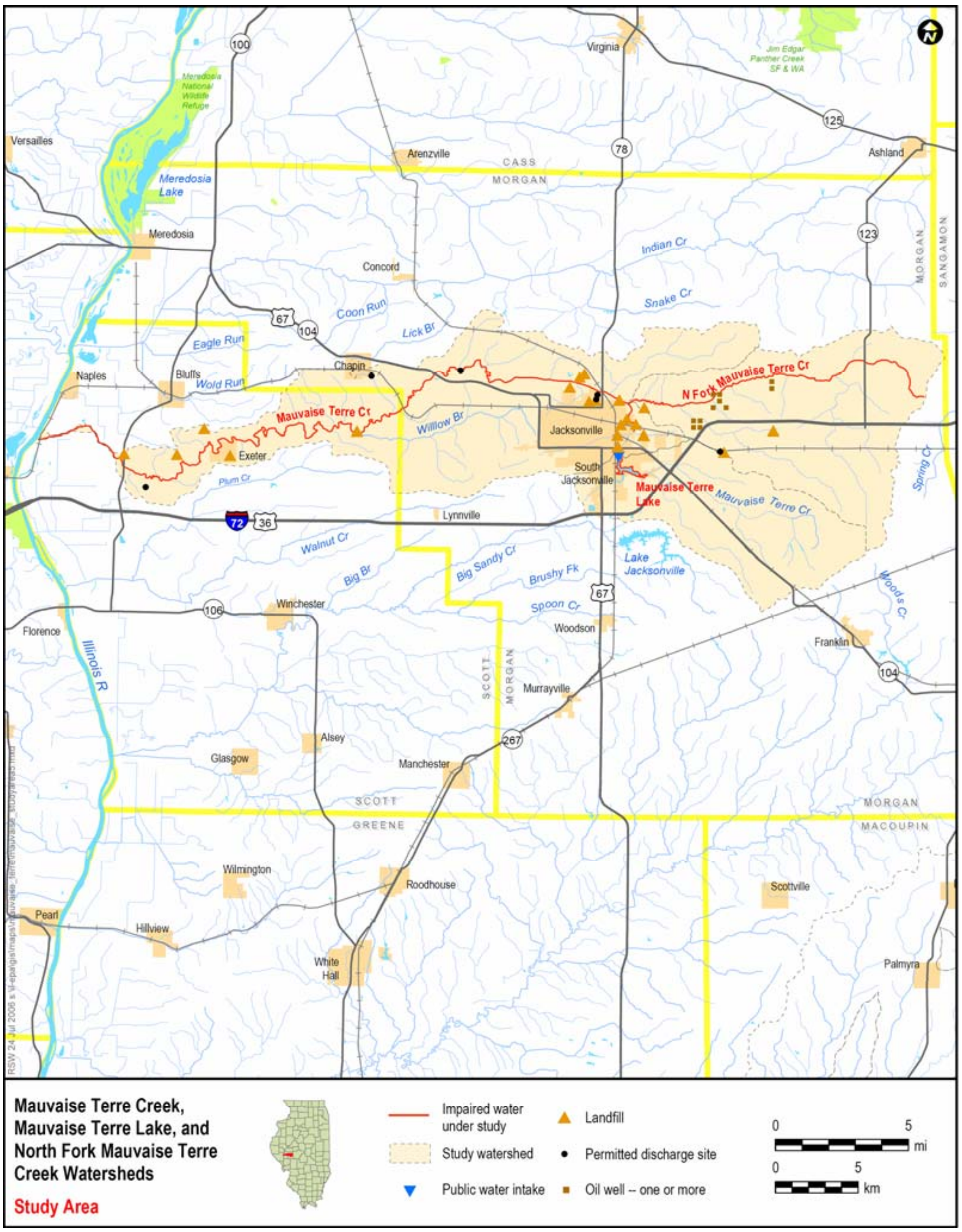
Illinois
Environmental
Protection Agency

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

August 2007

IEPA/BOW/07-008

Mauvaise Terre Creek Watershed TMDL Report



Printed on Recycled Paper

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

REPLY TO THE ATTENTION OF

SEP 19 2006

WW-16J

Marcia T. Willhite, Chief
Bureau of Water
Illinois Environmental Protection Agency
1021 North Grand Ave. East
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 (TMDLs) for the impaired segments in the Mauvaise Terre Creek watershed (IL_SDL, and IL_DD-04), including supporting documentation and follow up information. IEPA's submitted TMDLs address the presence of elevated levels of manganese, nitrate, phosphorus and suspended solids impairing the aquatic life use in the Mauvaise Terre Lake (Segment IL_SDL), and the presence of elevated levels of fecal coliforms impairing the primary contact use in the Mauvaise Terre Creek (Segment IL_DD-04). Based on this review, U.S. EPA has determined that Illinois's TMDLs for manganese, nitrate, total phosphorus and fecal coliforms 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 Illinois's four TMDLs for the impaired segments in the Mauvaise Terre Creek watershed (IL_SDL, and IL_DD-04). The statutory and regulatory requirements, and U.S. EPA's review of Illinois's compliance with each requirement, are described in the enclosed decision document.

We wish to acknowledge Illinois's effort in these submitted TMDLs, and look forward to future TMDL submissions by the State of Illinois. If you have any questions, please contact Mr. Kevin Pierard, Chief of the Watersheds and Wetlands Branch at 312-886-4448.

Sincerely yours,

for Jo Lynn Traub,
Director, Water Division

Enclosure

cc: Bruce Yurdin, IEPA
Jennifer Clarke, IEPA

RECEIVED
SEP 26 2006
Watershed Management Section
BUREAU OF WATER

Mauv - N. FK. Mauv.

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

SEP 06 2007

REPLY TO THE ATTENTION OF:

WW-16J

RECEIVED
SEP 10 2007
Watershed Management Section
BUREAU OF WATER

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

Dear Ms. Willhite: Marcia

The United States Environmental Protection Agency (U.S. EPA) has reviewed the final Total Maximum Daily Load (TMDL) from the Illinois Environmental Protection Agency (IEPA) for the North Fork Mauvaise Terre Creek (IL_DDC) Watershed in Illinois. The TMDL is for manganese and addresses manganese and Total Suspended Solids (TSS). The designated use of aquatic life is impaired.

Based on this review, U.S. EPA has determined that Illinois' TMDL for manganese meets 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 one TMDL for two impairments for the North Fork Mauvaise Terre Creek Watershed. 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 Mr. Kevin Pierard, Chief of the Watersheds and Wetlands Branch at 312-886-4448.

Sincerely yours,

Cheryl L. Newton

Cheryl L. Newton
Acting Director, Water Division

Enclosure

cc: Jennifer Clarke, IEPA

TABLE OF CONTENTS

STAGE 3 FINAL APPROVED TMDL, North Fork Mauvaise Terre Creek

Final Stage 1 Progress Report

Prepared for Illinois Environmental Protection Agency

April 2005

Mauvaise Terre Creek Watershed

Mauvaise Terre Creek (ILDD04)
Mauvaise Terre Lake (SDL), North Fork Mauvaise Terre Creek (DDC), Mauvaise Terre Creek (DD04)

Limno-Tech, Inc.
www.limno.com

This page is blank to facilitate double sided printing.

First Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

August 2004

Mauvaise Terre Creek Watershed:

Mauvaise Terre Creek (ILDD04)
Mauvaise Terre Lake (SDL), North Fork Mauvaise Terre Creek
(DDC), Mauvaise Terre Creek (DD04)

Limno-Tech, Inc.
www.limno.com

This page is blank to facilitate double sided printing.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

This is the first in a series of quarterly status reports documenting work completed on the Mauvaise Terre Creek project watershed. The objective of this report is to provide a summary of Stage 1 work that will ultimately be used to support Total Maximum Daily Load (TMDL) development in the project watershed.

Background

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the draft 2004 303(d) list (IEPA, 2004a), which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be completed for each pollutant listed for an impaired waterbody. TMDLs are prepared by the States and submitted to the U.S. EPA. In developing the TMDL, a determination is made of the greatest amount of a given pollutant that a waterbody can receive without exceeding water quality standards and designated uses, considering all known and potential sources. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation.

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. The results of this review are presented in this first quarterly status report.

Next, the Illinois EPA, with assistance from consultants, will recommend an approach for the TMDL, including an assessment of whether additional data are needed to develop a defensible TMDL.

Finally, Illinois EPA and consultants will conduct the TMDLs and will work with stakeholders to implement the necessary controls to improve water quality in the impaired waterbodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) would be strictly voluntary.

Methods

The effort completed in the first quarter included: 1) a site visit and collection of information to complete a detailed watershed characterization; 2) development of a water quality database and data analyses; and 3) synthesis of the watershed characterization information and the data analysis results to confirm the sufficiency of the data to support both the listing decision and the sources of impairment that are included on the draft 2004 303(d) list of impaired waterbodies.

This evaluation focuses on the following waterbodies and associated sources of impairment:

- Mauvaise Terre Lake: phosphorus, nitrate, manganese
- North Fork Mauvaise Terre Creek: low dissolved oxygen, manganese
- Mauvaise Terre Creek (below Town Brook): fecal coliform bacteria

Results

The available data, though in some cases very limited, support the listed impairments of the three waterbodies in the Mauvaise Terre watershed. Potential sources of phosphorus and nitrate to Mauvaise Terre Lake include agricultural sources, existing sediments, recreation activities, and possibly failing private sewage disposal systems. The primary source of manganese to both Mauvaise Terre Lake and North Fork Mauvaise Terre Creek may be background sources due to naturally high concentrations in area soils; in-place lake sediments may also contribute. The primary potential source of low dissolved oxygen in North Fork Mauvaise Terre Creek is agricultural runoff. Potential sources of fecal coliform bacteria to Mauvaise Terre Creek include livestock operations, agricultural runoff, and sewage disposal, including municipal sewage, CSO discharges, and private disposal systems.

INTRODUCTION

This Stage 1 report describes initial activities related to the development of TMDLs for impaired waterbodies in the Mauvaise Terre Creek watershed. Stage 1 efforts included watershed characterization activities and data analyses, to confirm the causes and sources of impairments in the watershed. This section provides some background information on the TMDL process, and Illinois assessment and listing procedures. The specific impairments in the Mauvaise Terre Creek watershed are also described.

TMDL Process

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is called the 303(d) list. The State of Illinois recently issued the draft 2004 303(d) list (IEPA 2004a), which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (USEPA, 1991).

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. The results of this review are presented in this first quarterly status report.

Next, the Illinois EPA, with assistance from consultants, will recommend an approach for the TMDL, including an assessment of whether additional data are needed to develop a defensible TMDL.

Finally, Illinois EPA and consultants will conduct the TMDLs and will work with stakeholders to implement the necessary controls to improve water quality in the impaired waterbodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) would be strictly voluntary.

Illinois Assessment and Listing Procedures

Water quality assessments in Illinois are based on a combination of chemical (water, sediment and fish tissue), physical (habitat and flow discharge), and biological (macroinvertebrate and fish) data. Illinois EPA conducts its assessment of water bodies using a set of five generic designated use categories: public water supply, aquatic life, primary contact (swimming), secondary contact (recreation), and fish consumption (IEPA, 2004b). For each water body, and for each designated use applicable to the water body, Illinois EPA's assessment concludes one of three possible "use-support" levels:

- Fully supporting (the water body attains the designated use);
- Partially supporting (the water body attains the designated use at a reduced level); or
- Not supporting (the water body does not attain the designated use).

All water bodies assessed as having partial or nonsupport attainment for any designated use are identified as "impaired." Waters identified as impaired based on biological (macroinvertebrate, macrophyte, algal and fish), chemical (water, sediment and fish tissue), and/or physical (habitat and flow discharge) monitoring data are placed on the 303(d) list. Potential causes and sources of impairment are also identified for impaired waters.

Following the U.S. EPA regulations at 40 CFR Part 130.7(b)(4), the Illinois Section 303(d) list was prioritized on a watershed basis. Illinois EPA watershed boundaries are based on the USGS ten-digit hydrologic units, to provide the state with the ability to address watershed issues at a manageable level and document improvements to a watershed's health (IEPA, 2004a).

List of Identified Watershed Impairments

The impaired waterbody segments included in the project watershed are listed in Table 1 below, along with the cause of the listing. These impairments were identified in the draft 2004 303(d) list (IEPA, 2004a). Those impairments that are the focus of this report are shown in bold font in Table 1. Note that unless otherwise noted, for purposes of this report, "Mauvaise Terre Creek" refers to the stream section below Town Brook (below both Mauvaise Terre Lake and North Fork Mauvaise Terre Creek), while "Mauvaise Terre Creek" refers to waters upstream of Mauvaise Terre Lake. On the draft 2004 303(d) list, Mauvaise Terre Lake (SDL) was listed as being in partial support of the overall use, aquatic life, and public water supply designated uses, and in nonsupport of primary contact (swimming) and secondary contact (recreation) designated uses. North Fork Mauvaise Terre Creek (DDC) was listed as being in partial support of the aquatic life designated use. Mauvaise Terre Creek (DD04) was identified as being full support of the following designated uses: aquatic life and fish consumption. Mauvaise Terre Creek is in nonsupport of the primary contact recreation (swimming) designated use.

Table 1. Impaired waterbodies in the project watershed

Waterbody segment	Waterbody name	Size (miles/acres)	Year Listed	Listed for[1]
SDL	Mauvaise Terre Lake	172	1994	**Manganese, Phosphorus, Nitrate**, total suspended solids, excess algal growth
DDC	N. Fork Mauvaise Terre Creek	14.03	2004	**Manganese, low dissolved oxygen**, total nitrogen, total suspended solids
DD 04	Mauvaise Terre Creek	36.55	1998	**Fecal coliform**

[1]Bold font indicates cause will be addressed in this report. Other potential causes of impairment listed for these waterbodies do not have numeric Water Quality Standards and are not subject to TMDL development at this time.

The remaining sections of this report include:

- Watershed characterization: *discussion of methods for information compilation and a detailed characterization of the watershed*
- Database development and data analysis: *discussion of data sources and methods of data analysis*
- Confirmation of causes and sources of impairment: *assessment of sufficiency of data to support the listing and identification of potential sources contributing to the impairment*
- Conclusions

WATERSHED CHARACTERIZATION

The purpose of watershed characterization was to obtain information describing the watershed to support the identification of sources contributing to manganese and total phosphorus impairments. Watershed characterization activities were focused on gaining an understanding of key features of the watershed, including geology and soils, climate, land cover and uses, and urbanization and growth. Active watershed organizations were also identified. The methods used to characterize the watershed, and the findings are described below.

Methods

Watershed characterization was conducted by compiling and analyzing data and information from various sources. Where available, data were obtained in electronic or Geographic Information System (GIS) format to facilitate mapping and analysis. To develop a better understanding of land management practices in the watershed, calls were placed to local agencies to obtain information on crops, pesticide and fertilizer application practices, tillage practices and best management practices employed. A site visit was conducted on June 28, 2004.

After the watershed boundaries for the impaired waterbodies (Table 1) in the project watershed were delineated in GIS using topographic and stream network (hydrography) information, other relevant information was obtained. Information obtained and processed for mapping and analysis purposes included:

- current land cover,
- current cropland,
- State and Federal lands,
- soils,
- point source dischargers,
- public water supply intakes,
- roads,
- railroads,
- state, county and municipal boundaries,
- landfills,
- oil and gas wells,
- coal mines,
- dams,
- data collection locations, and
- location of 303(d) listed lakes and streams.

To better describe the watershed and obtain information related to active local watershed groups, data collection efforts, agricultural practices, and septic systems, calls were placed to county-level officials at the Natural Resources Conservation District (NRCS), Soil and Water Conservation District, (SWCD), Agricultural Extension Office, and Health Department. A list of data sources and calls made is included in Appendix A.

Other information compiled for this task related to climate, population growth and urbanization. These data were obtained from State and Federal sources, including the National Weather Service, U.S. Census Bureau, and the State of Illinois.

Mauvaise Terre Creek Watershed Characterization

The Mauvaise Terre Creek watershed is located in Morgan and Scott counties in west-central Illinois. The three waterbodies of concern are Mauvaise Terre Lake (SDL), North Fork Mauvaise Terre Creek (DDC), and Mauvaise Terre Creek downstream of Town Brook (DD04). Mauvaise Terre Lake and North Fork Mauvaise Terre Creek lie in Morgan County, while Mauvaise Terre Creek flows through both Morgan and Scott Counties.

Mauvaise Terre Lake was constructed by damming the upper part of Mauvaise Terre Creek (above the North Fork). The lake has a surface area of 172 acres and serves as a source of drinking water for Jacksonville and several surrounding communities. Most of the water supply, however, comes from wells located 26 miles from the Jacksonville (City of Jacksonville, 2004). The combined drainage area of the three impaired waterbodies is approximately 164 square miles. Mauvaise Terre Lake is approximately "L" shaped, with an arm extending west from the inlet, and a second arm extending north to the dam. Mauvaise Terre Lake is connected near the corner of the "L" to a smaller lake called Morgan Lake.

Figure 1 shows a map of the watershed, and includes some key features such as waterways, impaired waterbodies, public water intakes and other key features. The map also shows the locations of point source discharges that have a permit to discharge under the National Permit Discharge Elimination System (NPDES).

The following sections provide a broad overview of the characteristics of the Mauvaise Terre Creek watershed.

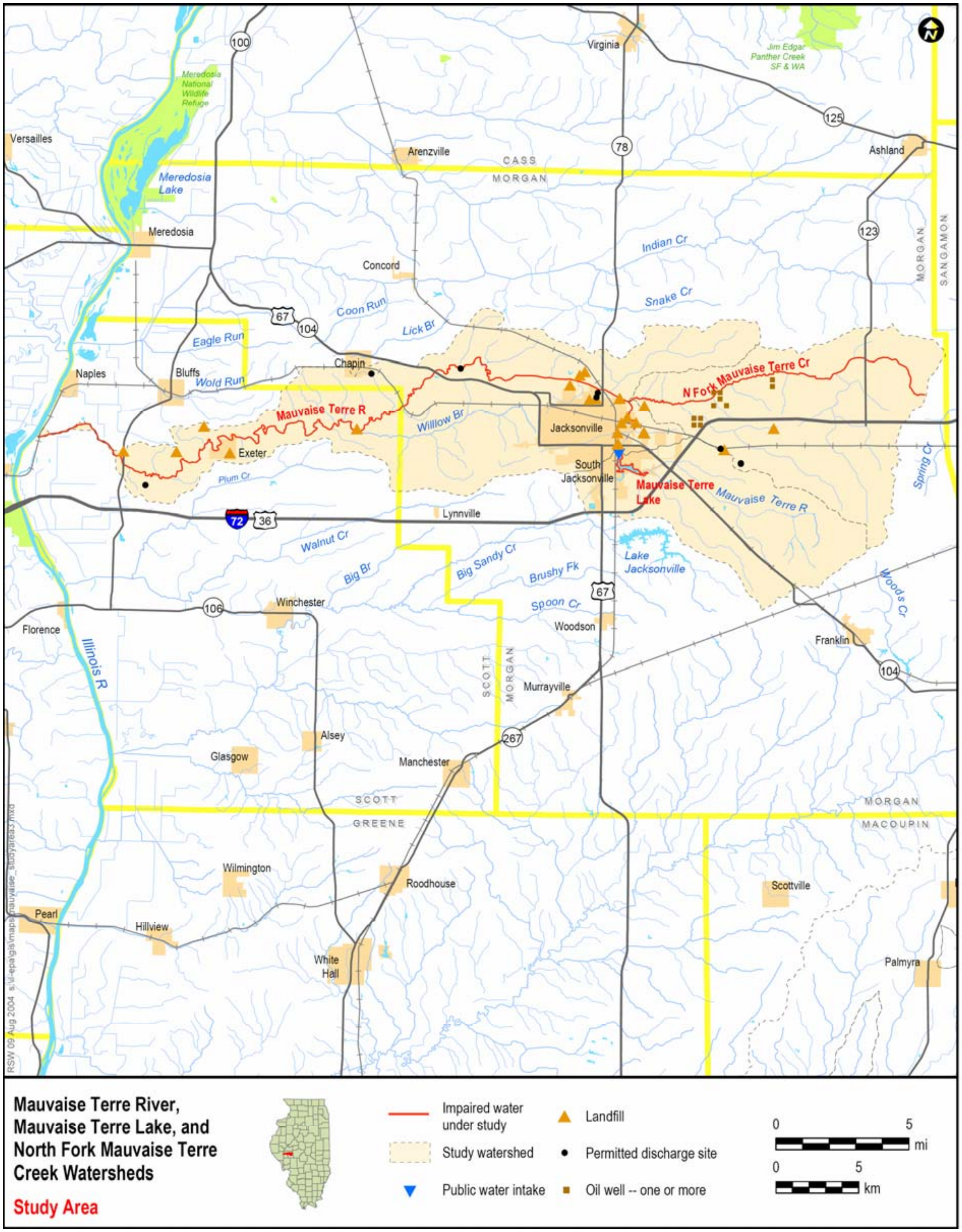


Figure 1. Point source dischargers, impaired waterbody segments, and other watershed characteristics

Geology and Soils

Information on soils and topography was compiled in order to understand whether the soils are a potential source of manganese. Figure 2 shows the major soil associations in the Mauvaise Terre Creek watershed. These are also listed in Table 2.

