this watershed, use of BMPs for crop production, animal operations, failing onsite septic systems, and historic mining are the primary management strategies to reach these goals. Participation of farmers and landowners is essential to improving water quality, but resistance to change and upfront costs may deter participation. Educational efforts and cost share programs will likely increase participation to levels needed to protect water quality.

Two of the incentive programs discussed below were administered under the 2002 Farm Bill, which expired September 30, 2007. The Conservation Reserve Program will continue to pay out existing contracts, but new enrollments will not be allowed until the bill is reinstated; no official date of reinstatement has been announced. Though the Environmental Quality Incentives Program was also part of the 2002 Farm Bill, it was extended beyond fiscal year 2007 by the Deficit Reduction Act of 2005 (Congressional Research Reports for the People, 2007).

8.1 Environmental Quality Incentives Program (EQIP)

Several cost share programs are available to farmers and landowners who voluntarily implement resource conservation practices in the Mary's river/North Fork Cox Creek watershed. The most comprehensive is the NRCS Environmental Quality Incentives Program (EQIP) which offers cost sharing and incentives to farmers statewide who utilize approved conservation practices to reduce pollutant loading from agricultural lands.

- The program will pay $10 for one year for each acre of farmland that is managed under a nutrient management plan (up to 400 acres per farmer).
- Use of vegetated filter strips will earn the farmer $100/ac/yr for three years (up to 50 acres per farmer).
- The program will also pay 60 percent of the cost to construct grassed waterways, riparian buffers, and windbreaks.
- Use of residue management will earn the farmer $15/ac for three years (up to 400 acres per farmer).
- Installation of drainage control structures on tile outlets will earn the farmer $5/ac/yr for three years for the effected drainage area as well as 60 percent of the cost of each structure.
- The program will pay 75 percent of the construction cost for a composting facility.
- Sixty percent of the fencing, controlled access points, spring and well development, pipeline, and watering facility costs are covered by the program.
- Waste storage facilities and covers for those facilities have a 50 percent cost share for construction.
- Prescribed grazing practices will earn the farmer $10/ac/yr for three years (up to 200 acres per farmer).

In order to participate in the EQIP cost share program, all BMPs must be constructed according to the specifications listed for each conservation practice.

The specifications and program information can be found online at:
http://www.il.nrcs.usda.gov/programs/eqip/cspractices.html.

8.2 Conservation Reserve Program (CRP)

The Farm Service Agency of the USDA supports the Conservation Reserve Program (CRP) which rents land converted from crop production to grass or forestland for the purposes of reducing erosion and protecting sensitive waters. This program is available to farmers who establish vegetated filter strips or grassed waterways. The program typically provides 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years.

More information about this program is available online at:
http://www.nrcs.usda.gov/programs/crp/

8.3 Conservation 2000

In 1995 the Illinois General Assembly passed the Conservation 2000 bill providing $100 million in funding over a 6-year period for the promotion of conservation efforts. In 1999, legislation was passed to extend the program through 2009.

General information concerning the Conservation 2000 Program can be found online at:
http://www.agr.state.il.us/Environment/conserv/

8.3.1 Conservation Practices Program (CPP)

The Conservation Practices Cost Share Program provides monetary incentives for conservation practices implemented on land eroding at one and one-half times or more the tolerable soil loss rate. Payments of up to 60 percent of initial costs are paid through the local Soil and Water Conservation Districts (SWCDs). Of the BMPs discussed in this plan, the program will cost share cover crops, filter strips, grassed waterways, no-till systems, and pasture planting. Other sediment control options such as contour farming and installation of stormwater ponds are also covered. Practices funded through this program must be maintained for at least 10 years.

More information concerning the Conservation Practices Program can be found online at:
http://www.agr.state.il.us/Environment/conserv/

8.3.2 Streambank Stabilization Restoration Program

Conservation 2000 also funds a streambank stabilization and restoration program aimed at restoring severely eroding streambanks. Research efforts are also funded to assess the effectiveness of vegetative and bioengineering techniques.

More information about this program is available online at:
http://dnr.state.il.us/orep/c2000/grants/proginfo.asp?id=20

8.3.3 Sustainable Agriculture Research and Education (SARE) Grant Program

The Sustainable Agricultural Research and Education (SARE) Grant Program funds research, education, and outreach efforts for sustainable agricultural practices. Private landowners, organizations, educational, and governmental institutions are all eligible for participation in this program.

More information concerning the Sustainable Agricultural Grant Program can be found online at:
http://www.sare.org/grants/

8.4 Nonpoint Source Management Program (NSMP)

Illinois EPA receives federal funds through Section 319(h) of the Clean Water Act to help implement Illinois' Nonpoint Source (NPS) Pollution Management Program. The purpose of the program is to work cooperatively with local units of government and other organizations toward the mutual goal of protecting the quality of water in Illinois by controlling NPS pollution. The program emphasizes funding for implementing cost-effective corrective and preventative best management practices (BMPs) on a watershed scale. Funding is also available for BMPs on a non-watershed scale and the development of information/education NPS pollution control programs.

The maximum federal funding available is 60 percent, with the remaining 40 percent coming from local match. The program period is two years unless otherwise approved. This is a reimbursement program.

Section 319(h) funds are awarded for the purpose of implementing approved NPS management projects. The funding will be directed toward activities that result in the implementation of appropriate BMPs for the control of NPS pollution or to enhance the public's awareness of NPS pollution. Applications are accepted June 1 through August 1.

More information about this program is available online at:
http://www.epa.state.il.us/water/financial-assistance/non-point.html

8.5 Agricultural Loan Program

The Agricultural Loan Program offered through the Illinois State Treasury office provides low-interest loans to assist farmers who implement soil and water conservation practices. These loans will provide assistance for the construction, equipment, and maintenance costs that are not covered by cost share programs.

The following are the major types of loans available:

- Purchase and conservation improvement loans of real estate are provided up to a ceiling of $200,000 with 5.37% interest rate and repayment period of 40 years. Farmers involved in active farming operations are qualified for this loan. The county also provides guaranteed loan programs that are processed by the terms of a bank with FSA giving 90% guarantee (Reynolds, 2007).
- Direct operating loan (machinery, operation, improvements, plant crop, seeds etc.) of $200,000 with a 7 year repayment period for various farming operations. The program is also provided in collaboration with a bank (Reynolds, 2007).

More information about this program is available online at:
http://www.state.il.us/TREAS/ProgramsServices.aspx

8.6 Illinois Conservation and Climate Initiative (ICCI)

The Illinois Conservation and Climate Initiative (ICCI) is a joint project of the State of Illinois and the Delta Pollution Prevention and Energy Efficiency (P2/E2) Center that allows farmers and landowners to earn carbon credits when they use conservation practices. These credits are then sold to companies or agencies that are committed to reducing their greenhouse gas emissions. Conservation tillage earns 0.5 metric tons (1.1 US ton) of carbon per acre per year (mt/ac/yr), grass plantings (applicable to filter strips and grassed waterways) earn 0.75 mt/ac/yr, and trees planted at a density of at least 250 stems per acre earn somewhere between 3.5 to 5.4 mt/ac/yr, depending on the species planted and age of the stand.

Carbon credits are currently selling at around $2.50 per mt. Current exchange rates are available online at http://chicagoclimatex.com. Administrative fees of $0.14/mt plus 8 percent are subtracted from the sale price.

Program enrollment occurs through the P2/E2 Center which can be found online at http://p2e2center.org/. The requirements of the program are verified by a third party before credits can be earned.

More information about carbon trading can be found online at:
http://illinoisclimate.org/

Table 8-1 and Table 8-2 summarize the cost share programs available for BMPs in the Mary's River/North Fork Cox Creek watershed.

Table 8-1. Summary of Assistance Programs Available in the Mary's River/North Fork Cox Creek Watershed.