Of primary concern for this evaluation are the soils in the North Fork Mauvaise Terre Creek and Mauvaise Terre Lake watersheds, since these waters are listed for manganese. As discussed below, many of the soils in the Mauvaise Terre watershed contain manganese and iron oxide concretions or accumulations and are also somewhat acidic. This could result in manganese and iron moving into solution and being transported in base flow and/or runoff.

The official soil series descriptions (Soil Survey Staff, 2004) describe the Ipava series as consisting of "very deep, somewhat poorly drained, moderately slowly permeable soils formed in loess on uplands", with slopes ranging from 0 to 5 percent. The Sable series consists of "very deep, poorly drained, moderately permeable soils formed in loess on nearly level broad summits of moraines and stream terraces. Slope ranges from 0 to 2 percent." The Sable series also has "very weakly cemented iron and manganese concretions throughout" in five of the seven soil horizons (8-47 inches deep) (Soil Survey Staff, 2004). Upper soil horizons (to 31 inches for Ipava and 23 inches for Sable) in these two series are described as slightly to moderately acidic. The Tama series consists of "deep, well and moderately well drained, moderately permeable soils formed in loess on upland and high stream benches." Slope ranges from 0 to 20 percent, and these soils are characterized as strongly acid from zero to 45 inches deep (Soil Survey Staff, 2004).

The Rozetta series consists of "very deep, well drained soils formed in loess on uplands. Permeability is moderate. Slope ranges from 0 to 25 percent." This series is described as moderate to strongly acid (0 to 50 inches deep), with some horizons (21-29 inches deep) having "masses of iron and manganese accumulation" (Soil Survey Staff, 2004). The Keomah series consists of "very deep, somewhat poorly drained soils formed in loess on uplands and high stream terraces. They are moderately slowly to slowly permeable. Slopes range from 0 to 5 percent", and most horizons (0 to 47 inches deep) are characterized as moderately to strongly acid. Four of the nine soil horizons in this series are also described as having "fine iron and manganese concretions" (Soil Survey Staff, 2004). The Hickory series consists of "very deep, well drained, moderately permeable soils on dissected till plains. They formed in till that can be capped with up to 20 inches of loess. Slope ranges from 5 to 70 percent." The upper horizons (up to 58 inches deep) are characterized as strongly to very strongly acid, and have "fine rounded black iron-manganese nodules" at 26-58 inches (Soil Survey Staff, 2004).

The upper part of the watershed (eastern half) is relatively flat, while west of Jacksonville, the topography is more rolling. The high point in the watershed is located about 0.5 mile west of Jacksonville, with an elevation of approximately 720 feet above mean sea level. The watershed drains to the Illinois Creek, with an elevation at the mouth of approximately 425 ft.

Table 2. Major Soil Associations in the Watershed

Soil Map Units (MUID)	Acres	Percentage
North Fork Mauvaise Terre Creek Watershed		
Ipava-Sable-Tama (Il003)	24,178	76.9%
Rozetta-Keomah-Hickory (Il036)	7,244	23.1%
Mauvaise Terre Lake Watershed		
Ipava-Sable-Tama (Il003)	16,513	75.1%
Rozetta-Keomah-Hickory (Il036)	5,479	24.9%
Mauvaise Terre Creek Watershed		
Ipava-Sable-Tama (Il003)	65,950	62.8%
Worthen-Littleton-Elburn (Il013)	259	0.2%
Beaucoup-Lawson-Darwin (Il029)	91	0.1%
Rozetta-Fayette-Hickory (Il034)	2,015	1.9%
Rozetta-Keomah-Hickory (Il036)	34,172	32.6%
Plainfield-Bloomfield-Sparta (Il056)	64	0.1%
Wakeland-Birds-Belknap (Il068)	1,818	1.7%
Ipava-Virden-Herrick (Il072)	592	0.6%

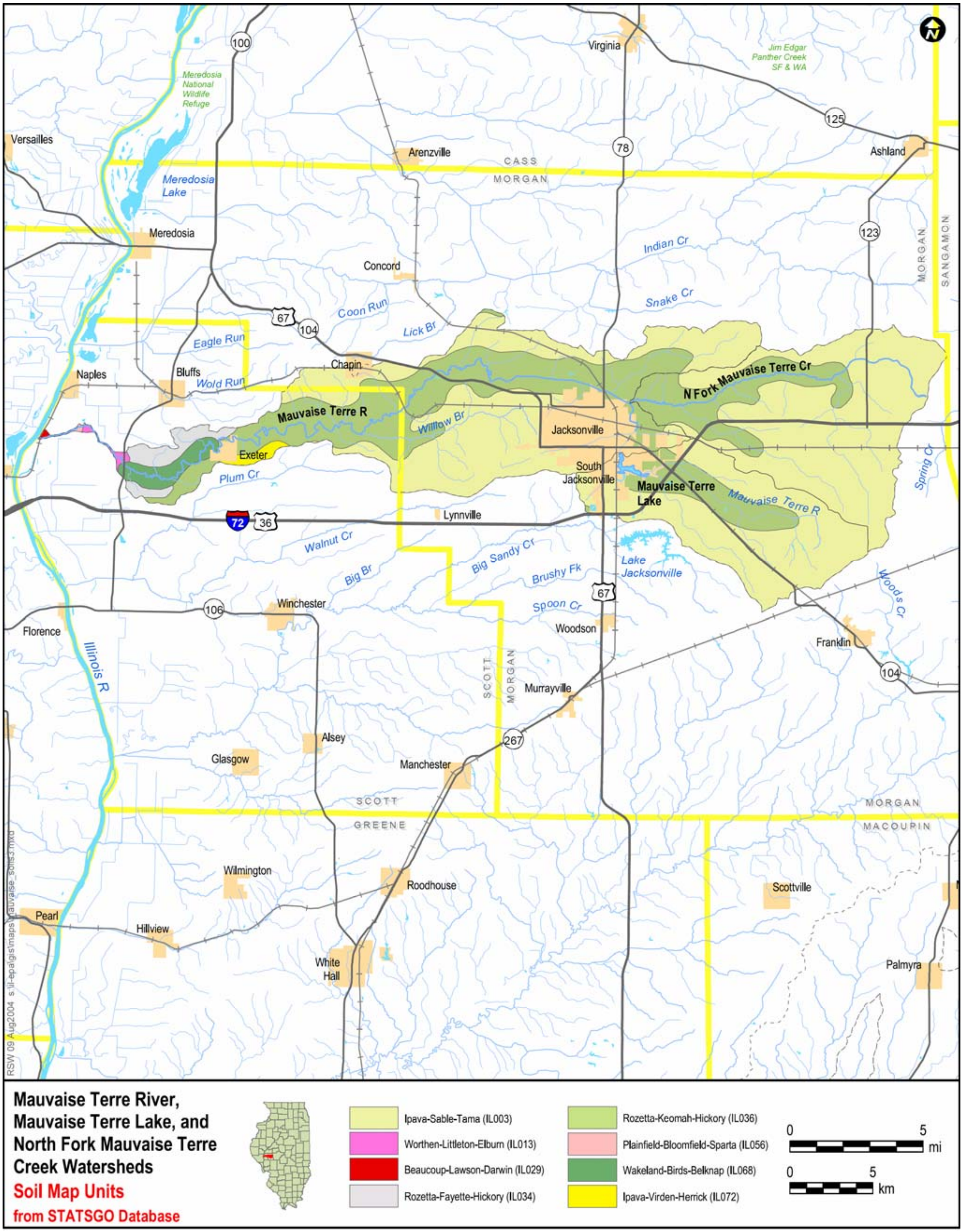


Figure 2. Major soil associations in the Mauvaise Terre Watershed

Climate

The Mauvaise Terre Creek watershed has a temperate climate and has cold winters and hot summers. The National Weather Service (NWS) maintains a weather station at Jacksonville through the Cooperative Observer Program (COOP). Climate data are archived at the National Climatic Data Center (NCDC) and summaries are available on the web page of the Illinois State Climatologist Office (Illinois State Water Survey, 2004). The average long-term precipitation (1971-2000) recorded at Jacksonville (Station 114442) is 38.47 inches. The maximum annual precipitation is 60.05 inches (1993) and the minimum annual precipitation is 21.64 inches (1901). On average, there are 106.5 days with precipitation of at least 0.01 inches and 9.8 days with precipitation greater than 1 inch. Average snowfall is approximately 23.3 inches per year.

Average maximum and minimum temperatures recorded at Jacksonville are 34.4 ^{o}F and 15.0 ^{o}F, in January and 87.0 ^{o}F and 62.7 ^{o}F in July (1971-2000 data). The average temperature recorded in January is 24.7 ^{o}F and the average temperature recorded in July is 74.9 ^{o}F.

Land Cover and Use

Runoff from the land surface contributes pollutants to nearby receiving waters. In order to understand sources contributing to the lake impairments, it was necessary to characterize land cover in the watershed. Land cover and land uses in the watersheds are shown in Figure 3, and listed in Tables 3 through 5. The predominant land use in the watershed is agriculture, shown in yellow on the map. Approximately 65.8% of the Mauvaise Terre Creek watershed (exclusive of the Mauvaise Terre Lake and North Fork Mauvaise Terre Creek watersheds) is cropland, while croplands make up 84.0% of the Mauvaise Terre Lake watershed and 90.8% of the North Fork Mauvaise Terre Creek watershed. Crops are primarily a corn-soy rotation, with a small amount of wheat (University of Illinois Agricultural Extension, 2004). Wheat is primarily grown for livestock operations, either for straw or manure application. Corn represents 55 to 59% of the total cropland.

According to estimates prepared by the Illinois Department of Agriculture (2002), in Morgan County approximately 57% of the corn croplands and 5% of the soybean crops are tilled using conventional tillage methods that leave little or no residue on the surface (Table 6). Approximately 24% of the corn and 16% of the soybeans are tilled by reduced tillage methods, which can reduce soil loss in comparison to conventional methods by 30%. The remaining 20% of corn croplands and 79% of soybean crops are planted either using mulch-till methods, in which at least 30% residue of the previous year’s crop remains on the land after planting the new crop, or without any tillage prior to planting, a process that can reduce soil loss by up to 75% (IDOA, 2002). Mulch-till and no-till are considered conservations tillage systems that can significantly reduce soil loss. Local agency staff (NRCS, Agricultural Extension) confirmed that these estimates are reasonable. The Morgan County Agricultural Extension suggested that the percentages for conventional till might be a little high, and a lot of farmers are going to “strip till” methods.

Scott County tillage practices are presented in Table 7. Approximately 18% of the corn crops and 1% of the soybean crops in the county are tilled using conventional tillage, 36% of the corn and 5% of the soybeans are tilled by reduced tillage methods, and 46% of the corn crops and 94% of the soybeans are planted using either mulch-till (22% of corn and 36% of soybeans) or no-till (24% of corn and 58% of soybeans) methods (IDOA, 2002). All of the small grain croplands are planted using mulch-till or no-till. Local agency staff (NRCS, Agricultural Extension) confirmed that these estimates are reasonable.

Management practices within the watershed vary by individual producer, but include things like buffer strips (Morgan County Agricultural Extension, personal communication). Many producers are taking advantage of cost-share programs through the NRCS. Buffer strips and streambank stabilization programs were observed during the June 28, 2004 site visit. A sign was also noted in the eastern part of the watershed, touting a nutrient management project. NRCS staff have indicated that in the western part of the watershed, downstream of the lake, flooding and erosion are a concern to producers, many of whom are experiencing lower yields due to topsoil loss.

The yellow areas on Figure 3 indicating agricultural land use include livestock operations. There are livestock operations throughout the watershed. Livestock are primarily cattle, with some hog lots. There may be a few landowners with goats, sheep, or horses, but cattle and hogs dominate (NRCS, personal communication). During the June 28, 2004 site visit, cattle and llamas were observed in the lower Mauvaise Terre Creek watershed, while horses (and evidence of horses being ridden on local roads) were observed in the Mauvaise Terre Lake watershed. The Morgan County NRCS is getting involved in grazing management and prescribed grazing, working on programs to limit access to creeks and streams, and improve the quality of pastures, which also reduces runoff. Many beef producers are going to management-intensive grazing, trying to distribute manure better, and use buffer strips. Morgan County has had several applications for cost-share funds for prescribed grazing; there have been more applications than available funds. The producers are interested in doing something about the problem (Morgan County NRCS, personal communication).

The green areas on Figure 3 show forested lands (ranging from approximately 2.0% of the North Fork Mauvaise Terre Creek watershed to approximately 12.8% of the lower Mauvaise Terre Creek watershed), which are both upland and floodplain. Also shown on the map (in red) are areas of low/medium and high density development. These areas indicate the locations of the towns and residential communities in the watershed. Jacksonville is the major urban area; the City lies entirely within the Mauvaise Terre Creek watershed. The City of South Jacksonville is also within the watershed. Other towns in the watershed include Exeter and Oxville. A portion of the town of Chapin also lies in the watershed.

The Morgan County Health Department indicated that the Jacksonville area has sewers, and perhaps a small area northwest of Jacksonville known as Marnico Village, but the rest of the watershed is on private disposal systems. Local maps note a sewage disposal location near Marnico Village; during the site visit on June 28, 2004, a pond was observed at this location. This pond appeared to be entirely covered by a mat of algae. The Health Department estimated that in the area near Mauvaise Terre Creek, 85% of homes are on private sewage disposal septic systems. They are not aware of surface discharging systems in the area. The Morgan County Health Department permits and inspects all septic systems and is unaware of any failing systems in the watershed.

There are several point source discharges in the watershed, including sewage disposal for the City of Jacksonville, food production facilities (ACH Food Company and Nestle), and several oil wells near North Fork Mauvaise Terre Creek. Jacksonville also has a combined sewer system and permitted combined sewer overflows (CSOs).

Interstate 72 passes through the watershed, crossing Mauvaise Terre Creek upstream of the lake. Other major roads include U.S. Highway 67 and State Route 104. Most of the other roads outside Jacksonville and South Jacksonville are unpaved rural roads.

Parkland and other recreational uses are in proximity to Mauvaise Terre Lake. There is a municipal park surrounding Morgan Lake, which is connected to Mauvaise Terre Lake. Parklands extend along the southwestern corner of Mauvaise Terre Lake. In addition to picnic areas, playgrounds, and a public swimming pool, the park includes a municipal golf course. The park drains to Morgan and Mauvaise Terre Lakes. There is also a large private golf course, the Jacksonville Country Club, along the northeast side of the "L" formed by the two arms of the lake. The country club is in close proximity to the lake, and culverts were observed draining to the lake from the golf course.

Table 3. Land Cover Distribution, Mauvaise Terre Lake Watershed

Land Cover Type	Area (Acres)	Percent of Total
Agriculture[1]	18,468	84.0%
Urban	1,395	6.3%
Grassland	1,145	5.2%
Forest	398	1.8%
Wetland	342	1.6%
Water	216	1.0%
Barren	15	0.1%

Source: Illinois Department of Agriculture, 1999-2000 data (http://www.agr.state.il.us/gis/)
[1] Agriculture is primarily comprised of corn (56%) and soybeans (43%), with lesser amount of winter wheat and other small grains.

Table 4. Land Cover Distribution, North Fork Mauvaise Terre Creek Watershed

Land Cover Type	Area (Acres)	Percent of Total
Agriculture[1]	28,520	90.8%
Grassland	1,744	5.6%
Urban	461	1.5%
Forest	418	1.3%
Wetland	226	0.7%
Water	34	0.1%
Barren	9	0.0%

Source: Illinois Department of Agriculture, 1999-2000 data (http://www.agr.state.il.us/gis/)
[1] Agriculture is primarily comprised of corn (59%) and soybeans (40%), with lesser amount of winter wheat and other small grains.

Table 5. Land Cover Distribution, Entire Mauvaise Terre Creek Watershed

Land Cover Type	Area (Acres)	Percent of Total
Agriculture[1]	80,879	77.1%
Grassland	8,158	7.8%
Urban	7,192	6.9%
Forest	5,558	5.3%
Wetland	2,548	2.4%
Water	393	0.4%
Barren	130	0.1%

Source: Illinois Department of Agriculture, 1999-2000 data (http://www.agr.state.il.us/gis/)
[1] Agriculture is primarily comprised of corn (57%) and soybeans (42%), with lesser amount of winter wheat and other small grains.

Table 6. Percent of Morgan County fields, by crop, with indicated tillage system

	Tillage system			
	Conventional Till[1]	Reduced-Till[2]	Mulch-Till[3]	No-Till[3]
Corn	57	24	3	17
Soybean	5	16	38	41
Small grain	0	0	21	79

Source: Illinois Department of Agriculture (2002)
[1] Residue level 0 – 15%
[2] Residue level 16-30%
[3] Residue level > 30%

Table 7. Percent of Scott County fields, by crop, with indicated tillage system

	Tillage system			
	Conventional Till[1]	Reduced-Till[2]	Mulch-Till[3]	No-Till[3]
Corn	18	36	22	24
Soybean	1	5	36	58
Small grain	0	0	30	70

Source: Illinois Department of Agriculture (2002)
[1] Residue level 0 – 15%
[2] Residue level 16-30%
[3] Residue level > 30%

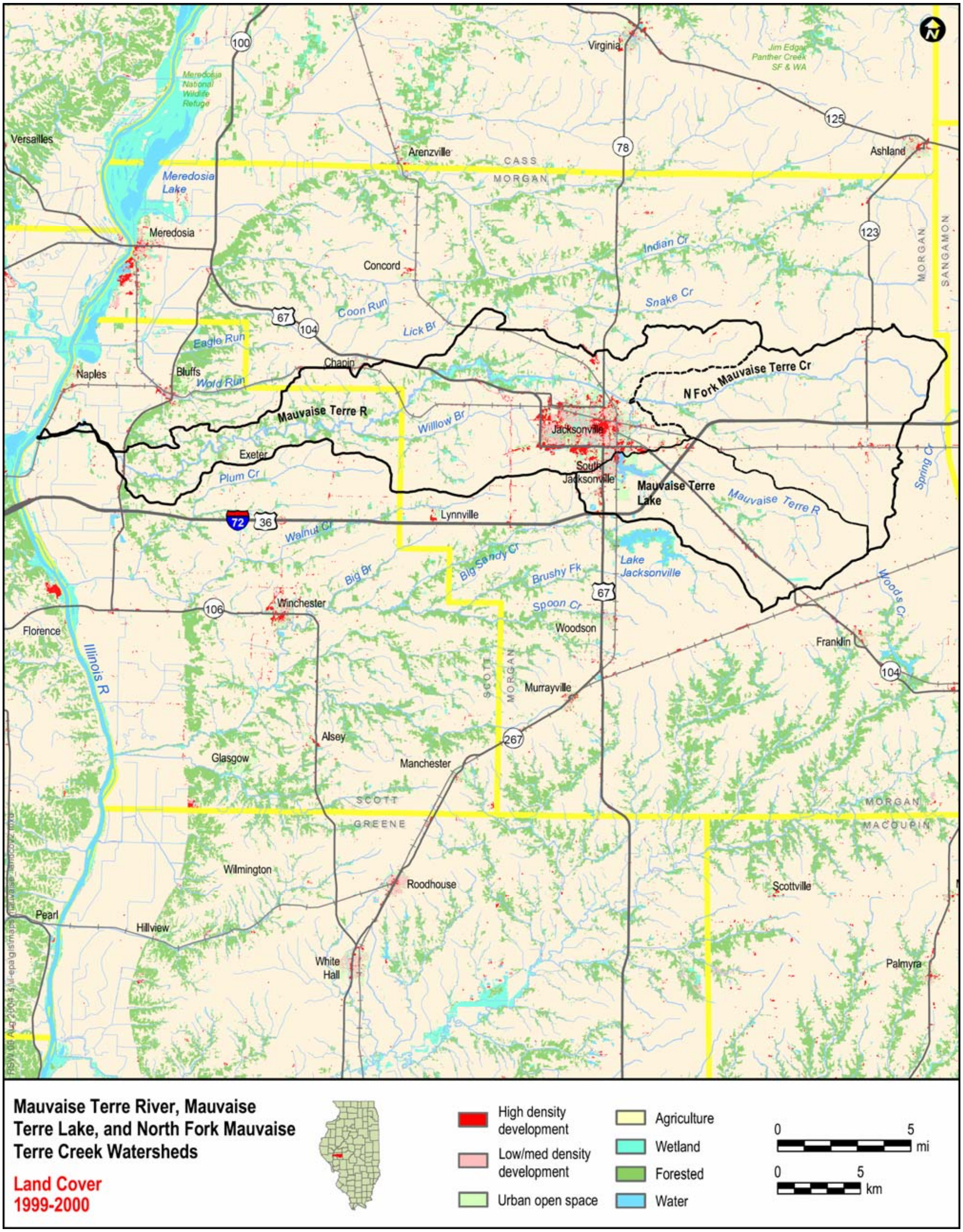


Figure 3. Current land cover in the project watershed

Urbanization and Growth

Jacksonville is the major urban area within the watershed; the City lies entirely within the Mauvaise Terre Creek watershed. The City of South Jacksonville is also within the watershed. Small towns in the watershed include Exeter and Oxville. A portion of the town of Chapin also lies in the watershed.

The current population of Morgan County, which contains the Mauvaise Terre Lake and North Fork Mauvaise Terre Creek watersheds, as well as part of the Mauvaise Terre Creek watershed, is approximately 36,616 (U.S. Census Bureau, 2000). Illinois Population Trends (State of Illinois, 1997) predict an increase in population of approximately 7.5% between 2000 and 2010 for Morgan County. The current population of Scott County, which includes the lower portion of the Mauvaise Terre Creek watershed, is approximately 5,537 (U.S. Census Bureau, 2000). Illinois Population Trends (State of Illinois, 1997) predict an increase in population for Scott County of approximately 8.7% between 2000 and 2010.

Hydrology

There is one USGS flow gage in the watershed. This gage is on the North Fork Mauvaise Terre Creek near Jacksonville, IL (USGS gage number 05586000). The drainage area upstream of this gage is 29.1 square miles. Data available at this location include water quality data (collected between October 1974 and February 1981), daily flow measurements (collected between December 1949 and September 1975) and peak flow measurements. Only peak annual streamflow measurements are currently being reported at this location.

Watershed Organizations

Local watershed organizations with an interest in watershed management are important for successful implementation of TMDLs. The Illinois Watershed Management Clearinghouse indicates that there may be a local watershed group for the Mauvaise Terre watershed. However, an attempt at calling the contact person listed was unsuccessful.

DATABASE DEVELOPMENT AND ANALYSIS

A water quality database was developed and the data were analyzed to confirm the sufficiency of the data to support both the listing decision and the sources of impairment that are included on the draft 2004 303(d) list.

Data Sources and Methods

All readily available existing data to describe water quality in the impaired lakes were obtained. Sources contacted for data include the Illinois Environmental Protection Agency (State and Regional offices) and the United States Geologic Survey (USGS). All available and relevant data were then compiled in electronic format along with sample location and collection information, in a project database. A list of data sources is included in Appendix A.

Summaries of readily available water quality data are presented for Mauvaise Terre Lake in Table 8 below, for North Fork Mauvaise Terre Creek in Table 9, and for Mauvaise Terre Creek in Table 10. Sampling station locations are shown in Figure 4.

Some data are also available for parameters that may be related to the sources if impairment, including dissolved phosphorus, chlorophyll *a*, and total suspended solids.

The water quality data were analyzed to confirm the cause of impairment for each waterbody and, in combination with the watershed characterization data, an assessment was made to confirm the sufficiency of the data to support the listing decision and the sources of impairment that are included on the draft 2004 303(d) list. Analysis methods included computing summary statistics, evaluating trends and correlations, and using graphical analysis to discern relationships in the data.

Table 8. Water quality data summary for Mauvaise Terre Lake (SDL)

Sample location and parameter	Criterion	Period of record and number of data points	Mean (mg/l)	Maximum (mg/l)	Minimum (mg/l)
Mauvaise Terre Lake, Near Dam Midway Between Spillway (Station SDL-1)					
Manganese	150 ug/l	April-Oct 2002 5 samples	183	420	67
Phosphorus	0.05 mg/l	1990-2002 47 samples	0.162	0.344	0.015
Nitrate	10 mg/l	1990-2002 47 samples	3.91	12	<0.01
Mauvaise Terre Lake, 800 yd E. of Ramp N. of Docks (Station SDL-2)					
Phosphorus	0.05 mg/l	1992 & 2002 10 samples	0.202	0.284	0.087
Nitrate	10 mg/l	1992 & 2002 10 samples	3.93	10	<0.01
Mauvaise Terre Lake, Mid Lake South of Red Brick House (Station SDL-3)					
Phosphorus	0.05 mg/l	1992 & 2002 10 samples	0.248	0.370	0.118
Nitrate	10 mg/l	1992 & 2002 10 samples	4.72	13	<0.01

*note that data are for nitrate + nitrite, but water quality standard and listing are for nitrate

Table 9. Water quality data summary for North Fork Mauvaise Terre Creek (DDC)

Sample location and parameter	Criterion	Period of record and number of data points	Mean (mg/l)	Maximum (mg/l)	Minimum (mg/l)
North Fork Mauvaise Terre Creek, 0.5 M NE of Jacksonville (Station DDC11)					
Dissolved oxygen	5 mg/l	June 2001; 1 sample	7.8	7.8	7.8
Manganese	150 ug/l	June 2001; 1 sample	78	78	78
North Fork Mauvaise Terre Creek, 3 Mi E of Jacksonville (Station DDC12)					
Dissolved oxygen	5 mg/l	July 2001; 2 samples	7.68	13.3	2.05
Manganese	150 ug/l	July-Oct. 2001; 2 samples	1,205	2,300	110

Table 10. Water quality data summary for Mauvaise Terre Creek (DD04)

Sample location and parameter	Criterion (cfu/100 ml)	Period of record and number of data points	Mean (mg/l)	Maximum (mg/l)	Minimum (mg/l)
Mauvaise Terre Creek, 1.5 mi NE of Merritt (Station DD04)					
Fecal coliform	400 cfu/100ml in < 10% of samples Geomean < 200 cfu/100 ml	1990-2004, 97 samples	5,388	240,000	<50

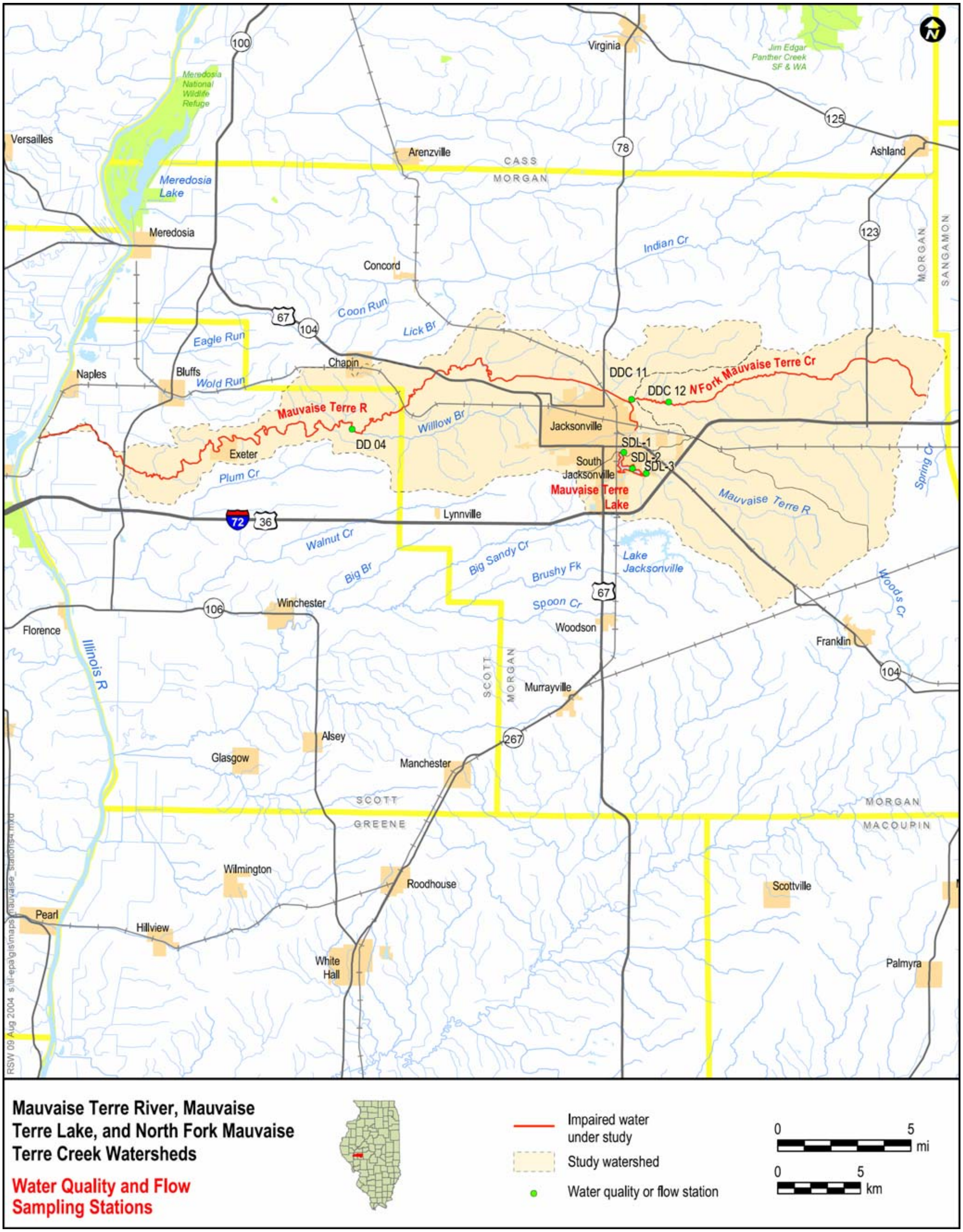


Figure 4. Sampling stations in the project watershed

CONFIRMATION OF CAUSES AND SOURCES OF IMPAIRMENT

Water quality data were evaluated, in combination with the watershed characterization data, to:

1. assess the sufficiency of the data to support the listing decision; and
2. identify suspected or known sources of impairment.

Mauvaise Terre Lake (SDL)

Mauvaise Terre Lake is listed on the 303(d) list as impaired by phosphorus, nitrate, and manganese. The available data support the listing for phosphorus. Only three of the 67 available samples did not exceed the water quality criterion of 0.05 mg/l. On average, sample results exceed the criterion by 2.4 to 4 times the criterion. Concentrations are generally highest at the sampling location nearest the inlet, and lowest at the dam, suggesting watershed sources may be significant.

There is not a strong relationship between total and dissolved phosphorus, suggesting that there may be multiple sources of phosphorus. Total phosphorus generally increases with increasing total suspended solids (Figure 5), suggesting a significant contribution from runoff or resuspended sediments. Phosphorus data were collected at different depths at station SDL-1 on two occasions; both of these show higher concentrations lower in the water column (Figure 6), which may suggest resuspension of in-place sediments as a source.

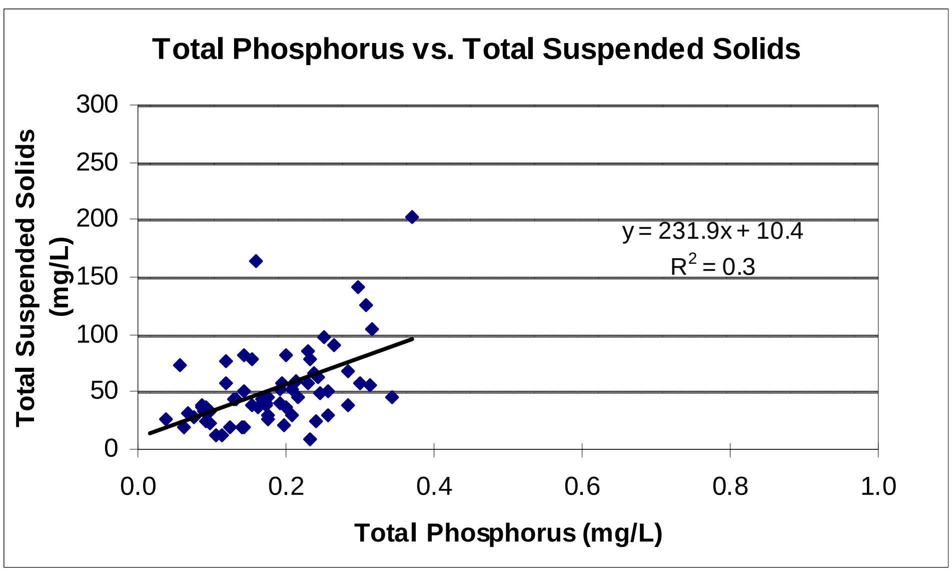


Figure 5. Total phosphorus vs. total suspended solids in Mauvaise Terre Lake

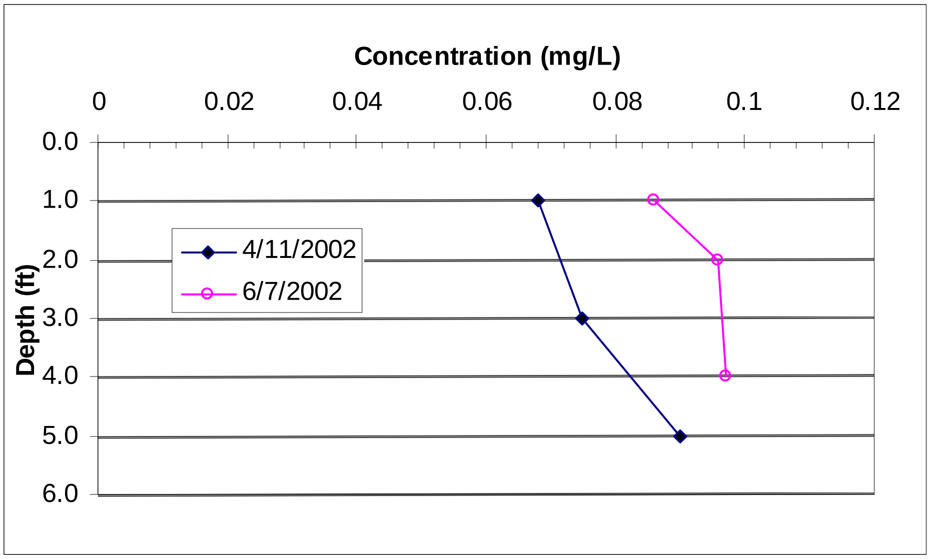


Figure 6. Total phosphorus profiles in Mauvaise Terre Lake (near the dam)

The available nitrate data support the listing decision. Overall, nearly 20% of the nitrate-nitrite samples exceeded the nitrate water quality criterion of 10 mg/l (note that data are only available for nitrate + nitrite, while the water quality criterion is for nitrate). Among the most recent samples, collected in 2002, 27% exceeded the criterion. A comparison with total nitrogen concentrations in the lake indicates that nitrate is the largest component of total nitrogen. The nitrate-nitrite samples show significant seasonality, with high concentrations in spring and low concentrations in summer.

For manganese, the available data are limited, but support the listing decision. IEPA guidelines (IEPA, 2004a) for identifying manganese as a cause in lakes state that the public water supply use is not supported if, in untreated water, greater than 10% of the observations exceed the applicable standard, for water samples collected in 1999 or later, and for which results are readily available. Two of the five samples (40%) collected in 2002 exceeded the public water supply criterion of 150 ug/l. One sample exceeded the criterion by 70 ug/l, while the other exceeded by 270 ug/l. Data were insufficient to discern relationships with other parameters.

Potential Sources

The Illinois EPA (IEPA, 2004a) defines potential sources as known or suspected activities, facilities or conditions that may be contributing to impairment of a designated use. Illinois EPA (IEPA, 2004a) identified habitat modification, stream bank modification/ destabilization, recreation and tourism activities, forest/grassland/parkland, and unknown sources as potential sources of impairment. (Note that these potential sources were identified for all listed causes of impairment, not only those evaluated in this report.)

Based on a review of available information, including telephone calls to local agency staff, site visits, and evaluation of the available water quality data, the following potential sources of phosphorus were identified:

- Agricultural sources
- Recreational activities (i.e., golf courses)
- Existing in-lake sediment sources

Private sewage disposal systems may also be a source, although the Morgan County Health Department was not aware of failing systems in the watershed.

The following potential sources of nitrate were identified:

- Agricultural sources
- Recreational activities (i.e., golf courses)

Agricultural fertilizer is the most likely source. Private sewage disposal systems may also be a source, although the Morgan County Health Department was not aware of failing systems in the watershed.

It appears that the primary source of manganese is natural background sources. Many of the soils in the Mauvaise Terre watershed contain manganese concretions or accumulations and are also somewhat acidic (Soil Survey Staff, 2004). This could result in manganese moving into solution and being transported in base flow and/or runoff. Lake sediments may also be a potential source, releasing manganese to the water column when dissolved oxygen is low. No point source discharges of manganese were identified. The observed levels of manganese are likely due to the natural geochemical environment and most likely reflect natural background conditions. For this reason, the general use standard may be difficult to attain.

North Fork Mauvaise Terre Creek (DDC)

North Fork Mauvaise Terre Creek is listed on the 303(d) list as impaired for manganese and dissolved oxygen. Very few data are available, with only three measurements each for manganese and dissolved oxygen. It is difficult to draw firm conclusions from these limited data. However, the available data confirm that the listings are appropriate.

For dissolved oxygen, the single measurement at station DDC11 did not violate the water quality criterion. At station DDC12, one of the two measurements violated the criterion of 5 mg/l. Insufficient data are available to assess relationships to other parameters. However, it is worth noting that North Fork Mauvaise Terre Creek is also listed as impaired by nitrogen and suspended solids. The nitrogen impairment suggests that excess nutrients may be leading to phytoplankton blooms and subsequent reductions in D.O.

For manganese, a single sample (out of a total of three) exceeded both the drinking water criterion (150 ug/l) and the general use criterion of 1,000 ug/l. The other two samples did not exceed either criterion. While it is difficult to draw conclusions from such a limited data set, it is noteworthy that the highest manganese concentration also corresponded to the highest total suspended solids in the data set.

Potential Sources

The Illinois EPA (IEPA, 2004a) defines potential sources as known or suspected activities, facilities or conditions that may be contributing to impairment of a designated use. Based on a review of available information, including telephone calls to local agency staff, site visits, and evaluation of the available water quality data, the following potential sources of low dissolved oxygen were identified:

- Agricultural sources

Illinois EPA (IEPA, 2004a) identified agriculture and crop-related sources as potential sources of impairment.

As discussed previously, some soils in the watershed are known to contain manganese. It appears likely that the primary source of manganese is natural sources. The apparent correspondence between high manganese and high total suspended solids, while based on only one sample, lends credence to soils as a source. The Illinois EPA (IEPA, 2004a) lists “unknown sources” as a suggested source of impairment.