Assistance Program	Program Description	Contact Information
NSMP	Provides grant funding for educational programs and implementation of nonpoint source pollution controls.	Illinois Environmental Protection Agency Bureau of Water Watershed Management Section, Nonpoint Source Unit P.O. Box 19276 Springfield, IL 62794-9276 Phone: (217) 782-3362
Agricultural Loan Program	Provides low-interest loans for the construction and implementation of agricultural BMPs. Loans apply to equipment purchase as well.	Office of State Treasurer Agricultural Loan Program 300 West Jefferson Springfield, Illinois 62702 Phone: (217) 782-2072 Fax: (217) 522-1217
ULWREP	Provides funding for implementation of BMPs and land improvement projects to farmers and landowners within the partnership.	IDNR Region 4 Office 4521 Alton Commerce Parkway Alton, IL 62002 Phone: 618-462-1181 Fax: 618-462-2424
NRCS EQIP	Offers cost sharing and rental incentives to farmers statewide who utilize approved conservation practices to reduce pollutant loading from agricultural lands. Applies to nutrient management plans, filter strips, grassed waterways, riparian buffers, and conservation tillage.	Randolph County SWCD (RCSWCD) 313 West Belmont Sparta, IL 62286
FSA CRP	Offsets income losses due to land conversion by rental agreements. Targets highly erodible land or land near sensitive waters. Provides up to 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years for converted land.	
Conservation 2000 CPP	Provides up to 60 percent cost share for several agricultural BMPs: cover crops, filter strips, grassed waterways.	
Conservation 2000 Streambank Stabilization Restoration Program	Provides 75 percent cost share for establishment of riparian corridors along severely eroding stream banks. Also provides technical assistance and educational information for interested parties.	
SARE	Funds educational programs for farmers concerning sustainable agricultural practices.	
Local SWCD	Provides incentives for individual components of nutrient management planning, use of strip tillage, and restoration of riparian buffers.	
ICCI	Allows farmers to earn carbon trading credits for use of conservation tillage, grass, and tree plantings.	

Table 8-2. Assistance Programs Available for Agricultural BMPs.

BMP	Cost Share Programs and Incentives
Education and Outreach	Conservation 2000 Streambank Stabilization Restoration Program SARE NSMP Local SWCD ULWREP
Nutrient Management Plan	EQIP: $10/ac for one year, 400 ac. max. Local SWCD: up to $30/ac for one year ULWREP: contact agency for individual resource allocations
Conservation Tillage	EQIP: $15/ac for three years, 400 ac. max. ICCI: earns 0.5 mt/ac/yr of carbon trading credit ULWREP: contact agency for individual resource allocations
Cover Crops	CPP: cost share of 60 percent ULWREP: contact agency for individual resource allocations
Filter Strips	EQIP: $100/ac for three years, 50 ac. max. CPP: 60 percent of construction costs CRP: 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years ICCI: earns 0.75 mt/ac/yr of carbon trading credit for each acre planted
Grassed Waterways	EQIP: 60 percent of construction costs CPP: 60 percent of construction costs CRP: 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years ICCI: earns 0.75 mt/ac/yr of carbon trading credit for each acre planted
Land Retirement of Highly Erodible Land or Land Near Sensitive Waters	CRP: 50 percent of the costs of establishing vegetative cover and cash incentive of $185/ac/yr for 15 years ICCI: earn between 0.75 and 5.4 mt/ac/yr of carbon trading credit depending on species planted ULWREP: contact agency for individual resource allocations
Restoration of Riparian Buffers	EQIP: 60 percent of construction of costs CRP: 50 percent of the costs of establishing vegetative cover and cash incentive of $185/ac/yr for 15 years ICCI: earn between 0.75 and 5.4 mt/ac/yr of carbon trading credit depending on species planted ULWREP: contact agency for individual resource allocations

Note: Cumulative cost shares from multiple programs will not exceed 100 percent of the cost of construction.

9.0 IMPLEMENTATION TIMELINE

This implementation plan for the Mary's River North Fork Cox Creek watershed defines a phased approach for achieving the water quality standards (Figure 9-1). Ideally, implementing control measures for nonpoint sources of pollutant loading will be based on voluntary participation, which will depend on 1) the effectiveness of the educational programs for farmers, landowners, and owners of onsite wastewater systems, and 2) the level of participation in the programs.

Phase I of this implementation plan should focus on education of farm and mine owners concerning the benefits of BMPs on water quality as well as cost share programs available in the watershed. It is expected that initial education through public meetings, mass mailings, TV and radio announcements, and newspaper articles could be achieved in less than 6 months. As described in Section 8.0, assistance with educational programs is available through the following agencies: the Illinois Department of Agriculture Conservation 2000 Streambank Stabilization Restoration Program, the Illinois Department of Agriculture Sustainable Agriculture Grant Program (SARE), the Illinois Environmental Protection Agency Nonpoint Source Management Program (NSMP), and the local Soil and Water Conservation Districts.

Phase II of the implementation schedule will involve the voluntary participation of farmers and landowners in utilizing BMPs such as filter strips, composting, constructed wetlands, conservation tillage, and grassed waterways. The local Natural Resources Conservation Service office will be able to provide technical assistance and cost share information for these BMPs. In addition, initial inspections of all onsite wastewater treatment systems and necessary repairs may begin. Continued monitoring of water quality in the watershed should continue throughout this phase, which will likely take one to three years.

If pollutant concentrations measured during Phase II monitoring remain above the water quality standards, Phase III of the implementation plan will be necessary. The load reductions achieved during Phase II should be estimated by 1) summarizing the areas where BMPs are in use, 2) calculating the reductions in loading from BMPs, and 3) determining the impacts on pollutant concentrations measured before and after Phase II implementation. If the BMPs result in decreased concentrations, and additional areas could be incorporated, further efforts to include more stakeholders in the voluntary program will be needed. If the Phase II BMPs are not having the desired impacts on pollutant concentrations, or additional areas of incorporation are not available, supplemental BMPs, such as restoration of riparian areas and stream channels will be needed to control phosphorus.