Mauvaise Terre Creek (DD 04)

Mauvaise Terre Creek is listed on the 303(d) list as impaired by fecal coliform bacteria. The available data support this listing. Data are available for a single sampling location, station DD04. Of the 97 fecal coliform samples collected at this station, 49 were collected between May and October. An analysis of the May – October fecal data revealed that 36 of the 49 fecal samples (73%) were greater than 400 cfu/100 ml.

A comparison of fecal coliform levels to total suspended solids concentrations (Figure 7) suggests that fecal coliform increases with increasing suspended solids concentration.

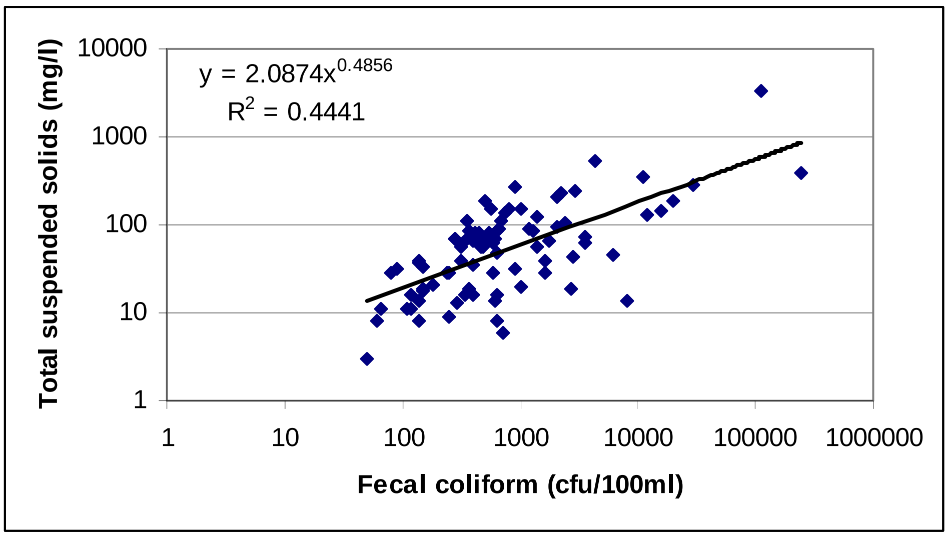


Figure 7. Fecal coliform and total suspended solids concentrations in Mauvaise Terre Creek

Potential Sources

The Illinois EPA (IEPA, 2004a) defines potential sources as known or suspected activities, facilities or conditions that may be contributing to impairment of a designated use. Through a review of available information, including telephone calls to local agency staff, site visits, and evaluation of the available water quality data, the following potential sources of fecal coliform were identified:

- Livestock operations
- Runoff from manure-fertilized cropland
- Municipal sewage disposal
- Jacksonville combined sewer overflows
- Private sewage disposal systems

The Illinois EPA listed "unknown" sources as the source of the impairment. The data suggest that agricultural runoff in particular is a likely source of the impairment. The apparent relationship in the data between fecal coliform and total suspended solids suggests a watershed source (such as runoff) for the fecal coliform. Livestock operations are present throughout the watershed. During the June 2004 site visit, the smell of manure was apparent at several locations in the lower watershed, although the exact source was unclear. There are also several municipal sewage discharges to the creek, as well as private septic systems, that may be contributing to the impairment.

CONCLUSIONS

The available data, though in some cases very limited, support the listed impairments of the three waterbodies in the Mauvaise Terre watershed. Potential sources of phosphorus and nitrate to Mauvaise Terre Lake include agricultural sources, existing sediments, recreation activities, and possibly failing private sewage disposal systems. The primary source of manganese to both Mauvaise Terre Lake and North Fork Mauvaise Terre Creek may be background sources due to naturally high concentrations in area soils, with possible contributions from in-place sediments. The primary potential source of low dissolved oxygen in North Fork Mauvaise Terre Creek is agricultural runoff. Potential sources of fecal coliform bacteria to Mauvaise Terre Creek include livestock operations, agricultural runoff, and sewage disposal, including municipal sewage, CSO discharges, and private disposal systems.

NEXT STEPS

In the upcoming quarter, methods, procedures and models that will be used to develop TMDLs for the project watershed will be identified and described. This description will include documentation of any important assumptions underlying the recommended approach (methods, procedures and models) and a discussion of data needed to support the development of a credible TMDL.

REFERENCES

City of Jacksonville, 2004. Utilities Department Water Supply Information, http://www.jacksonvilleil.com/utilities2.htm

Illinois Department of Agriculture, 2002. 2002 Illinois Soil Conservation Transect Survey Summary.

Illinois Environmental Protection Agency (IEPA), 2004a. Draft Illinois 2004 Section 303(d) List. Bureau of Water, Watershed Management Section. April 2004. IEPA/BOW/04-005 http://www.epa.state.il.us/water/watershed/reports/303d-report/303d-2004.pdf

Illinois Environmental Protection Agency (IEPA), 2004b. Final Draft Illinois Water Quality Report 2004. Bureau of Water, May 2004. IEPA/BOW/04-006. http://www.epa.state.il.us/water/water-quality/305b/305b-2004.pdf

Illinois State Water Survey, Illinois State Climatologist Office. Illinois Climate Summary for Jacksonville, Illinois. http://www.sws.uiuc.edu/atmos/statecli/Summary/114442.htm

Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Official Soil Series Descriptions [Online WWW]. Available URL: "http://soils.usda.gov/soils/technical/classification/osd/index.html" [Accessed 3 August 2004].

State of Illinois. 1997 edition. Illinois Population Trends 1990-2020.

United States Census Bureau, 2000. Census 2000 Data for the State of Illinois. http://www.census.gov/census2000/states/il.html

United States Environmental Protection Agency (USEPA). 1991. *Guidance for Water Quality-based Decisions: The TMDL Process*. EPA 440/4-91-001, Office of Water, Washington, DC.

University of Illinois Extension, 2004. Personal communication.

APPENDIX A. DATA SOURCES AND LOCAL CONTACTS

Table A-1. Data sources

Data description	Agency	Website
Climate summaries	Illinois State Water Survey	http://www.sws.uiuc.edu/atmos/statecli/index.htm
NPDES permit limits	United States Environmental Protection Agency	http://www.epa.gov/enviro/html/pcs/pcs_query.html
Aerial photography	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/webdocs/doqs/graphic.html
Coal mines: active and abandoned - polygons part 1	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Coal mines: active and abandoned - polygons part 2	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Coal mines: active and abandoned – points	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Coal mine permit boundaries	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
County boundaries	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Cropland	United States Department of Agriculture, National Agricultural Statistics Service, via Illinois Department of Agriculture	http://www.agr.state.il.us/gis/pass/nassdata/
Dams	National Inventory of Dams (NID)	http://crunch.tec.army.mil/nid/webpages/nid.cfm
Elevation	United States Geological Survey	http://seamless.usgs.gov/viewer.htm
Federally-owned lands	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Hydrologic cataloging units	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Hydrography	United States Geological Survey	http://nhd.usgs.gov/
Impaired lakes	Illinois Environmental Protection Agency	http://maps.epa.state.il.us/website/wqinfo/
Impaired streams	Illinois Environmental Protection Agency	http://maps.epa.state.il.us/website/wqinfo/
Land cover	Illinois Department of Agriculture	http://www.agr.state.il.us/gis/
Landfills	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Municipal boundaries	U.S. Census Bureau	
Municipal boundaries	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
National Pollutant Discharge Elimination System (NPDES) permitted sites	United States Environmental Protection Agency	
NPDES discharge data	Illinois Environmental Protection Agency	
Nature preserves	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Oil wells	United States Geological Survey	http://energy.cr.usgs.gov/oilgas/noga/
Railroads	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Roads	Illinois Natural Resources	http://www.isgs.uiuc.edu/nsdihome/

Data description	Agency	Website
	Geospatial Data Clearinghouse	
Roads – state highways	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Roads – U.S. highways	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Roads- detailed road network	U.S. Census Bureau	http://www.census.gov/geo/www/tiger/tigerua/ua_tgr2k.html
Survey-level soils	United States Department of Agriculture Natural Resources Conservation Service	http://www.il.nrcs.usda.gov/technical/soils/ssurgo.html
State-level soils	United States Department of Agriculture Natural Resources Conservation Service	http://www.il.nrcs.usda.gov/technical/soils/statsgo_inf.html - statsgo8
State boundary	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
State conservation areas	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
State forests	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
State fish and wildlife areas	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
State parks	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Topographic map quadrangle index	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Topographic map quadrangles	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
USGS stream gages	Illinois State Water Survey	
Water quality data	Illinois Environmental Protection Agency	
Watersheds	Illinois Environmental Protection Agency	http://maps.epa.state.il.us/website/wqinfo/
Water supply – Public water supply intakes	Illinois State Water Survey	

Table A-2. Local and state contacts

Contact	Agency/ Organization	Contact Means	Phone #	Subject
Aaron Dufelmeier	Morgan County Agricultural Extension	Telephone	217-479-4627	Nutrient and pathogen sources, management practices
Quentin Lucassen	Morgan County Health Department	Telephone	217-245-5111	Onsite sewage disposal, potential sources of contaminants
Matt Bunger	Morgan County NRCS	Telephone	217-243-1535 ext 3	Nutrient and pathogen sources, agricultural practices
Brenda	Scott County Agricultural Extension	Telephone	217-742-9572	Referred us to Morgan County office
Reg	Scott County Farm Service Agency	Telephone	217-742-9561 ext 2	Referred us to Morgan County NRCS
Rich Nickels	Illinois Department of Agriculture	Telephone	217-782-6297	Requested Cropland Transect Survey
Sue Ebetsch	Illinois State Data Center	Telephone	217-782-1381	Requested Population projection report
Laura Biewick	U.S. Geological Survey	Telephone	303-236-7773	GIS data for oil & gas wells
Kathy Brown	Illinois State Water Survey	Telephone	217-333-6778	USGS gage locations; water supply intakes
Sharie Heller	SW Illinois GIS resource Center	Telephone	618-566-9493	Discussed CRP maps
Steve Sobaski	Illinois Department of National Resources	e-mail	ssobaski@dnrmail .state.il.us	Formal request for conservation related GIS files
Don Pitts	United States Department of Agriculture Natural Resources Conservation Service	Telephone	217-353-6642	Potential sources of iron and manganese in south-central Illinois surface waters.
Tony Meneghetti	IEPA	Telephone and e-mail	217-782-3362 Anthony.Meneghetti@epa.state.il.us	Lake data and SWAPs
Dave Muir	IEPA Marion Regional office	Personal visit	618-993-7200	Assessment data used in 303(d) and 305(b) reports
Tim Kelly	IEPA Springfield Regional office	Telephone and e-mail	217-786-6892 Tim.Kelly@epa.state.il.us	NPDES DMR data
Jeff Mitzelfelt	IEPA	e-mail	jeff.mitzelfelt@epa .state.il.us	Websites for GIS information

This page is blank to facilitate double sided printing.

APPENDIX B: PHOTOGRAPHS

Agricultural and park lands draining to Morgan Lake (adjacent to Mauvaise Terre Lake).

Park lands draining to Morgan Lake (adjacent to Mauvaise Terre Lake).

Culverts draining to Morgan Lake (adjacent to Mauvaise Terre Lake).

Mauvaise Terre Lake: From Vandalia Rd looking north, an industrial facility is on the west side of the lake, and a golf course on the east side

Golf course on the east side of Mauvaise Terre Lake

The golf course, Jacksonville Country Club, is not directly adjacent to the lake. Country Club Drive, which follows the north and east shores of the lake, runs between the course and the lake. However, at least one culvert was observed between a pond at the Country Club and the lake

Drainages from the west side of Country Club Drive to the eastern arm of the lake

Surface foam and filamentous algae in Mauvaise Terre Lake

Mauvaise Terre Lake at Vandalia Rd.


Mauvaise Terre Creek at Rte 104

Mauvaise Terre Creek at Rte 104

Mauvaise Terre Creek below the lake, at Johnson St.

West of Jacksonville along Rte 67/104 near Mauvaise Terre Creek

Mauvaise Terre Creek at Mt. Zion Rd, north of Hwy 104, near Marnico Village

Mauvaise Terre Creek at Mt. Zion Rd., just south of Apple Rd


Mauvaise Terre Creek, along Markham Rd.


Mauvaise Terre Creek, along Willow Branch Rd


Mauvaise Terre Creek along Willow Branch Rd. (stream stabilization program)

Second Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

October 2004

Mauvaise Terre Creek Watershed

Mauvaise Terre Creek (ILDD04)
Mauvaise Terre Lake (SDL), North Fork Mauvaise Terre Creek (DDC), Mauvaise Terre Creek (DD04)

Limno-Tech, Inc.
www.limno.com

This page is blank to facilitate double sided printing.

Table of Contents

List of Tables

List of Figures

This page is blank to facilitate double sided printing.

EXECUTIVE SUMMARY

This is the second in a series of quarterly status reports documenting work completed on the Mauvaise Terre Creek project watershed. The objective of this report is to provide a summary of Stage 1 work that will ultimately be used to support Total Maximum Daily Load (TMDL) development in the project watershed.

Background

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the draft 2004 303(d) list (IEPA, 2004), which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be completed for each pollutant listed for an impaired water body. TMDLs are prepared by the States and submitted to the U.S. EPA. In developing the TMDL, a determination is made of the greatest amount of a given pollutant that a water body can receive without exceeding water quality standards and designated uses, considering all known and potential sources. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation.

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. The results of this review were presented in the first quarterly status report.

The intent of this second quarterly status report is to:

- Identify and briefly describe the methodologies/procedures/models to be used in the development of TMDLs
- Document important assumptions underlying the recommended methodologies
- Identify the data needs for the methodologies to be used in TMDL development, including an assessment of whether additional data are needed to develop credible TMDLs

In future phases of this project, Illinois EPA and consultants will develop the TMDLs and will work with stakeholders to implement the necessary controls to improve water quality in the impaired water bodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) would be strictly voluntary.

Methods

The effort completed in the second quarter included: 1) summarizing potentially applicable model frameworks for TMDL development, 2) Recommending specific model frameworks for application to the three impaired waterbodies in the Mauvaise Terre Creek watershed, and 3) Making a determination whether sufficient data exist to allow development of a credible TMDL. Selection of specific model frameworks was based upon consideration of three separate factors, consistent with the guidance of DePinto et al (2004):

- **Site-specific characteristics:** The characteristics define the nature of the watershed and water bodies. For Mauvaise Terre Creek below Town Brook, the relevant site-specific characteristics include a watershed with predominantly agricultural land use, and a creek impaired by fecal coliform. For Mauvaise Terre Lake, the relevant site-specific characteristics include a watershed with predominantly agricultural land use and a lake impaired by manganese, total phosphorus and nitrate. For North Fork Mauvaise Terre Creek, the relevant site-specific characteristics include a watershed with predominantly agricultural land use and a creek impaired by manganese and low dissolved oxygen.
- **Management objectives:** These objectives consist of the specific questions to be addressed by the model. For this application, the management objective is to define a credible TMDL.
- **Available resources:** This corresponds to the amount and time and data available to support TMDL development. Water quality data currently exist for Mauvaise Terre Creek, North Fork Mauvaise Terre Creek and Mauvaise Terre Lake. One aspect of this work is to define whether or not the existing data are sufficient to allow development of a credible TMDL.

Results

Several modeling frameworks potentially applicable for developing TMDLs were identified, spanning a range of detail from simple to complex. Selection of a specific modeling framework is complicated by the fact that the definition of a “credible” TMDL depends upon the level of detail to be contained in the implementation plan. If the goal of the TMDL implementation plan is to define the primary sources of impairment and quickly identify the general level of reduction required, relatively simple models can be used to develop a credible TMDL. If the goal of the TMDL implementation plan is to explicitly define the specific levels of controls required, more detailed models (and additional data) are required to develop a credible TMDL. Specific recommendations are provided which correspond to the level of detail provided in other Illinois TMDL implementation plans conducted to date.

The recommended approach for Mauvaise Terre Creek consists of developing a load-duration curve to address fecal coliform impairments. This will allow for determination of the degree of impairment under different flow conditions and the respective importance of dry weather and wet weather fecal coliform sources. Results from the load-duration curve can also be used to identify the approximate level of source control needed under each set of flow conditions.

The recommended approach for North Fork Mauvaise Terre Creek consists of using the water quality model QUAL2E to address dissolved oxygen problems. Manganese impairments will be addressed via spreadsheet calculations. Watershed loads for this segment will be defined using an empirical approach. QUAL2E was selected for dissolved oxygen modeling because it is the most commonly used water quality model for addressing low flow conditions. Because problems appear to be restricted to low flow conditions, watershed loads are not expected to be significant contributors to the impairment. For this reason, an empirical approach was selected for determining watershed loads.

The recommended approach for Mauvaise Terre Lake consists of using the GWLF and BATHTUB models to address total phosphorus, manganese and nitrate problems in Mauvaise Terre Lake. Specifically, GWLF will be applied to calculate phosphorus and nitrate loads to the reservoir from different land uses, over a time scale consistent with their nutrient residence times in Mauvaise Terre Lake. BATHTUB will then be used to predict the relationship between nutrient (phosphorus and nitrate) load and resulting in-lake phosphorus and dissolved oxygen concentrations, and resulting potential for manganese release from sediments. This relationship will be used to define the dominant sources of nutrients to the lake, and the extent to which they must be controlled to attain water quality standards. The BATHTUB model was selected because it does not have extensive data requirements (and can therefore be applied with existing data), yet still provides the capability for calibration to observed Mauvaise Terre Lake data. GWLF was selected as the watershed model because it can provide loading information on the time-scale required by BATHTUB, with moderate data requirements that can be satisfied by existing data.

Alternative model frameworks are also provided that will support the development of differing levels of TMDL implementation plans. Some of these frameworks will require no additional data collection; however, other frameworks have significantly greater data requirements, and their use would require additional data collection.

INTRODUCTION/PURPOSE

This Stage 1 report describes intermediate activities related to the development of TMDLs for impaired water bodies in the Mauvaise Terre Creek watershed. Earlier Stage 1 efforts included watershed characterization activities and data analyses, to confirm the causes and sources of impairments in the watershed.

The remaining sections of this report include:

- **Identification of potentially applicable methodologies to be used in TMDL development:** This section describes the range of potentially applicable watershed loading and water quality methodologies that could be used to conduct the TMDL, and identifies their strengths and weaknesses.
- **Model selection process:** This section describes how management objectives, available resources and site-specific conditions in the Mauvaise Terre Creek watershed affect the recommendation of specific methodologies.
- **Selection of specific methodologies and future data requirements:** This section provides specific recommendation of methodologies for the Mauvaise Terre Creek watershed, along with the data needed to support application of the methodologies.

IDENTIFICATION OF POTENTIALLY APPLICABLE MODELS AND PROCEDURES TO BE USED IN TMDL DEVELOPMENT

Development of TMDLs requires: 1) a method to estimate the amount of pollutant load being delivered to the water body of interest from all contributing sources, and 2) a method to convert these pollutant loads into an in-stream (or in-lake) concentration for comparison to water quality targets. Both of these steps can be accomplished using a wide range of methodologies, ranging from simple calculations to complex computer models. This section describes the methodologies that are potentially applicable for the three 303(d) listed waterbodies in the Mauvaise Terre Creek watershed, and is divided into separate discussions of watershed methodologies and receiving water quality model frameworks.

Watershed Methodologies and Modeling Frameworks

Numerous methodologies exist to characterize watershed loads for TMDL development. These include:

- Empirical Approaches
- Unit Area Loads/Export Coefficients
- Universal Soil Loss Equation
- Watershed Characterization System (WCS) Sediment Tool
- Generalized Watershed Loading Functions (GWLF) Model
- Agricultural Nonpoint Source Pollution Model (AGNPS)
- Hydrologic Simulation Program - Fortran (HSPF)
- Better Assessment Science Integrating point and Nonpoint Sources (BASINS)/ Nonpoint Source Model (NPSM)
- Storm Water Management Model (SWMM)
- Soil & Water Assessment Tool (SWAT)

This section describes each of the model frameworks and their suitability for characterizing watershed loads for TMDL development. Table 1 summarizes some important characteristics of each of the models relative to TMDL application.