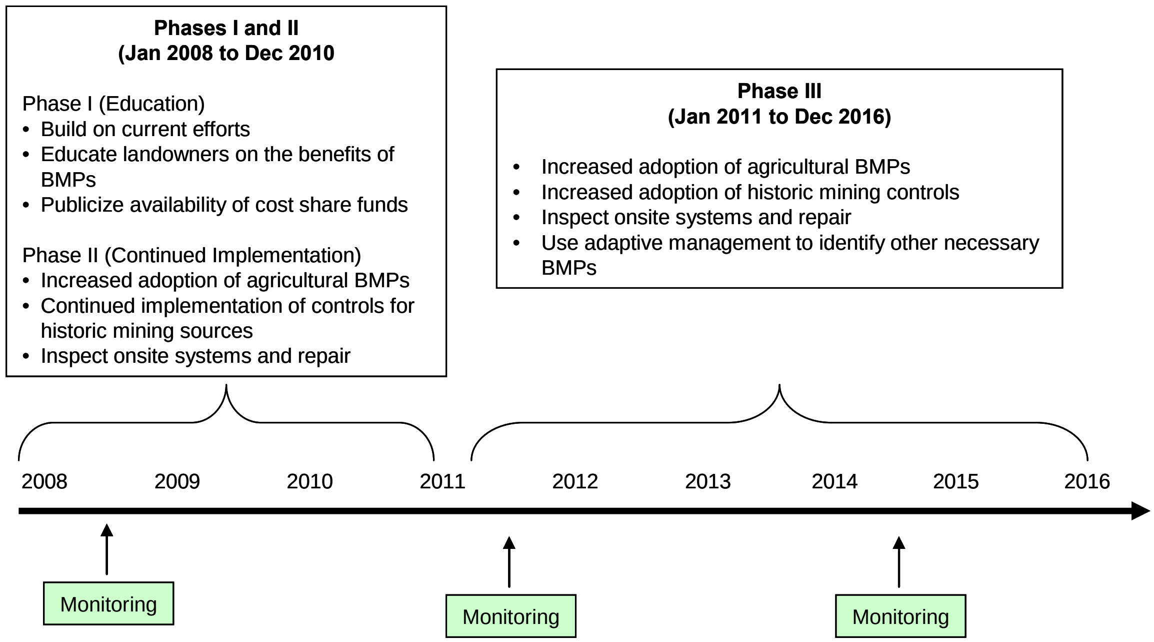

Figure 9-1. Timeline for the Mary's River/North Fork Cox Creek TMDL Implementation Plan.

10.0 REFERENCES

Al-Kaisi, M., M. Hanna, and M. Tidman. 2000. Survey: Iowa No-till Holds Steady. Integrated Crop Management, IC-484(23), October 23, 2000.

ASAE. 1998. *ASAE Standards, 45th edition: Standards, Engineering Practices, Data.* St. Joseph, MI. American Society of Agricultural Engineers.

Buman, R.A., B.A. Alesii, J.L. Hatfield, and D.L. Karlen. 2004. Profit, yield, and soil quality effects of tillage systems in corn - soybean rotations, *Journal of Soil and Water Conservation*, Vol.59, No. 6.

CCSWCD. 2003. Homer Lake Application for Section 319(h) Financial Assistance. Submitted to Illinois Environmental Protection Agency Division of Water Pollution Control. Submitted by Champaign County Soil and Water Conservation District in cooperation with the Champaign County Forest Preserve District, July 31, 2003.

CDM, 2006. Mary's River/North Fork Cox Creek Watershed TMDL, Illinois. Prepared for the Illinois Environmental Protection Agency.

Congressional Research Reports for the People. 2007. Possible Expiration of the 2002 Farm Bill RL34154 August 31, 2007.

Cooke, G.D., E.B. Welch, S.A. Peterson, and P.R. Newroth. 1993. Restoration and management of lakes and reservoirs. Lewis Publishers, Boca Raton, FL. 548 pp.

Cooke, Richard. 2005. Economic Aspects of Drainage and Water Management, University of Illinois, 2005 Corn & Soybean Classic.

CPAAC. 1999. Guidance Manual For The Design, Construction And Operations Of Constructed Wetlands For Rural Applications In Ontario Funded by the Canadapt Program of the Agricultural Adaptation Council, Ontario.

CWP. 2004. The Stormwater Manager's Resource Center: Fact Sheets on Residential Pollution Prevention Practices. Center for Watershed Protection, Ellicott City, MD.

Czapar, G.F., J.M. Laflen, G.F. McIsaac, D.P. McKenna. 2006. Effects of Erosion Control Practices on Nutrient Loss, University of Illinois.

Dierberg, F.E. and V. P. Williams. 1989. Lake management techniques in Florida, USA: costs and water quality effects. Environ. Manage. 13:729-742.

Ebelhar, S.A. and M. P. Plumer. 2007. Annual Ryegrass Varieties for Southern Illinois. University of Illinois Department of Crop Sciences.

Eger, P. 1994. Wetland treatment for trace metal removal from mine drainage: The importance of aerobic and anaerobic processes. Water Sci. Technology.

Gentry, L.E., M.B. David, T.V. Royer, C.A. Mitchell, and K.M. Starks. 2007. Phosphorus Transport Pathways to Streams in Tile-Drained Agricultural Watersheds. *Journal of Environmental Quality* Volume 36: 408:415, American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America.

Gilliam, J.W., D.L. Osmond, and R.O. Evans. 1997. Selected Agricultural Best Management Practices to Control Nitrogen in the Neuse River Basin. North Carolina Agricultural Research Service Technical Bulletin 311, North Carolina State University, Raleigh, NC.