Table 1. Summary of Potentially Applicable Models for Estimating Watershed Loads

Model	Data Needs	Output Timescale	Potential Accuracy	Calibration	Applicability for TMDL
Empirical Approach	High	Any	High	N/A	Good for defining existing total load; less applicable for defining individual contributions or future loads
Unit Area Loads	Low	Annual average	Low	None	Acceptable when limited resources prevent development of more detailed model
USLE	Low	Annual average	Low	Requires data describing annual average load	Acceptable when limited resources prevent development of more detailed model
WCS Sediment Tool	Low	Annual average	Low	Requires data describing annual average load	Acceptable when limited resources prevent development of more detailed model
GWLF	Moderate	Monthly average	Moderate	Requires data describing flow and concentration	Good for mixed use watersheds; compromise between simple and more complex models
SWMM	Moderate	Continuous	Moderate	Requires data describing flow and concentration	Primarily suited for urban watersheds
AGNPS	High	Continuous	High	Requires data describing flow and concentration	Primarily suited for rural watersheds; highly applicable if sufficient resources are available
HSPF	High	Continuous	High	Requires data describing flow and concentration	Good for mixed use watersheds; highly applicable if sufficient resources are available
SWAT	High	Continuous	High	Requires data describing flow and concentration	Primarily suited for rural watersheds; highly applicable if sufficient resources are available

Empirical Approaches

Empirical approaches estimate pollutant loading rates based upon site-specific measurements, without the use of a model describing specific cause-effect relationships. Time series information is required on both stream flow and pollutant concentration.

The advantage to empirical approaches is that direct measurement of pollutant loading will generally be far more accurate than any model-based estimate. The approach, however, has several disadvantages. The empirical approach provides information specific to the storms that are monitored, but does not provide direct information on conditions for events that were not monitored. Statistical methods (e.g., Preston et al., 1989) can be used to integrate discrete measurements of suspended solids concentrations with continuous flow records to provide estimates of solids loads over a range of conditions.

The primary limitation of empirical techniques is their inability to separate individual contributions from multiple sources. This problem can be addressed by collecting samples from tributaries serving single land uses, but most tributary monitoring stations reflect multiple land uses. The EUTROMOD and BATHTUB water quality models described below contain routines that apply the empirical approach to estimating watershed loads.

Unit Area Loads/Export Coefficients

Unit area loads (also called export coefficients) are routinely used to develop estimates of pollutant loads in a watershed. An export coefficient is a value expressing pollutant generation per unit area and unit time for a specific land use (Novotny and Olem, 1994).

The use of unit areal loading or export coefficients has been used extensively in estimating loading contributions from different land uses (Beaulac 1980, Reckhow et al. 1980, Reckhow and Simpson 1980, Uttormark et al. 1974). The concept is straightforward; different land use areas contribute different loads to receiving waters. By summing the amount of pollutant exported per unit area of land use in the watershed, the total pollutant load to the receiving system can be calculated.

These export coefficients are usually based on average annual loads. The approach permits estimates of current or existing loading, as well as reductions in pollutant export for each land use required to achieve a target TMDL pollutant load. The accuracy of the estimates is dependent on good land use data, and appropriate pollutant export coefficients for the region. EUTROMOD is a spreadsheet-based modeling procedure for estimating phosphorus loading and associated lake trophic state variables, which can estimates phosphorus loads derived from watershed land uses or inflow data using approaches developed by Reckhow et al. (1980) and Reckhow and Simpson (1980). The FLUX module of the BATHTUB software program estimates nutrient loads or fluxes to a lake/reservoir and provides five different algorithms for estimating these nutrient loads based on the correlation of concentration and flow. In addition, the potential errors in loading estimates are quantified.

Universal Soil Loss Equation

The Universal Soil Loss Equation (USLE), and variations of the USLE, are the most widely used methods for predicting soil loss. When applied properly, the USLE can be used as a means to estimate loads of sediment and sediment-associated pollutants for TMDLs. The USLE is empirical, meaning that it was developed from statistical regression analyses of a large database of runoff and soil loss data from numerous watersheds. It does not describe specific erosion processes. The USLE was designed to predict long-term average annual soil erosion for combinations of crop systems and management practices with specified soil types, rainfall patterns, and topography.

Required model inputs to the USLE consist of:

- Rainfall erosivity index factor
- Soil-erodibility factor
- Slope length factor reflecting local topography
- Cropping-management factor
- Conservation practice factor

Most of the required inputs for application of the USLE are tabulated by county Natural Resources Conservation Service (NRCS) offices.

There are also variants to the USLE: the Revised USLE (RUSLE) and the Modified USLE (MUSLE). The RUSLE is a computerized update of the USLE incorporating new data and making some improvements. The basic USLE equation is retained, but the technology for evaluating the factor values has been altered and new data introduced to evaluate the terms for specific conditions. The MUSLE is a modification of USLE, with the rainfall energy factor of the USLE replaced with a runoff energy factor. MUSLE allows for estimation of soil erosion on an event-specific basis.

While the USLE was originally designed to consider soil/sediment loading only, it is also commonly used to define loads from pollutants that are tightly bound to soils. In these situations, the USLE is used to define the sediment load, with the result multiplied by a pollutant concentration factor (mass of pollutant per mass of soil) to define pollutant load.

The USLE is among the simplest of the available models for estimating sediment and sediment-associated loads. It requires the least amount of input data for its application and consequently does not ensure a high level of accuracy. It is well suited for screening-level calculations, but is less suited for detailed applications. This is because it is an empirical model that does not explicitly represent site-specific physical processes. Furthermore, the annual average time scale of the USLE is poorly suited for model calibration purposes, as field data are rarely available to define erosion on an annual average basis. In addition, the USLE considers erosion only, and does not explicitly consider the amount of sediment that is delivered to stream locations of interest. It is best used in situations where data are available to define annual loading rates, which allows for site-specific determination of the fraction of eroded sediment that is delivered to the surface water.

Watershed Characterization System (WCS) Sediment Tool

The Watershed Characterization System (WCS) Sediment Tool was developed by EPA Region 4. The Watershed Characterization System is an ArcView-based application used to display and analyze GIS data including land use, soil type, ground slope, road networks, point source discharges, and watershed characteristics. WCS has an extension called the Sediment Tool that is specifically designed for sediment TMDLs. For each grid cell within the watershed, the WCS Sediment Tool calculates potential erosion using the USLE based on the specific cell characteristics. The model then calculates the potential sediment delivery to the stream grid network. Sediment delivery can be calculated using one of the four available sediment delivery equations: a distance-based equation, a distance slope-based equation, an area-based equation, or a WEPP-based regression equation.

The applicability of WCS for estimating sediment loads for TMDLs is similar to that of the USLE in terms of data requirements and model results; i.e., it is relatively simple to apply but has the potential to be inaccurate. It provides three primary enhancements over the USLE: 1) Model inputs are automatically incorporated into the model through GIS coverages; 2) Topographic factors are calculated in the model based on digital elevation data; and 3) The model calculates the fraction of eroded sediment that is delivered to the surface water. It is only applicable to sediment TMDLs whose target represents long-term loading conditions. Because its predictions represent average annual conditions, it is not suitable for predicting loads associated with specific storm events. Like the USLE, it is does not lend itself to model calibration unless data are available to define annual loading rates.

Generalized Watershed Loading Functions Model (GWLF)

The Generalized Watershed Loading Functions Model (GWLF) simulates runoff and sediment loadings from mixed-use watersheds. It is a continuous simulation model (i.e., predicts how concentrations change over time) that uses daily time steps for weather data and water balance calculations. Sediment results are provided on a monthly basis. GWLF requires the user to divide the watershed into any number of distinct groups, each of which is labeled as rural or urban. The model does not spatially distribute the source areas, but simply aggregates the loads from each area into a watershed total; in other words, there is no spatial routing. Erosion and sediment yield for rural areas are estimated using monthly erosion calculations based on the USLE (with monthly rainfall-runoff coefficients). A sediment delivery ratio based on watershed size and a transport capacity based on average daily runoff are then applied to the calculated erosion to determine how much of the sediment eroded from each source area is delivered to the watershed outlet. Erosion from urban areas is considered negligible.

GWLF provides more detailed temporal results than the USLE, but also requires more input data. Specifically, daily climate data are required as well as data on processes related to the hydrologic cycle (e.g., evapotranspiration rates, groundwater recession constants). By performing a water balance, it has the ability to predict concentrations at a watershed outlet as opposed to just loads. It lacks the ability to calculate the sediment delivery ratio that is present in the WCS sediment tool. Because the model performs on a continuous simulation basis, it is more amenable to site-specific calibration than USLE or the WCS sediment tool.

Agricultural Nonpoint Source Pollution Model (AGNPS)

The Agricultural Nonpoint Source Pollution Model (AGNPS) is a joint USDA-Agricultural Research Service and -Natural Resources Conservation Service system of computer models developed to predict nonpoint source pollutant loadings within agricultural watersheds. The sheet and rill erosion model internal to AGNPS is based upon RUSLE, with additional routines added to allow for continuous simulation and more detailed consideration of sediment delivery.

AGNPS was originally developed for use in agricultural watersheds, but has been adapted to allow consideration of construction sources.

AGNPS provides more spatial detail than GWLF and is therefore more rigorous in calculating the delivery of eroded sediment to the receiving water. This additional computational ability carries with it the cost of requiring more detailed information describing the topography of the watershed, as well as requiring more time to set up and apply the model.

Hydrologic Simulation Program – Fortran (HSPF)

The Hydrologic Simulation Program – Fortran (HSPF) uses continuous rainfall and other meteorologic records to compute stream flow hydrographs and pollutographs. HSPF is well suited for mixed-use (i.e., containing both urban and rural land uses) watersheds, as it contains separate sediment routines for pervious and impervious surfaces. HSPF is an integrated watershed/stream/reservoir model, and simulates sediment routing and deposition for different classes of particle size. HSPF was integrated with a geographical information system (GIS) environment with the development of Better Assessment Science Integrating point and Nonpoint Sources (BASINS). Although BASINS was designed as a multipurpose analysis tool to promote the integration of point and nonpoint sources in watershed and water quality-based applications, it also includes a suite of water quality models. One such model is Nonpoint Source Model (NPSM). NPSM is a simplified version of HSPF that is linked with a graphical user interface within the GIS environment of BASINS. HSPC is another variant of the HSPF model, consisting of the equations used by HSPF recoded into the C++ programming language.

HSPF provides a more detailed description of urban areas than AGNPS and contains direct linkage to a receiving water model. This additional computational ability carries with it the cost of requiring more detailed model inputs, as well as requiring more time to set up and apply the model. BASINS software can automatically incorporate existing environmental databases (e.g., land use, water quality data) into HSPF, although it is important to verify the accuracy of these sources before using them in the model.

Storm Water Management Model (SWMM)

The Storm Water Management Model (SWMM) is a comprehensive computer model for analysis of quantity and quality problems associated with urban runoff. SWMM is designed to be able to describe both single events and continuous simulation over longer periods of time. SWMM is commonly used to simulate urban hydraulics, although its sediment transport capabilities are not as robust as some of the other models described here.

Soil & Water Assessment Tool (SWAT)

The Soil & Water Assessment Tool (SWAT) is a basin-scale, continuous-time model designed for agricultural watersheds. It operates on a daily time step. Sediment yield is calculated with the Modified Universal Soil Loss Equation. It contains a sediment routing model that considers deposition and channel erosion for various sediment particle sizes. SWAT is also contained as part of EPA's BASINS software.

SWAT is a continuous time model, i.e., a long-term yield model. The model is not designed to simulate detailed, single-event flood routing. SWAT was originally developed strictly for application to agricultural watersheds, but it has been modified to include consideration of urban areas.

Water Quality Methodologies and Modeling Frameworks

Numerous methodologies exist to characterize the relationship between watershed loads and water quality for TMDL development. These include:

- Spreadsheet Approaches
- EUTROMOD
- BATHTUB
- WASP5
- CE-QUAL-RIV1
- CE-QUAL-W2
- EFDC

This section describes each of the methodologies and their suitability for defining water quality for TMDL development. Table 2 summarizes some important characteristics of each of the models relative to TMDL application.

Table 2. Summary of Potentially Applicable Models for Estimating Water Quality

Model	Time scale	Water body type	Spatial scale	Data Needs	Pollutants Simulated	Applicability for TMDL
Spreadsheet approaches	Steady State	Creek or lake	0- or 1-D	Low	DO, nutrients, algae, metals	Good for screening-level assessments
EUTROMOD	Steady State	Lake	0-D	Low	DO, nutrients, Algae	Good for screening-level assessments
BATHTUB	Steady State	Lake	1-D	Moderate	DO, nutrients, algae	Good for screening-level assessments; can provide more refined assessments if supporting data exist
QUAL2E	Steady State	Creek	1-D	Moderate	DO, nutrients, algae, bacteria	Good for low-flow assessments of conventional pollutants in rivers
WASP5	Dynamic	Creek or lake	1-D to 3-D	High	DO, nutrients, metals, organics	Excellent water quality capability; simple hydraulics
CE-QUAL-RIV1	Dynamic	Creek	1-D	High	DO, nutrients, algae	Good for conventional pollutants in hydraulically complex rivers
HSPF	Dynamic	Creek or lake	1-D	High	DO, nutrients, metals, organics, bacteria	Wide range of water quality capabilities, directly linked to watershed model
CE-QUAL-W2	Dynamic	Lake	2-D vertical	High	DO, nutrients, algae, some metals	Good for conventional pollutants in stratified lakes or impoundments
EFDC	Dynamic	Creek or lake	3-D	High	DO, nutrients, metals, organics, bacteria	Potentially applicable to all sites, if sufficient data exist

Spreadsheet Approaches

A wide range of simple methods are available to describe the relationship between pollutant loads and receiving water quality, for a variety of situations including rivers and lakes. These methods are documented in Mills et al. (1985). These approaches do not require specific computer software, and are designed to be implemented on a hand calculator or computer spreadsheet. These approaches have the benefit of relatively low data requirements, as well as being easy to apply. Because of their simplistic nature, these approaches are best considered as screening procedures incapable of producing highly accurate results. They do provide good initial estimates of the primary cause-effect relationships.

EUTROMOD

EUTROMOD is a spreadsheet-based modeling procedure for estimating phosphorus loading and associated lake trophic state variables, distributed by the North American Lake Management Society (Reckhow 1990). The modeling system first estimates phosphorus loads derived from watershed land uses or inflow data using approaches developed by Reckhow et al. (1980) and Reckhow and Simpson (1980). The model accounts for both point and nonpoint source loads. Statistical algorithms are based on regression analyses performed on cross-sectional lake data. These algorithms predict in-lake phosphorus, nitrogen, hypolimnetic dissolved oxygen, chlorophyll, and trihalomethane precursor concentrations, and transparency (Secchi depth). The model also estimates the likelihood of blue-green bacteria dominance in the lake. Lake morphometry and hydrologic characteristics are incorporated in these algorithms. EUTROMOD also has algorithms for estimating uncertainty associated with the trophic state variables and hydrologic variability and estimating the confidence interval about the most likely values for the various trophic state indicators.

BATHTUB

BATHTUB is a software program for estimating nutrient loading to lakes and reservoirs, summarizing information on in-lake water quality data, and predicting the lake/reservoir response to nutrient loading (Walker 1986). It was developed, and is distributed, by the U.S. Army Corps of Engineers. BATHTUB consists of three modules: FLUX, PROFILE, and BATHTUB (Walker 1986). The FLUX module estimates nutrient loads or fluxes to the lake/reservoir and provides five different algorithms for estimating these nutrient loads based on the correlation of concentration and flow. In addition, the potential errors in loading estimates are quantified. PROFILE is an analysis module that permits the user to display lake water quality data. PROFILE algorithms can be used to estimate hypolimnetic oxygen depletion rates, area-weighted or mixed layer average constitutent concentrations, and similar trophic state indicators. BATHTUB is the module that predicts lake/reservoir responses to nutrient fluxes. Because reservoir ecosystems typically have different characteristics than many natural lakes, BATHTUB was developed to specifically account for some of these differences, including the effects of non-algal turbidity on transparency and algae responses to phosphorus.

BATHTUB contains a number of regression equations that have been calibrated using a wide range of lake and reservoir data sets. It can treat the lake or reservoir as a continuously stirred, mixed reactor, or it can predict longitudinal gradients in trophic state variables in a reservoir or narrow lake. These trophic state variables include in-lake total and ortho-phosphorus, organic nitrogen, hypolimnetic dissolved oxygen, metalimnetic dissolved oxygen, and chlorophyll concentrations, and Secchi depth (transparency). Uncertainty estimates are provided with predicted trophic state variables. There are several options for estimating uncertainty based on the distribution of the input and in-lake data. Both tabular and graphical displays are available from the program.

QUAL2E

QUAL2E is a one-dimensional water quality model that assumes steady-state flow, but allows simulation of diurnal variations in dissolved oxygen and temperature. It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The model simulates the following state variables: temperature, dissolved oxygen, biochemical oxygen demand, ammonia, nitrate, organic nitrogen, inorganic phosphorus, organic phosphorus, algae, and conservative and non-conservative substances. QUAL2E also includes components that allow implementation of uncertainty analyses using sensitivity analysis, first-order error analysis, or Monte Carlo simulation. QUAL2E has been used for wasteload allocation purposes throughout the United States. QUAL2E is also linked into EPA's BASINS modeling system.

The primary advantages of using QUAL2E include its widespread use and acceptance, and ability to simulate all of the conventional pollutants of concern. Its disadvantage is that it is restricted to one-dimensional, steady-state analyses.

WASP5

WASP5 is EPA's general-purpose surface water quality modeling system. It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The model can be applied in one, two, or three dimensions and is designed for linkage with the hydrodynamic model DYNHYD5. WASP5 has also been successfully linked with other one, two, and three-dimensional hydrodynamic models such as RIVMOD, RMA-2V and EFDC. WASP5 can also accept user-specified advective and dispersive flows. WASP5 provides separate submodels for conventional and toxic pollutants. The EUTRO5 submodel describes up to eight state variables in the water column and bed sediments: dissolved oxygen, biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, organic phosphorus, and phytoplankton. The TOXI5 submodel simulates the transformation of up to three different chemicals and three different solids classes.

The primary advantage of using WASP5 is that it provides the flexibility to describe almost any water quality constituent of concern, along with its widespread use and acceptance. Its primary disadvantage is that it is designed to read hydrodynamic results only from the one-dimensional RIVMOD-H and DYNHYD5 models. Coupling of WASP5 with multi-dimensional hydrodynamic model results will require extensive site-specific linkage efforts.

CE-QUAL-RIV1

CE-QUAL-RIV1 is a linked hydrodynamic-water quality model, supported by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi. Water quality state variables consist of temperature, dissolved oxygen, carbonaceous biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, coliform bacteria, dissolved iron, and dissolved manganese. The effects of algae and macrophytes can also be included as external forcing functions specified by the user.

The primary advantage of CE-QUAL-RIV1 is its direct link to an efficient hydrodynamic model. This makes it especially suitable to describe river systems affected by dams or experiencing extremely rapid changes in flow. Its primary disadvantage is that it simulates conventional pollutants only, and contains limited eutrophication kinetics. In addition, the effort and data required to support the CE-QUAL-RIV1 hydrodynamic routines may not be necessary in naturally flowing rivers.

HSPF

HSPF (Hydrological Simulation Program - FORTRAN) is a one-dimensional modeling system for simulation of watershed hydrology, point and non-point source loadings, and receiving water quality for both conventional pollutants and toxicants (Bicknell et al, 1993). It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The water quality component of HSPF allows dynamic simulation of both conventional pollutants (i.e. dissolved oxygen, nutrients, and phytoplankton) and toxics. The toxics routines combine organic chemical process kinetics with sediment balance algorithms to predict dissolved and sorbed chemical concentrations in the upper sediment bed and overlying water column. HSPF is also linked into EPA's BASINS modeling system.

The primary advantage of HSPF is that it exists as part of a linked watershed/receiving water modeling package. Nonpoint source loading and hydrodynamic results are automatically linked to the HSPF water quality submodel, such that no external linkages need be developed.