Goo, R. 2004. Do's and Don'ts Around the Home. U.S. Environmental Protection Agency, Nonpoint Source Control Branch.

Haith, D.A., R. Mandel, and R.S. Wu. 1992. GWLF, Generalized Watershed Loading Functions, Version 2.0, User's Manual. Dept. of Agricultural & Biological Engineering, Cornell University, Ithaca, NY.

Hajjar, L.M. 2000. Final Report for Section 309 – Cumulative and Secondary Impacts Task 2 – Model Septic System Maintenance Program. Office of Ocean and Coastal Resource Management South Carolina Department of Health and Environmental Control.

Harman, W.L., T. Gerik, H.A. Torbert III, K.N. Potter. 2003. Agronomic and economic implications of conservation tillage and ultra-narrow row cropping systems. National Conservation Tillage Cotton and Rice Conference Proceedings. Jan. 23-24, Houston, TX. p. 11-13.

Henrot, J., and R.K. Wieder. 1990. Processes of iron and manganese retention in laboratory peat microcosms subjected to acid mine drainage. J. Environ. Qual. 19:312-320.

Hellier, W.W. 1996. The Bark Camp Run constructed wetlands: Findings and Recommendations for Future Design Criteria. Thirteenth American Society for Surface Mining and Reclamation Conference, May 18-23, 1996. Knoxville, TN.

HRWCI. 2005. Agricultural Phosphorus Management and Water Quality in the Midwest. Heartland Regional Water Coordination Initiative. Iowa State University, Kansas State University, the University of Missouri, the University of Nebraska–Lincoln and the USDA Cooperative State Research, Education and Extension Service.

IAH. 2002. Illinois Agronomy Handbook, 23rd Edition. University of Illinois Extension, College of Agricultural, Consumer, and Environmental Sciences.

IASS. 2004. Illinois Farm Report. Illinois Department of Agriculture, Agricultural Statistics Service.

IDA. 2001. The Livestock Management Facilities Program. Illinois Department of Agriculture.

Iowa State University. 2005. Estimated Costs for Livestock Fencing. Iowa State University Extension. FM1855. Revised July 2005.

Kalita, Prasanta. 2000. Vegetative Filter Strips to Reduce Pathogens and Nutrients in Runoff from Livestock Feedlots. Department of Crop Sciences College of Agriculture, Consumer and Environmental Sciences, University of Illinois Extension.

Lewandrowski, J., M. Peters, C. Jones, R. House, M. Sperow, M. Eve, and K. Paustian. 2004. Economics of Sequestering Carbon in the U.S. Agricultural Sector, Technical Bulletin No. (TB1909) 69 pp, United States Department of Agriculture, Economic Research Service.

Mallarino, A. 2004. Agronomic and environmental soil testing for phosphorus and threshold levels in soils. Volume 13 Leopold Center Progress Report.

Mannering, J.V., D.R. Griffith, and K.D. Johnson. 1998. Winter Cover Crops – Their Value and Management. Department of Agriculture, Purdue University, Cooperative Extension Service, Publication AY-247.

Marsh, L. 2001. Pumping Water from Remote Locations for Livestock Watering. Virginia Tech Cooperative Extension, Publication Number 442-755.

NCDENR. 2005. Updated Draft Manual of Stormwater Best Management Practices. North Carolina Department of Environment and Natural Resources, Division of Water Quality.

NCEEP. 2004. North Carolina Ecosystem Enhancement Program Annual Report 2003-2004. North Carolina Department of Environment and Natural Resources.

NCSU. 2002. Riparian Buffers and Controlled Drainage to Reduce Agricultural Nonpoint Source Pollution. Departments of Soil Science and Biological and Agricultural Engineering, North

Carolina Agricultural Research Service, North Carolina State University, Raleigh, North Carolina. Technical Bulletin 318, September 2002.

NRCS. 2002a. Natural Resources Conservation Service Conservation Practice Standard Field Border (Feet) Code 386.

NRCS. 2002b. Natural Resources Conservation Service Conservation Practice Standard Constructed Wetland (Feet) Code 656. United States Department of Agriculture, Natural Resources Conservation Service.

NRCS. 2003. Costs Associated With Development and Implementation of Comprehensive Nutrient Management Plans Part I—Nutrient Management, Land Treatment, Manure and Wastewater Handling and Storage, and Recordkeeping. United States Department of Agriculture, Natural Resources Conservation Service.

Olson, K.D. and N.B. Senjem. 2002. Economic Comparison of Incremental Changes in Till Systems in the Minnesota River Basin, University of Minnesota, 2002.

OSUE. 1990. Hairy Vetch as an Ohio Cover Crop. Ohio State University Extension Food, Agricultural and Biological Engineering. Fact Sheet AGF-006-90.

OSUE. 1994. Vegetative Filter Strips: Application, Installation and Maintenance. Ohio State University Extension Food, Agricultural and Biological Engineering. Fact Sheet AEX-467-94.

Otte, Marinus L. and Aisling D. O'Sullivan. 2006. Using Ecosystem Processes In A Constructed Wetland to Treat Mine Wastewater in Ireland. *National University of Ireland at Dublin. In Press (pre-printed with kind permission) in Encyclopedia of Water, Wiley Publishers*

Pastorack, R.A., R.C. Ginn and M.W. Lorenzen. 1981. Evaluation of aeration/circulation as a lake restoration technique. USEPA 600/3-81-014.

Pastorak, R.A., M.W. Lorenzen and T.C. Ginn. 1982. Environmental aspects of artificial aeration and oxygenation of reservoirs: A review of theory, techniques and experiences. Tech. Rept. No. E-82-3, USACE.

Reynolds, T. 2007. Personal communication via telephone dated November 5, 2007. Tim Reynolds, Farm Loan Manager, Williamson County.

Robertson, D.M. 1996. Sources and Transport of Phosphorus in the Western Lake Michigan Drainages. USGS Fact Sheet FS-208-96.

Rouge River. 2001. Planning and Cost Estimating Criteria for Best Management Practices (Update). Rouge River National Wet Weather Demonstration Project, Wayne County, Michigan. April 2001. TR-NPS25.00.

Sample, Trevor. 2007. Comments Concerning Drafts of Homer Lake Implementation Plan. Champaign County Soil and Water Conservation District.

Schueler, T. 1997. Comparative pollutant removal capability of urban BMPs: A reanalysis. *Watershed Protection Techniques* 2(4):515.520.

Skousen, J., A. Rose, G. Geidel, J. Foreman, R. Evans, and W. Hellier. 1998. Handbook of technologies for avoidance and remediation of acid mine drainage. National Mine Land Reclamation Center, Morgantown, WV.

Skousen J. and Paul Ziemkiewicz. 2005. Performance of 116 Passive Treatment Systems for Acid Mine Drainage. Published by ASMR, 3134 Montavesta Rd., Lexington, KY 40502.

Smolen, M.D., D.W. Miller, L.C. Wyatt, J. Lichthardt, and A.L. Lanier. 1988. *Erosion and Sediment Control Planning and Design Manual*. North Carolina Sedimentation Control Commission; North

Carolina Department of Environment, Health, and Natural Resources; and Division of Land Resources, Land Quality Section, Raleigh, NC.

Stauffer, R.E. 1981. Sampling strategies for estimating the magnitude and importance of internal phosphorus supplies in lakes. U.S. EPA 600/3-81-015. Washington, D.C.

Stikkers, Bruce. 2007. Comments Concerning First Draft of Homer Lake Implementation Plan. Champaign County Soil and Water Conservation District.

Sullivan, P. 2003. Overview of Cover Crops and Green Manure. National Sustainable Agriculture Information Service ATTRA Publication #IP024.