CE-QUAL-W2

CE-QUAL-W2 is a linked hydrodynamic-water quality model, supported by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi. CE-QUAL-W2 simulates variations in water quality in the longitudinal and lateral directions, and was developed to address water quality issues in long, narrow reservoirs. Water quality state variables consist of temperature, algae, dissolved oxygen, carbonaceous biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, coliform bacteria, and dissolved iron.

The primary advantage of CE-QUAL-W2 is the ability to simulate the onset and breakdown of vertical temperature stratification and resulting water quality impacts. It will be the most appropriate model for those cases where these vertical variations are an important water quality consideration. In un-stratified systems, the effort and data required to support the CE-QUAL-W2 hydrodynamic routines may not be necessary.

EFDC

EFDC (Environmental Fluid Dynamics Code) is a three-dimensional hydrodynamic and water quality model supported by the U. S. EPA Ecosystems Research Division. EFDC simulates variations in water quality in the longitudinal, lateral and vertical directions, and was developed to address water quality issues in rivers, lakes, reservoirs, wetland systems, estuaries, and the coastal ocean. EFDC transports salinity, heat, cohesive or noncohesive sediments, and toxic contaminants that can be described by equilibrium partitioning between the aqueous and solid phases. Unique features of EFDC are its ability to simulate wetting and drying cycles, it includes a near field mixing zone model that is fully coupled with a far field transport of salinity, temperature, sediment, contaminant, and eutrophication variables. It also contains hydraulic structure representation, vegetative resistance, and Lagrangian particle tracking. EFDC accepts radiation stress fields from wave refraction-diffraction models, thus allowing the simulation of longshore currents and sediment transport.

The primary advantage of EFDC is the ability to combine three-dimensional hydrodynamic simulation with a wide range of water quality modeling capabilities in a single model. The primary disadvantages are that data needs and computational requirements can be extremely high.

MODEL SELECTION

A wide range of watershed and water quality modeling tools is available and potentially applicable to develop TMDLs for waterbodies in the Mauvaise Terre Creek watershed. This chapter presents the general guidelines used in model selection process, and then applies these guidelines to make specific recommendations. In summary, two alternative approaches can be considered for Mauvaise Terre Creek, three for Mauvaise Terre Lake, and one approach is recommended for North Fork Mauvaise Terre Creek. The final selection of approach is dependent upon the level of implementation to be immediately conducted for the TMDLs. The recommendation provided here for Mauvaise Terre Creek and Mauvaise Terre Lake assumes a level of implementation that is consistent with other recent Illinois TMDLs.

General Guidelines

A wide range of watershed and water quality modeling tools is available and potentially applicable to develop TMDLs. This section provides the guidelines to be followed for the model selection process, based upon work summarized in (DePinto et al, 2004). Three factors will be considered when selecting an appropriate model for TMDL development:

- **Management objectives:** Management objectives define the specific purpose of the model, including the pollutant of concern, the water quality objective, the space and time scales of interest, and required level or precision/accuracy.
- **Available resources:** The resources available to support the modeling effort include data, time, and level of effort of modeling effort

- **Site-specific characteristics:** Site-specific characteristics include the land use activity in the watershed, type of water body (e.g. lake vs. river), important transport and transformation processes, and environmental conditions.

Model selection must be balanced between competing demands. Management objectives typically call for a high degree of model reliability, although available resources are generally insufficient to provide the degree of reliability desired. Decisions are often required regarding whether to proceed with a higher-than-desired level of uncertainty, or to postpone modeling until additional resources can be obtained. There are no simple answers to these questions, and the decisions are often made using best professional judgment.

The required level of reliability for this modeling effort is one able to “support development of a credible TMDL”. The amount of reliability required to develop a credible TMDL depends, however, on the degree of implementation to be included in the TMDL. TMDL implementation plans that require complete and immediate implementation of strict controls will require much more model reliability than an implementation plan based upon adaptive management which allows incremental controls to be implemented and includes follow-up monitoring of system response to dictate the need for additional control efforts.

The approach to be taken here regarding model selection is to provide recommendations which correspond to the level of detail provided in other Illinois TMDL implementation plans conducted to date. Alternative methodologies are also provided that will support the development of differing levels of TMDL implementation plans. For each approach, the degree of implementation that can be supported to produce a credible TMDL will be provided. Specific recommendations are provided which correspond to the level of detail provided in other Illinois TMDL implementation plans conducted to date.

Model Selection for the Mauvaise Terre Creek Watershed

Tables 1 and 2 summarized the characteristics of the various watershed and water quality methodologies with potential applicability to TMDL development. This section reviews the relevant site-specific characteristics of the systems, summarizes the data available, and provides recommended approaches. Data needs, assumptions, and level of TMDL implementation support are provided for each of the recommended approaches.

Site Characteristics

Watershed characterization for the Mauvaise Terre Creek watershed was provided in the first quarterly status report (LTI, 2004). In summary, the Mauvaise Terre Creek watershed is located in Morgan and Scott counties in west-central Illinois. The three waterbodies of concern are Mauvaise Terre Lake (SDL), North Fork Mauvaise Terre Creek (DDC), and Mauvaise Terre Creek downstream of Town Brook (DD04). Mauvaise Terre Lake and North Fork Mauvaise Terre Creek lie in Morgan County, while Mauvaise Terre Creek flows through both Morgan and Scott Counties.

Mauvaise Terre Lake was constructed by damming the upper part of Mauvaise Terre Creek. The lake has a surface area of 172 acres and serves as a source of drinking water for Jacksonville and several surrounding communities. Most of the water supply, however, comes from wells located 26 miles from Jacksonville (City of Jacksonville, 2004). The combined drainage area of the three impaired waterbodies is approximately 164 square miles. Mauvaise Terre Lake is approximately “L” shaped, with an arm extending west from the inlet, and a second arm extending north to the dam. Mauvaise Terre Lake is connected near the corner of the “L” to a smaller lake called Morgan Lake.

Land use in each of the three watersheds is predominantly agricultural. Crops are primarily a corn-soy rotation, with a small amount of wheat. Urban areas comprise approximately 7% of the Mauvaise Terre Creek watershed, 6% of the Mauvaise Terre Lake watershed and 1.5% of the North Fork Mauvaise Terre Creek watershed. Jacksonville is the major urban area; the City lies entirely within the Mauvaise Terre Creek watershed. The City of South Jacksonville is also within the watershed. Other towns in the watershed include Exeter and Oxville. A portion of the town of Chapin also lies in the watershed. The Morgan County Health Department indicated that the Jacksonville area has sewers, and perhaps a small area northwest of Jacksonville known as Marnico Village, but the rest of the watershed is on private disposal systems. The Morgan County Health Department permits and inspects all septic systems and is unaware of any failing systems in the watershed. There are several point source discharges in the watershed, including sewage disposal for the City of Jacksonville, food production facilities (ACH Food Company and Nestle), and several oil wells near North Fork Mauvaise Terre Creek. Jacksonville also has a combined sewer system and permitted combined sewer overflows (CSOs).

The listing of Mauvaise Terre Creek on the Illinois 303(d) list for impairment due to fecal coliform has been confirmed based on a review of the data. The listing of Mauvaise Terre Lake for manganese, total phosphorus and nitrate and North Fork Mauvaise Terre Creek for manganese and low dissolved oxygen have similarly been confirmed.

Potential sources of phosphorus and nitrate to Mauvaise Terre Lake include agricultural sources, existing sediments, recreation activities, treated combined sewer discharges, and possibly failing private sewage disposal systems. The primary source of manganese to both Mauvaise Terre Lake and North Fork Mauvaise Terre Creek may be background sources due to naturally high concentrations in area soils. In-place sediments may also contribute to elevated water column concentrations in the lake. The primary potential source of low dissolved oxygen in North Fork Mauvaise Terre Creek is agricultural runoff. Potential sources of fecal coliform bacteria to Mauvaise Terre Creek include livestock operations, agricultural runoff, and sewage disposal, including municipal sewage, CSO discharges, and private disposal systems.

Data Available

Tables 3, 4 and 5 provide a summary of available water quality data from the first quarterly status report (LTI, 2004). This amount of data is sufficient to confirm the presence of water quality impairment, but not sufficient to support development of a rigorous watershed or water quality model. Specific items lacking in this data set include tributary loading data for all pollutants of concern, data describing the distribution of total phosphorus, nitrate, manganese and fecal coliform throughout the watershed, and continuous flow data. A USGS gage is located in a nearby watershed on Spring Creek near Springfield (05577500), but a more accurate estimate of flows for the three waterbodies would be obtained from a gage located within the Mauvaise Terre watershed.

Table 3. Water Quality Data Summary for Mauvaise Terre Creek (DD04)

Sample location and parameter	Criterion (cfu/100 ml)	Period of record and number of data points	Mean (mg/l)	Maximum (mg/l)	Minimum (mg/l)
Mauvaise Terre Creek, 1.5 mi NE of Merritt (Station DD04)					
Fecal coliform	400 cfu/100ml in < 10% of samples Geomean < 200 cfu/100 ml	1990-2004, 97 samples	5,388	240,000	<50

Table 4. Water Quality Data Summary for North Fork Mauvaise Terre Creek (DDC)

Sample location and parameter	Criterion	Period of record and number of data points	Mean (mg/l)	Maximum (mg/l)	Minimum (mg/l)
North Fork Mauvaise Terre Creek, 0.5 M NE of Jacksonville (Station DDC11)					
Dissolved oxygen	5 mg/l	June 2001; 1 sample	7.8	7.8	7.8
Manganese	150 ug/l	June 2001; 1 sample	78	78	78
North Fork Mauvaise Terre Creek, 3 Mi E of Jacksonville (Station DDC12)					
Dissolved oxygen	5 mg/l	July 2001; 2 samples	7.68	13.3	2.05
Manganese	150 ug/l	July-Oct. 2001; 2 samples	1,205	2,300	110

Table 5. Water Quality Data Summary for Mauvaise Terre Lake (SDL)

Sample location and parameter	Criterion	Period of record and number of data points	Mean (mg/l)	Maximum (mg/l)	Minimum (mg/l)
Mauvaise Terre Lake, Near Dam Midway Between Spillway (Station SDL-1)					
Manganese	150 ug/l	April-Oct 2002 5 samples	183	420	67
Phosphorus	0.05 mg/l	1990-2002 47 samples	0.162	0.344	0.015
Nitrate	10 mg/l	1990-2002 47 samples	3.91	12	<0.01
Mauvaise Terre Lake, 800 yd E. of Ramp N. of Docks (Station SDL-2)					
Phosphorus	0.05 mg/l	1992 & 2002 10 samples	0.202	0.284	0.087
Nitrate	10 mg/l	1992 & 2002 10 samples	3.93	10	<0.01
Mauvaise Terre Lake, Mid Lake South of Red Brick House (Station SDL-3)					
Phosphorus	0.05 mg/l	1992 & 2002 10 samples	0.248	0.370	0.118
Nitrate	10 mg/l	1992 & 2002 10 samples	4.72	13	<0.01

*note that data are for nitrate + nitrite, but water quality standard and listing are for nitrate

Recommended Approaches

This section provides recommendations for specific modeling approaches to be applied for the Mauvaise Terre Creek watershed TMDLs. Two alternative sets of approaches are provided for Mauvaise Terre Creek and three are provided for Mauvaise Terre Lake. One approach is recommended for the North Fork Mauvaise Terre Creek. The recommended approaches are presented in Tables 6, 7 and 8, with each approach having unique data needs and resulting degree of detail.

Table 6. Recommended Modeling Approaches for Mauvaise Terre Creek (DD04)

Modeling Approach	Pollutants considered	Watershed Model	Water Quality Model	Additional data needs	Level of TMDL implementation supported
Recommended					
	Fecal coliform	Load duration curve		None	Identify whether sources occur during dry or wet weather; and identify approximate level of control needed
Alternative					
	Fecal coliform	HSPF	HSPF	Tributary flow and coliform concentrations at multiple locations	Define specific sources of bacteria and detailed control strategies

The recommended approach for Mauvaise Terre Creek consists of developing a load-duration curve to address fecal coliform impairments. A load-duration curve is a graphical representation of observed pollutant load compared to maximum allowable load over the entire range of flow conditions. Such a graph can be developed by 1) developing a flow duration curve by ranking the daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results as shown in Figure 1; 2) translating the flow duration curve into a load duration curve by multiplying the flows by the water quality standard as shown in Figure 2; and 3) plotting observed pollutant loads (measured concentrations times stream flow) on the same graph as shown in Figure 3.

% Exceed	Flow
99	694.2
95	803.3
90	920.2
85	1213.3
80	1629.7
75	2081.3
70	2692.9
65	3130.3
60	3583.3
55	4177.9
50	5092.2
45	6074.7
40	7068.8
35	8398.1
30	9801.8
25	11617.5
20	13838.5
15	17136.8
10	22281.1

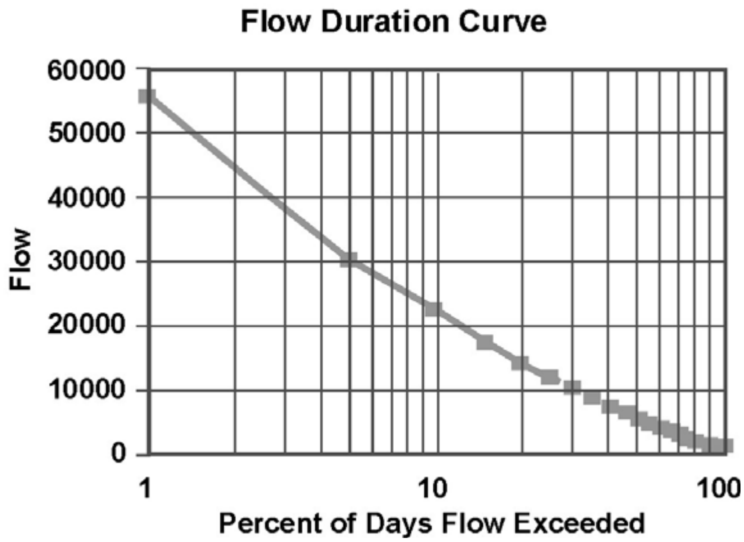


Figure 1. Calculation of a Flow Duration Curve (from Freedman et al., 2003)

% Exceed	Flow	Atrazine (lbs/day)
99	694.2	11.50
95	803.3	13.31
90	920.2	15.25
85	1213.3	20.10
80	1629.7	27.00
75	2081.3	34.49
70	2692.9	44.62
65	3130.3	51.87
60	3583.3	59.38
55	4177.9	69.23
50	5092.2	84.38
45	6074.7	100.66
40	7068.8	117.13
35	8398.1	139.16
30	9801.8	162.42
25	11617.5	192.50
20	13838.5	229.30
15	17136.8	283.96
10	22281.1	369.20
5	30245.9	501.17
1	55562.3	920.67

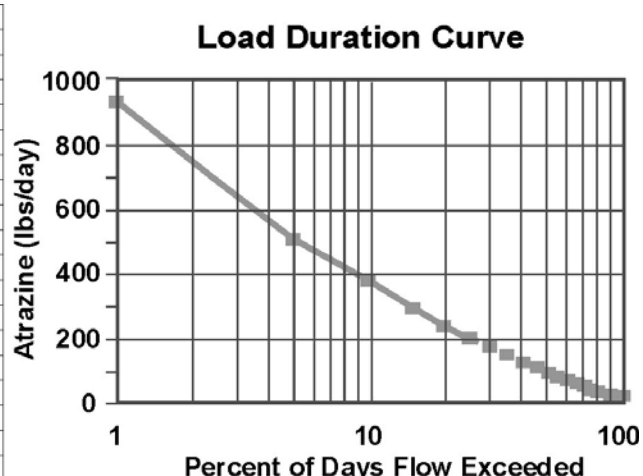


Figure 2. Calculation of a Load Duration Curve (from Freedman et al., 2003)

% Exceed	Flow	Atrazine (lbs/day)	Atrazine Load
99	694.2	11.50	4.33
95	803.3	13.31	
90	920.2	15.25	
85	1213.3	20.10	12.92
80	1629.7	27.00	
75	2081.3	34.49	
70	2692.9	44.62	122.91
65	3130.3	51.87	
60	3583.3	59.38	95.87
55	4177.9	69.23	
50	5092.2	84.38	
45	6074.7	100.66	
40	7068.8	117.13	
35	8398.1	139.16	
30	9801.8	162.42	
25	11617.5	192.50	
20	13838.5	229.30	
15	17136.8	283.96	154.43
10	22281.1	369.20	804.32
5	30245.9	501.17	
1	55562.3	920.67	

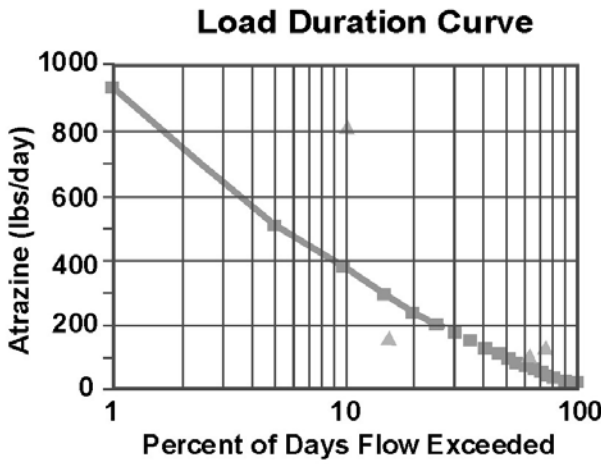


Figure 3. Load Duration Curve with Observed Loads (from Freedman et al., 2003)

The load duration curve provides information to:

- Help identify the issues surrounding the problem and differentiate between point and nonpoint source problems, as discussed immediately below;
- Address frequency of deviations (how many samples lie above the curve vs. those that plot below), and duration (potentially how long the deviation is present) questions; and
- Aid in establishing the level of implementation needed, by showing the magnitude by which existing loads exceed standards for different flow conditions.

The location of loads that plot above the load duration curve is meaningful. Loads which plot above the curve in the area of the plot defined as being exceeded 85-99 percent of the time are considered indicative of point source influences on the water quality. Those loads plotting above the curve over the range of 10-70 percent exceedence likely reflect nonpoint source load contributions. NPS loads are pollution associated with runoff or snowmelt from numerous, dispersed sources over an extended area. Some combination of the two source categories lies in the transition zone of 70-85 percent exceedence. Those loads plotting above the curve at exceedences less than 10 percent or more than 99 percent reflect extreme hydrologic conditions of flood or drought (Freedman et al, 2003).

The load duration curve approach will identify broad categories of coliform sources and the extent of control required from these sources to attain water quality standards.

The alternative approach for Mauvaise Terre Creek consists of applying the HSPF model to define watershed loads for all fecal coliform sources and using the water quality component of this model to simulate in-stream concentrations and water quality response. This approach, coupled with intensive monitoring, would define specific sources of bacteria and identify detailed control strategies necessary to attain water quality standards.

Table 7. Recommended Modeling Approaches for North Fork Mauvaise Terre Creek (DDC)

Modeling Approach	Pollutants considered	Watershed Model	Water Quality Model	Additional data needs	Level of TMDL implementation supported
Recommended					
	Dissolved Oxygen	Empirical approach	QUAL2E	Low flow stream surveys	Identify primary sources to be controlled, and approximate level of control needed
	Manganese	Empirical approach	Spreadsheet approach	Low flow stream surveys	Identify manmade versus natural sources

The recommended approach for North Fork Mauvaise Terre Creek consists of using the water quality model QUAL2E to address dissolved oxygen problems. Manganese impairments will be addressed via spreadsheet calculations. Watershed loads for this segment will be defined using an empirical approach. QUAL2E was selected for dissolved oxygen modeling because it is the most commonly used water quality model for addressing dissolved oxygen for low flow conditions. Because problems appear to be restricted to low flow conditions, watershed loads are not expected to be significant contributors to the impairment. For this reason, an empirical approach was selected for determining watershed loads. The recommended approach (in conduction with additional monitoring described below) will identify the primary sources of dissolved oxygen to be controlled, as well as the level of control needed

Table 8. Recommended Modeling Approaches for Mauvaise Terre Lake (SDL)

Modeling Approach	Pollutants considered	Watershed Model	Water Quality Model	Additional data needs	Level of TMDL implementation supported
Recommended					
	Manganese, Total Phosphorus, Nitrate	GWLF	BATHTUB	None	Identify primary sources to be controlled; and approximate level of control needed
Alternative 1					
	Manganese, Total Phosphorus, Nitrate	None	BATHTUB	None	Identify approximate level of control needed
Alternative 2					
	Manganese, Total Phosphorus, Nitrate	SWAT	CE-QUAL-W2	Tributary flow and concentrations; lake concentrations	Define detailed control strategies

The recommended approach for Mauvaise Terre Lake consists of using the GWLF and BATHTUB models to address total phosphorus, manganese and nitrate problems in Mauvaise Terre Lake. Specifically, GWLF will be applied to calculate phosphorus and nitrate loads to the reservoir from different land uses, over a time scale consistent with their nutrient residence times in Mauvaise Terre Lake. BATHTUB will then be used to predict the relationship between nutrient (phosphorus and nitrate) load and resulting in-lake phosphorus and dissolved oxygen concentrations, and resulting potential for manganese release from sediments. This relationship will be used to define the dominant sources of nutrients to the lake, and the extent to which they must be controlled to attain water quality standards. The BATHTUB model was selected because it does not have extensive data requirements (and can therefore be applied with existing data), yet still provides the capability for calibration to observed Mauvaise Terre Lake data. GWLF was selected as the watershed model because it can provide loading information on the time-scale required by BATHTUB, with moderate data requirements that can be satisfied by existing data. This approach will identify the primary sources to be controlled, as well as the approximate level of control needed.

The first alternative approach for Mauvaise Terre Lake would not include any watershed modeling for phosphorus or nitrate, but would focus only on determining the pollutant loading capacity of the lake. Determination of existing loading sources and prioritization of restoration alternatives would be conducted by local experts as part of the implementation process. Based upon their recommendations, a voluntary implementation plan would be developed that includes both accountability and the potential for adaptive management.

The second alternative approach for Mauvaise Terre Lake would consist of applying the SWAT watershed model to define watershed loads for all pollutants, coupled with application of the reservoir models CE-QUAL-W2 to describe in-lake water quality response. CE-QUAL-W2 would be applied to define hydrodynamics and eutrophication processes.

Assumptions Underlying the Recommended Methodologies

The recommended approach is based upon the following assumptions:

- The only controllable source of manganese to Mauvaise Terre Lake is that which enters from lake sediments during periods of low dissolved oxygen; this source can be (partially) controlled by reducing phosphorus loads and increasing hypolimnetic dissolved oxygen concentrations.
- A credible TMDL implementation plan can be developed based upon relatively simple models

LTI believes that these assumptions are appropriate.

DATA NEEDS FOR THE METHODOLOGIES TO BE USED

The recommended modeling approaches for Mauvaise Terre Creek and Mauvaise Terre Lake can be applied without collection of any additional data. The first alternative approach for Mauvaise Terre Lake can also be applied without additional data collection. However, follow-up monitoring is strongly recommended after controls are implemented, to verify their effectiveness in reducing loads and documenting the river and lake response. Application of the recommended modeling approaches for North Fork Mauvaise Terre Creek will require conduct of additional field sampling to support TMDL development. The existing data, while sufficient to document impairment, are not sufficient to define the cause-effect relationships. Two low- to medium-flow surveys are recommended to synoptically measure sources and receiving water concentrations of oxygen demanding substances, and manganese in the North Fork Mauvaise Terre Creek.

Should the alternative approach be selected for Mauvaise Terre Creek or the second alternative approach selected for Mauvaise Terre Lake, extensive data collection efforts would be required in order to calibrate the watershed and water quality models. The purpose of the detailed data collection is as follows:

1) define the distribution of specific loading sources throughout the watershed,
2) define the extent to which these loads are being delivered to the river or lake, and
3) define important reaction processes in Mauvaise Terre Lake.

To satisfy objective one for Mauvaise Terre Lake and Mauvaise Terre Creek, wet weather event sampling of phosphorus, manganese, ammonia, nitrate and fecal coliform at multiple tributary and mainstem locations in the watershed will be needed. To satisfy objective two, routine monitoring of loads to the lake and to the river will be needed. Flows could be estimated using the USGS gage on Spring Creek at Springfield (05577500), however, it is recommended that flows be measured in the watershed at the mouth of Mauvaise Terre Creek or on Mauvaise Terre Creek near Jacksonville, to reflect watershed-specific flow conditions. Water quality sampling and analyses would be required for several wet and dry weather events for the lake for: total suspended solids, manganese, total phosphorus, ortho-phosphorus, dissolved oxygen, CBOD, ammonia, organic nitrogen, nitrate-nitrogen and chlorophyll a. Water quality sampling and analyses would be required for several wet and dry weather events for Mauvaise Terre Creek for total suspended solids and fecal coliform. To satisfy the third objective, routine in-lake monitoring will be needed. In Mauvaise Terre Lake, bi-monthly sampling would need to be conducted for water temperature, in addition to total suspended solids, manganese, total phosphorus, ortho-phosphorus, dissolved oxygen, CBOD, ammonia, organic nitrogen, nitrate-nitrogen, and chlorophyll a.

REFERENCES

Beaulac, M.N., 1980. Sampling design and nutrient export coefficients: An examination of variability within differing land uses. MS Thesis. Department of Natural Resources, Michigan State University, East Lansing, MI.

Bicknell, B.R., Imhoff, J.C., Kittle, J.L., Donigan, A.S., and Johanson, R.C., 1993, *Hvdrological Simulation Program-Fortran--User's manual for release 10:* U.S. Environmental Protection Agency Report EPA/600/R-93/174, 660 p.

DePinto, J.V., P.L. Freedman, D.W. Dilks, and W.M. Larson (2004). "Models Quantify the Total Maximum Daily Load Process." *Jour. Env. Eng.*, 130(6), 703-713.

Freedman, P.L., W.M. Larson, D.W. Dilks, D.S. Schechter, A. Nemura, T. Naperala, J.V. DePinto, M.G. Prothro, G.W. Boese, A. Dettelbach, L. Nothman, K. Thornton, D. Ford, P. Massirer, T. Soerens, K. B. Stevens and J. Sobrinho. 2003. Navigating the TMDL Process: Evaluation and Improvements. Co-published by IWA Publishing and Water Environment Research Federation. 00-WSM-1.

Illinois Environmental Protection Agency, 2004a. Final Draft Illinois Water Quality Report 2004 Illinois Environmental Protection Agency Bureau of Water. IEPA/BOW/04-006. May 2004

Limno-Tech, Inc., 2004. First Quarterly Status Report Mauvaise Terre Creek Watershed. August 2004.

Mills, W. B., D. B. Porcella, M. J. Ungs, S. A. Gherini, K. V. Summers, L. Mok, G. L. Rupp, G. L. Bowie, and D. A. Haith. 1985. Water Quality Assessment: A Screening Procedure for Toxic and Conventional Pollutants in Surface and Ground Water, Parts I and II. EPA/600/6-85/002a,b.

Novotny, V. and H. Olem, 1994. Water Quality Prevention, Identification and Management of Diffuse Pollution. John Wiley & Sons, Inc. New York, New York.

Preston, S.D., V.J. Bierman Jr. and S.E. Silliman. 1989 Evaluation of Methods for the Estimation of Tributary Mass Loading Rates. Report submitted to the U.S. Geological Survey, Reston, VA. Project No. G1561-04. Technical Report No. 187. p. 50.

Reckhow, K.H. and J.T. Simpson, 1980. A procedure using modeling and error analysis for the prediction of the lake phosphorus concentration from land use information. *Can J Fish Aquat Sci* 37: 1439-1448.

Reckhow, K.H., 1990. EUTROMOD spreadsheet program – a regional modeling scheme for nutrient runoff and lake trophic state modeling. School of Forestry and Environmental Studies. Duke University. Durham, NC.

Reckhow, K.H., M.N. Beaulac, and J.T. Simpson, 1980. Modeling Phosphorus Loading and Lake Response Under Uncertainty: a Manual and Compilation of Export Coefficients. U.S. EPA 440/5-80-011.

Uttormark, P.D., J.D. Chapin, and K.M. Green. 1974. Estimating nutrient loading of lakes from nonpoint sources. US Environmental Protection Agency. EPA-660/13-74-020. Washington, D.C.

Walker, W. W., 1986. *Empirical Methods for Predicting Eutrophication in Impoundments; Report 3, Phase III: Applications Manual*. Technical Report E-81-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Third Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

October 2004

Mauvaise Terre Creek Watershed

Mauvaise Terre Creek (ILDD04)
Mauvaise Terre Lake (SDL), North Fork Mauvaise Terre Creek (DDC), Mauvaise Terre Creek (DD04)

Limno-Tech, Inc.
www.limno.com

This page is blank to facilitate double sided printing.

Table of Contents

List of Figures

This page is blank to facilitate double sided printing.

EXECUTIVE SUMMARY

This is the third in a series of quarterly status reports documenting work completed on the Mauvaise Terre Creek project watershed. The objective of this report is to provide a summary of Stage 1 work that will ultimately be used to support Total Maximum Daily Load (TMDL) development in the project watershed.

Background

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the draft 2004 303(d) list (IEPA, 2004), which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be completed for each pollutant listed for an impaired water body. TMDLs are prepared by the States and submitted to the U.S. EPA. In developing the TMDL, a determination is made of the greatest amount of a given pollutant that a water body can receive without exceeding water quality standards and designated uses, considering all known and potential sources. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation.

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. The results of this review were presented in the first quarterly status report.

In a second quarterly status report, the methodologies/procedures/models to be used in the development of TMDLs were identified and described and models were recommended for application to the project watershed.

The intent of this third quarterly status report is to:

- Identify the amount of data needed to support the modeling (if additional data collection is recommended);
- Provide a general data collection plan; and
- Identify, to the extent possible, the responsible parties for additional data collection.

In future phases of this project, Illinois EPA and consultants will develop the TMDLs and will work with stakeholders to implement the necessary controls to improve water quality in the impaired water bodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) would be strictly voluntary.

Methods

The effort completed in the third quarter included summarizing additional data needs to support the recommended methodologies/procedures/models to be used in the development of TMDLs, and where needed, providing general information related to the data collection.

Results

The recommended approach for North Fork Mauvaise Terre Creek consists of using the water quality model QUAL2E to address dissolved oxygen problems. Manganese impairments will be addressed via spreadsheet calculations. Watershed loads for this segment will be defined using an empirical approach. The recommended approach for Mauvaise Terre Creek consists of developing a load-duration curve to address fecal coliform impairments. The recommended approach for Mauvaise Terre Lake consists of using the GWLF and BATHTUB models to address total phosphorus, manganese and nitrate problems in Mauvaise Terre Lake.

Application of the recommended approaches for North Fork Mauvaise Terre Creek will require conduct of additional field sampling to synoptically measure sources and receiving water concentrations of oxygen demanding substances, dissolved oxygen and manganese. A data collection plan is provided for one low-flow survey of the North Fork Mauvaise Terre Creek watershed.

Application of the recommended models to Mauvaise Terre Lake and Mauvaise Terre Creek will require no additional data collection.

INTRODUCTION/PURPOSE

This Stage 1 report describes intermediate activities related to the development of TMDLs for impaired water bodies in the North Fork Mauvaise Terre Creek watershed. Earlier Stage 1 efforts included watershed characterization activities and data analyses, to confirm the causes and sources of impairments in the watershed, and the recommendation of models to support TMDL development.

The remaining sections of this report include:

- **Description of additional data collection, if any, to support modeling:** This section describes the amount (temporal and spatial) of data, if any, to be collected, and also includes a general description of a data collection plan. Potential parties that may be responsible for additional data collection are also identified.
- **Next steps**

DESCRIPTION OF ADDITIONAL DATA COLLECTION TO SUPPORT MODELING

In the second quarterly progress report for the Mauvaise Terre Creek watershed (LTI, 2004), modeling approaches were recommended. The recommended approach for North Fork Mauvaise Terre Creek consists of using the water quality model QUAL2E to address dissolved oxygen problems. Manganese impairments will be addressed via spreadsheet calculations. Watershed loads for this segment will be defined using an empirical approach.

The recommended approach for Mauvaise Terre Creek consists of developing a load-duration curve to address fecal coliform impairments. This will allow for determination of the degree of impairment under different flow conditions and the respective importance of dry weather and wet weather fecal coliform sources. Results from the load-duration curve can also be used to identify the approximate level of source control needed under each set of flow conditions.

The recommended approach for Mauvaise Terre Lake consists of using the GWLF and BATHTUB models to address total phosphorus, manganese and nitrate problems in Mauvaise Terre Lake. Specifically, GWLF will be applied to calculate phosphorus and nitrate loads to the reservoir from different land uses, over a time scale consistent with their nutrient residence times in Mauvaise Terre Lake. BATHTUB will then be used to predict the relationship between nutrient (phosphorus and nitrate) load and resulting in-lake phosphorus and dissolved oxygen concentrations, and resulting potential for manganese release from sediments. This relationship will be used to define the dominant sources of nutrients to the lake, and the extent to which they must be controlled to attain water quality standards. The BATHTUB model was selected because it does not have extensive data requirements (and can therefore be applied with existing data), yet still provides the capability for calibration to observed Mauvaise Terre Lake data. GWLF was selected as the watershed model because it can provide loading information on the time-scale required by BATHTUB, with moderate data requirements that can be satisfied by existing data.

Data Collection Plan

The data collection plan outlined in general terms below, will support development of the recommended approaches for TMDL development. One low-flow survey is recommended to synoptically measure sources and receiving water concentrations of oxygen demanding substances and manganese in the North Fork Mauvaise Terre Creek watershed. No additional data collection is recommended for Mauvaise Terre Lake or Mauvaise Terre Creek.

Sample collection

Four essential monitoring stations are shown in Figure 1. It is recommended that these four essential stations be sampled during low-flow conditions to support model development and application. The essential stations are located along North Fork Mauvaise Terre Creek and on one tributary to characterize tributary contributions and instream water quality.

Essential monitoring

One low-flow survey is recommended to provide data to support model development and application. At each of the four essential stations shown in Figure 1, it is recommended that the following measurements be collected on the same day:

- dissolved oxygen,
- water temperature,
- biochemical oxygen demand (BOD),
- ammonia,
- total manganese, and
- channel morphometry.

In addition, it is recommended that depth and velocity be measured at two locations: North Fork Mauvaise Terre Creek near the headwaters (Rte 123 overpass) and near the mouth (Station DDC 11). Depth and velocity should be measured at the same time as the water quality sampling, to support flow calculation.

Finally, at a station determined to be representative based on a field survey, it is recommended that sediment oxygen demand (SOD) be measured, in addition to either continuous dissolved oxygen measurements or dissolved oxygen measurements collected in the morning and afternoon. The purpose of these dissolved oxygen measurements is to assess the effect of algae on instream dissolved oxygen concentrations.

Potential parties that may be responsible for additional data collection

Both Baetis Environmental Services, Inc. and Limno-Tech, Inc. are qualified to conduct the recommended data collection in the North Fork Mauvaise Terre Creek watershed. Another potential partner for data collection may be MacMurray College, which is located in Jacksonville.

NEXT STEPS

In the upcoming month, the IEPA will confer with the Scientific Advisory Committee to discuss the work presented in the three quarterly status reports. A public meeting will also be scheduled and held in the watershed to present the conclusions and recommendations of Stage 1 to local stakeholders and to obtain feedback on the work completed to date.

REFERENCES

Illinois Environmental Protection Agency, 2004. Final Draft Illinois Water Quality Report 2004 Illinois Environmental Protection Agency Bureau of Water. IEPA/BOW/04-006. May 2004

Limno-Tech, Inc., 2004. Second Quarterly Status Report Mauvaise Terre Watershed. October 2004.

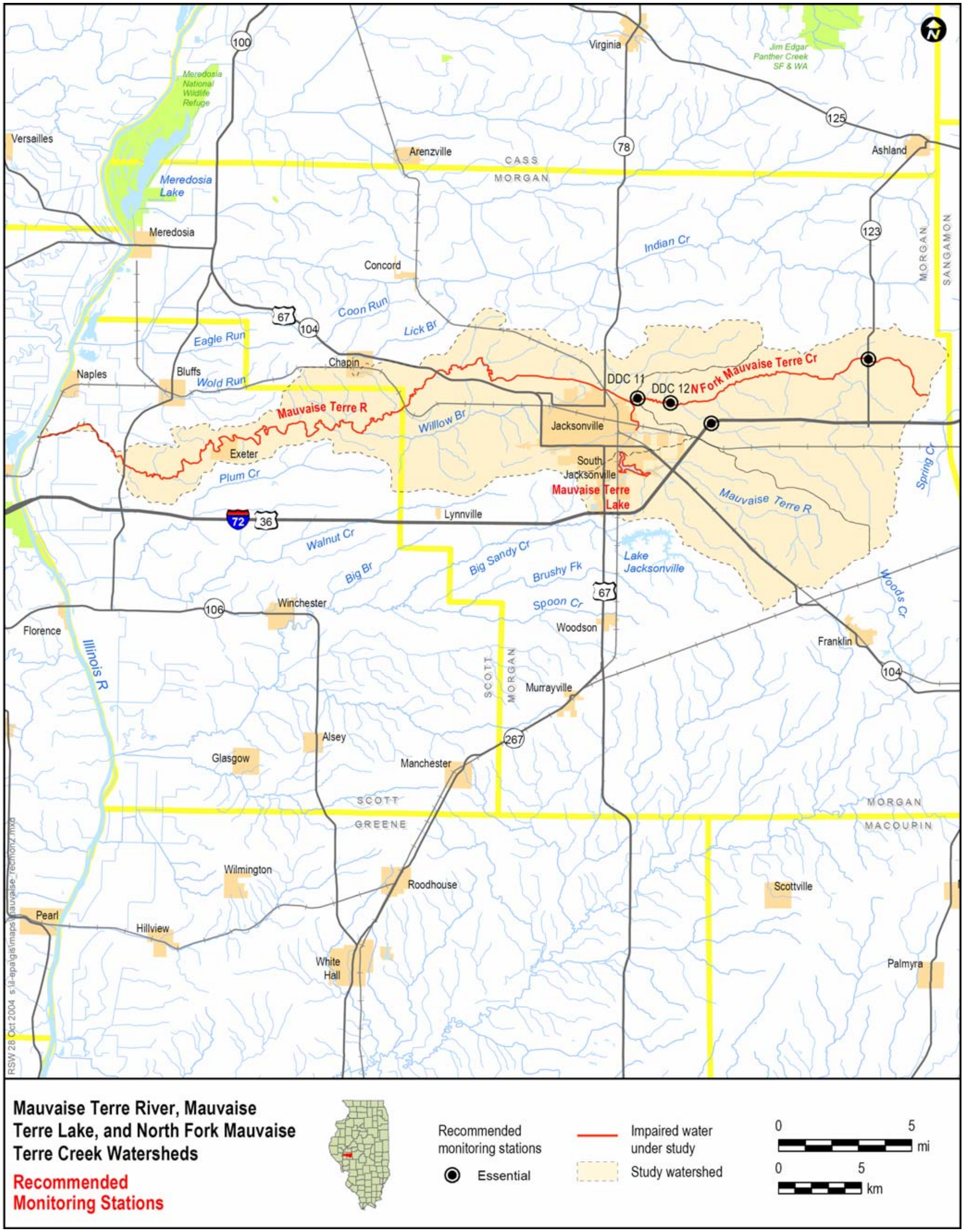


Figure 1. Recommended Stage 2 Sampling Locations

This page is blank to facilitate double sided printing.

Fourth Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

April 2005

Mauvaise Terre Creek Watershed

Mauvaise Terre Creek (ILDD04)
Mauvaise Terre Lake (SDL), North Fork Mauvaise Terre Creek (DDC), Mauvaise Terre Creek (DD04)

Limno-Tech, Inc.
www.limno.com

This page is blank to facilitate double sided printing.

PUBLIC PARTICIPATION

Stage 1 of the Mauvaise Terre Creek TMDL activities included opportunities for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in Summer 2004 to initiate Stage 1. As quarterly progress reports were produced, the Agency posted them to their website.