Tan, C.S., C.F. Drury, T.Q. Zhang, W.D. Reynolds, J.D. Gaynor. 2003. Wetland-Reservoir System Improves Water Quality and Crop Production, Paper number 032327, 2003 ASAE Annual Meeting.

Tetra Tech. 2002. In-Lake Assessment of Management Alternatives for Cane Creek Reservoir and University Lake. Prepared for the Orange Water and Sewer Authority Carrboro, North Carolina, May 2002.

Tetra Tech. 2006. Lake Maumelle Watershed Management Plan. Prepared for Board of Commissioners Central Arkansas Water, October 2006, draft.

UME. 1996. Tillage Best Management Practices for Corn-Soybean Rotations in the Minnesota River Basin, University of Minnesota Extension, FO-06676.

USDA. 1999. CORE4 Conservation Practices Training Guide The Common Sense Approach to Natural Resource Conservation. United States Department of Agriculture, Natural Resources Conservation Service.

USDA. 2003. Agricultural Phosphorus and Eutrophication Second Edition. United States Department of Agriculture, Agricultural Research Service ARS–149 September 2003.

USDA-ERS. 2005. Commodity Costs and Returns: U.S. and Regional Cost and Return Data. U.S. Department of Agriculture, Economic Research Service.

USEPA. 1992. Stormwater Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 1993. *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters*. EPA 840-B-92-002. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 2002a. Development Document for the Final Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations. EPA-821-R-03-001. December 2002.

USEPA. 2002b. *Onsite Wastewater Treatment Systems Manual.* EPA/625/R-00/008. February 2002.

USEPA. 2002c. Post-Construction Storm Water Management in New Development & Redevelopment. U.S. Environmental Protection Agency, Office of Wastewater Management.

USEPA. 2003. National Management Measures to Control Nonpoint Source Pollution from Agriculture. EPA 841-B-03-004, July 2003.

USEPA. 2007. National Pollution Discharge Elimination System. URL:http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm. (Accessed 12 December, 2007)

VDCR (Virginia Department of Conservation and Recreation). 1995. *Virginia Erosion & Sediment Control Field Manual*. 2nd ed. Virginia Department of Conservation and Recreation, Division of Soil and Water Conservation, Richmond, VA.

Weiss, P.T., J.S. Gulliver, and A.J. Erickson. 2007. Cost and Pollutant Removal of Stormwater Treatment Practices. *Journal of Water Resources Planning and Management*, ASCE, May-June 2007, 133:3 (218).

Welch, E.B. 1992. Ecological effects of wastewater. 2nd Edition. Chapman and Hall, New York, NY.

Wenger, S. 1999. A Review of the Scientific Literature on Riparian Buffer Width, Extent, and Vegetation. for the Office of Public Service & Outreach Institute of Ecology, University of Georgia, Revised Version March 5, 1999.

Wenzel, W. 2002. Pollution Control. Farm Industry News, October 1, 2002.

WIDNR. 2003. Alum Treatments to Control Phosphorus in Lakes. Wisconsin Department of Natural Resources, March 2003.

Winer, R. 2000. National Pollutant Removal Performance Database for Stormwater Treatment Practices, 2nd Edition. Center for Watershed Protection. Ellicott City, MD.

Winner Global Energy & Environmental Services. Environmental Services. URL:http://www.winner-energy.com/enviromental.htm. (Accessed 12 December, 2007)

Woerner, B. and J. Lorimer. 2006. Alternative Treatments to Minimize Water Pollution from Open Animal Feedlots. Department of Ag and Bio Systems Engineering, Iowa State University.

Wossink, A., and D. Osmond. 2001. Cost and Benefits of Best Management Practices to Control Nitrogen in the Piedmont. North Carolina Cooperative Extension Service.

Ziemkiewizz and Brant. 1996. The Casselman River Restoration Project. Proceedings, Eighteenth West Virginia Surface Mine Drainage Task Force Symposium, April 15-16, 1996, Morgantown, WV.