In January 2005, a public meeting was announced for presentation of the Stage 1 findings. This announcement was mailed to everyone on the previous TMDL mailing list and published in local newspapers. The public meeting was held at 6:30 pm on Tuesday, March 1, 2005 at the Jacksonville Municipal Building in Jacksonville, Illinois. In addition to the meeting's sponsors, nine (9) individuals attended the meeting. Attendees registered and listened to an introduction to the TMDL Program from Illinois EPA and a presentation on the Stage 1 findings by Limno-Tech, Inc. (LTI). This was followed by a general question and answer session.

The Agency entertained questions and concerns from the public through April 1, 2005. The City of Jacksonville Municipal Utilities submitted written comments. Discussion at the public meeting included corrections to the information presented in the TMDL reports (the water body is referred to as Mauvaise Terre Creek, rather than Mauvaise Terre River; the Jacksonville CSOs discharge downstream of Mauvaise Terre Lake), and questions regarding the available water quality data and how the proposed modeling tools would be used. The City Jacksonville expressed concerns that data were insufficient to determine the source of fecal coliform in Mauvaise Terre Creek based on only one sampling location, and that the City may bear the brunt of the necessary reductions in fecal coliform discharges, even if the City is not the primary contributor. Illinois EPA agreed to consider additional monitoring for fecal coliform

This is the fourth in a series of quarterly status reports documenting work completed on the Mauvaise Terre Creek project watershed. The objective of this report is to provide a summary of Stage 1 work that will ultimately be used to support Total Maximum Daily Load (TMDL) development in the project watershed.

This page is blank to facilitate double sided printing.

DATA REPORT

Prepared for Illinois Environmental Protection Agency

July 2006

North Fork Mauvaise Terre Creek Watershed

This page is blank to facilitate double-sided printing.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Attachment

This page is blank to facilitate double-sided printing.

INTRODUCTION

Limno-Tech, Inc. (LTI) completed surface water sampling in the summer of 2006 to support Total Maximum Daily Load (TMDL) development for impaired water bodies in State of Illinois North Fork Mauvaise Terre Creek watershed. This report describes the field investigation and results of the sampling program completed in 2006. This report is divided into sections describing:

- Field investigation overview
- Water sample collection and field measurements
- Discharge measurements
- Sediment oxygen demand and continuous dissolved oxygen monitoring
- Quality assurance review
- Conclusions

FIELD INVESTIGATION OVERVIEW

The North Fork Mauvaise Terre Creek and a tributary were sampled in June, 2006, during low-to-medium flow conditions. The purpose of the sampling was to collect data to support water quality modeling and TMDL development. The sampled waterbodies and the watershed are depicted in Figure 1.

Sampling of the North Fork Mauvaise Terre watershed was initially planned for the summer or fall of 2005 along with five other watersheds, as described in the IEPA-approved Quality Assurance Project Plan (LTI, 2005); however, dry weather conditions prohibited sampling at that time. Drought conditions in southern Illinois during summer and fall 2005 created very low water levels and stream velocities. Field observations of "no apparent flow" were recorded at the time and there was insufficient water to conduct the sampling and SOD measurement.

Table 1 presents a summary of the sampling completed, field observations, and any changes in station location.

The sampling and analysis activities included:

- collection of water samples for laboratory analysis;
- measurement of in-stream water quality and channel morphology parameters;
- stream discharge measurements at two locations;
- continuous dissolved oxygen (DO) monitoring at one location; and
- sediment oxygen demand (SOD) measurements at one location.

In accordance with the QAPP, sample collection and field measurement activities (quality, morphometry and discharge) and continuous DO and SOD monitoring were conducted during one dry weather period.

Following the completion of field investigation and laboratory analysis activities, the generated data were compiled and a quality assurance review was conducted to assess data quality and usability.

Table 1. Sampling Summary

Site ID	Station Description	Location Change From QAPP Listing	DO, NH_3, BOD_5, Water Temp, Channel Morphometry	Mn	Flow (depth & velocity)	SOD & diurnal DO	Notes
NFMAUV-1	N Fork Mauvaise Terre Cr at Lisbon Rd		✔	✔	✔		Water present, flow observed; Sampled u.s. side of bridge
NFMAUV-2	N Fork Mauvaise Terre Cr at Mobil Rd		✔	✔		✔	Water present, flow observed; Sampled d.s. side of bridge
NFMAUV-3	Unnamed tributary at Old State Rd	No access at I-72/Fox Ln., no bridge, moved d.s. to nearest bridge	✔	✔			Water present, flow observed; Sampled u.s. side of bridge
NFMAUV-4	N Fork Mauvaise Terre Cr at Rte 123		✔	✔	✔		Water present, flow observed; Sampled ~100' d.s. of bridge after channel narrows back to normal

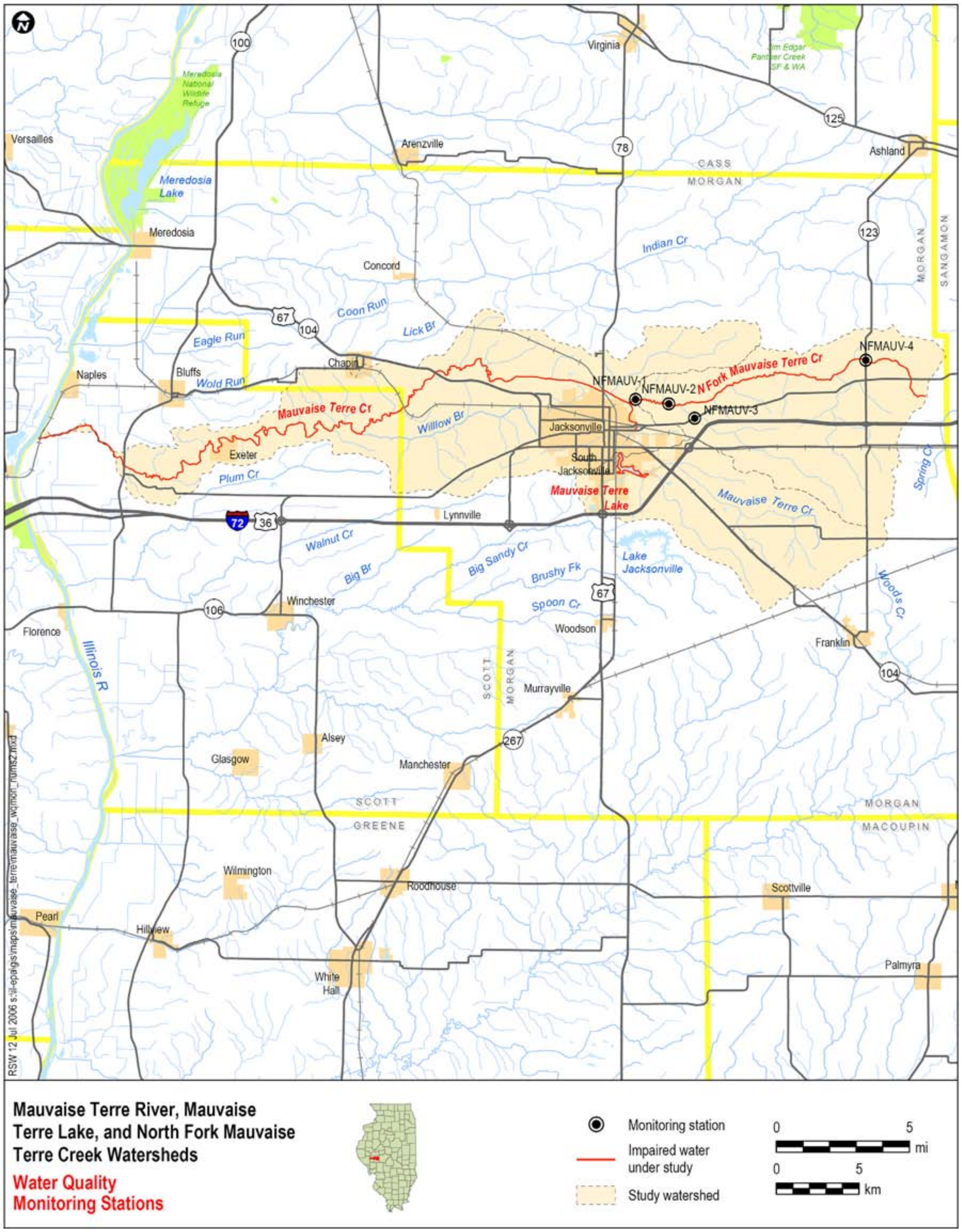


Figure 1. North Fork Mauvaise Terre Creek Watershed Sampling Locations

WATER SAMPLE COLLECTION AND FIELD MEASUREMENTS

Sampling activities were conducted in accordance with the QAPP during low-to-medium flow conditions on June 29, 2006. Surface water samples and field measurements were collected by LTI at 4 stream locations. Table 1 presents a summary of the parameters analyzed at each location. Analytes were based on the causes of impairment identified in the 303(d) list. Field instruments were used to measure in-situ water quality parameters, and Brighton Analytical, Inc. conducted all laboratory analyses. At all locations, water samples were collected for laboratory analysis of ammonia, 5-day biochemical oxygen demand (BOD_5), and manganese; while field measurements included dissolved oxygen (DO), water temperature (T), and channel morphometry (water depth and width).

The analytical and field measurement results are presented in Tables 2 and 3.

Table 2. Laboratory and Field Measurement Results

Sample ID	Colletion Date/Time	Ammonia (mg/L)	BOD_5 (mg/L)	Total Mn (mg/L)	Temp (degC)	DO (mg/L)
NFMAUV-1	6/29/06 12:05	<0.01	<2	0.06	23.0	9.3
NFMAUV-2	6/29/06 12:05	<0.01	<2	0.06	24.0	10.2
NFMAUV-2 Dup	6/29/06 11:40	<0.01	<2	0.07		
NFMAUV-3	6/29/06 11:10	<0.01	<2	0.08	23.0	9.2
NFMAUV-4	6/29/06 9:40	0.17	2.8	0.15	25.8	6.0
Rinse Blank	6/29/06 16:00	0.22	<2	<0.02		

Table 3. Stream Morphometry Results

Site ID	Time	River Width (ft)	Avg. Water Depth (ft)
	6/29/2006		
NFMAUV-1	16:50	17	0.64
NFMAUV-2	15:00	34	2.45
NFMAUV-3	17:35	9	0.37
NFMAUV-4	18:10	10.5	0.35

DISCHARGE MEASUREMENTS

Discharge measurements were conducted at two locations that were most representative of the water bodies in the watershed. Discharge measurements were recorded using standard USGS techniques employing an electromagnetic point velocity meter (Marsh–McBirney Flo-Mate 2000) and a wading rod. Information supporting flow calculation was recorded in field notebooks and included:

- Site location,
- Date and time,

- Measurement monitoring point,
- Distance between measurement points,
- Depth at each measurement point,
- Velocities at each measurement point,
- Angle of flow at each measurement point, and
- Any significant observations of monitoring procedures or river conditions

The discharge measurement results are presented in Table 4.

Table 4. Discharge Results

	NFMAUV-1		NFMAUV-4	
Date	Time	Discharge (cfs)	Time	Discharge (cfs)
6/29/2006	16:50	5.66	18:10	0.64

SEDIMENT OXYGEN DEMAND AND CONTINUOUS DO MONITORING

Sediment oxygen demand and continuous dissolved oxygen were measured at one location (Location 2 at Mobile Road) in the North Fork Mauvaise Terre Creek. A SOD respirometer chamber was installed in accordance with the QAPP, and DO measurements during SOD testing were manually recorded in the field notes for a period of 2 hours or until DO dropped by 2 mg/L or to zero mg/L. The data were used to calculate SOD rates for use in the DO modeling activities. The SOD rate results are presented in Table 5.

A Hydrolab Model 4a multi-parameter data-logging sonde was used for continuous DO measurements. The sonde was deployed for approximately 21 hours to document the majority of the daily diurnal DO cycle. The sonde was calibrated for DO using the Winkler titration method immediately prior to and after deployment to check the system for drift in DO values over time. Calibration and drift-check results were recorded in the field notes and are presented in Table 6. DO 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 DO and temperature data are presented in Figure 2.

There appears to be a uniform downward shift of approximately 0.3 mg/L in DO values after approximately 9:00 on 6/30/06 until the end of the sonde deployment period. DO fluctuations of a similar magnitude can also be observed at the begining of deployment, between approximately 15:00 and 20:00 on 6/29/06. The downward shift in DO is suspected to be caused by DO exertion from resuspended bottom sediments. Bottom sediments may have been inadvertently stirred up during Sonde installation and again near the end of the Sonde deployment period, when the SOD respirometer was deployed. Thunderstorms that came through the area at the end of the sampling, may also have contributed to the DO shift during the end of Sonde deployment. Note that sampling had been completed by the time the rainfall began.

Table 5. Sediment Oxygen Demand Results

Date	Site ID	<=SOD, g/m2/day @ 20^c
6/30/06	NFMAUV-2	1.27

Table 6. Continuous DO Sonde Calibration Values and Drift Check Results

	Pre-Deployment Calibration	Post-Deployment Drift Check						
Station	Winkler DO (mg/L)	Water Sample DO (mg/L)	Winkler DO (mg/L)	DO Drift (mg/L)	DO Drift (%)	Hours Deployed	Average Drift/hr (mg/L)	Average Drift/hr (%)
NFMAUV-2	7.1	7.61	6.6	1.01	14.2%	21	0.0481	0.68%

Notes: Sonde deployed was Hydrolab MiniSonde 4a

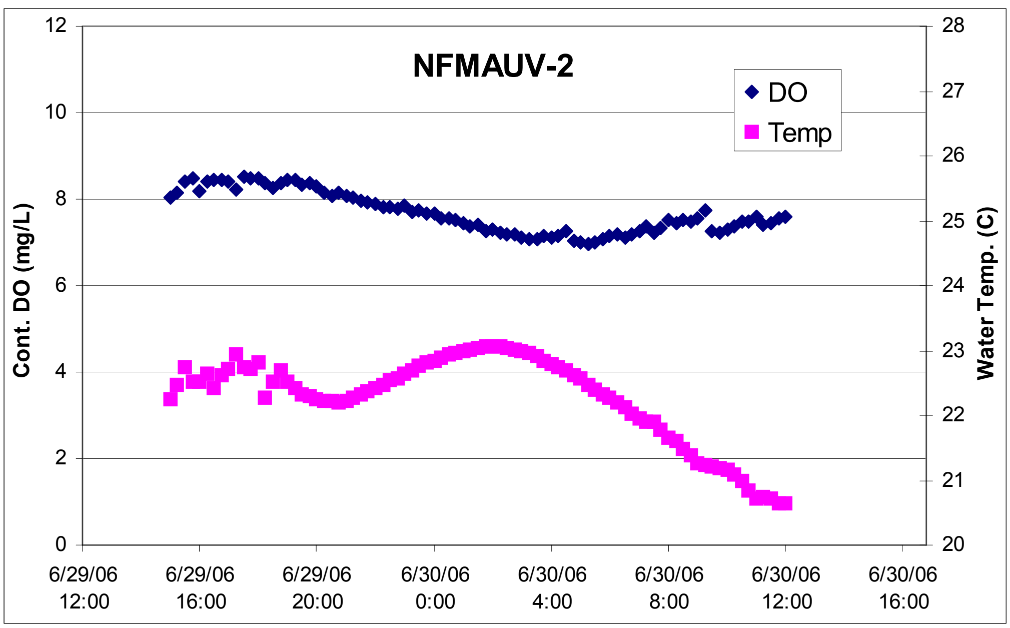


Figure 2. Continuous DO and Temperature at North Fork Mauvaise Terre Creek Station NFMAUV-2

QUALITY ASSURANCE REVIEW

A review was conducted to assess the quality and usability of data generated from implementation of the work activities and to assess adherence to protocols specified in the QAPP. Field and laboratory methods were reviewed and found to be in accordance with the QAPP; however, certain changes to sampling and analysis activities were implemented that deviated from the sampling plan presented in the QAPP and are documented in the remainder of this section. Field measurement data and laboratory analytical data were verified and validated in accordance with the QAPP.

Overall, the data generated are of satisfactory quality and suitable for the intended uses, which include stream characterization and modeling for TMDL development. Some of the data, though acceptable for use, are qualified because of deficiencies in field or laboratory quality control procedures or conditions. Other data, though not specifically flagged with a data qualifier, are associated with uncertainties that prompt caution in their use. These are discussed in this section.

The following subsections of this document present the deviations, deficiencies and cautions associated with the data generated during the investigations. These subsections include the sampling plan changes implemented during the course of the investigation and the results of the data verification and data validation activities.

Changes from Sampling Plan (QAPP)

Certain changes were made to the sampling plan or sampling protocols specified in the QAPP as noted in the following list.

- One sampling location was changed from that presented in the QAPP because of difficult access conditions noted during field reconnaissance. The location change is documented in Table 1.
- Manganese measurements were not originally outlined in the QAPP for the North Fork Mauvaise Terre Creek watershed. These analyses were added after discussions with the IL-EPA project manager and prior to the sampling event. Manganese results are presented in Table 2.

Data Verification and Validation

The data generated are of overall good quality and acceptable for use with some qualifications as discussed below.

Field QC data. Field quality control (QC) samples were collected to assess bias associated with field and laboratory methods. The field QC samples included one field duplicate sample pair and one rinse blank sample. The results of these analyses are presented below.

- ***Ammonia contamination in rinse blank*** - Ammonia was detected in the rinse blank (0.22 mg/L) analyzed during the sampling event. The rinse blank was collected from a clean sampling device just prior to using this device for collecting the surface water sample at station NFMAUV-4 (0.17 mg/L ammonia).

The sampling device was rinsed with stream water prior to collection of the surface water sample. NFMAUV-4 was the only station where a separate sampling device was used to collect water for filling the laboratory sample containers. At all other locations, surface water samples were collected directly into the laboratory sample containers.

Although no qualifications were made to the sample results based on the presence of rinse blank contamination, the possibility must be acknowledged that ammonia results for these samples (i.e., Rinse Blank and NFMAUV-4) may be attributable to contamination introduced during field sampling and rinsing procedures and not representative of stream quality. The presence of ammonia in the rinse blank is not expected to affect the useability of NFMAUV-4 results with respect to model and TMDL development. Additionally, the magnitude of ammonia concentrations observed in these two samples is small, relative to the management concern (i.e., ammonia concentration < 1.0 mg/l isn't considered a problem).

- ***Field Duplicates*** – One field duplicate pair was analyzed with the monitoring data. Positive sample results and relative percent differences (RPD) are presented in Table 7 along with the criteria for precision (relative percent difference values). All duplicate recoveries were within acceptable ranges.

Table 7. Field Duplicate Pair Sample Results

Sample ID	Ammonia (mg/L)	BOD_5 (mg/L)	Total Mn (mg/L)
NFMAUV-2	<0.01	<2.0	0.06
NFMAUV-2 Dup	<0.01	<2.0	0.07
RPD (%)			**3.8 a**

a Acceptable metal duplicate; sample results are within +/- the laboratory reporting limit or <= 20% RPD (for aqueous samples).

*RPD= |S-D| x100 / (S+D)/2 where S: original sample; D: Duplicate sample

Conformance to Data Quality Objectives. Overall, the data generated during the investigation conformed to the project data quality objectives (DQOs) and are suitable for their intended uses. The monitored parameters were evaluated in terms of minimum measurement criteria, minimum measurement objectives, required detection limits, accuracy, precision and completeness using the DQOs presented in the project QAPP. Table 8 summarizes the results of the DQO quality assurance (QA) check.

Table 8. Measurement Objectives and Criteria Check

Parameter	Minimum Measurement Criteria	Minimum Measurement Objectives	Method*; MDL[1]	QA check	MS/MSD * Accuracy (% recovery)	QA check	Precision (RPD)	QA check	LCS * Accuracy (% recovery)	QA check	Completeness Criteria	QA check
Dissolved Oxygen	NA	0.1 mg/l [s]	Field; NA	S	NA	NA	NA	NA	NA	NA	90%	S (100%)
Water Temperature	NA	0.1 degree C [s]	Field; NA	S	NA	NA	NA	NA	NA	NA	90%	S (100%)
Ammonia	15.0 mg/l[G]	3.0 mg/l	EPA 350.1/ 350.3; 0.01/0.03 mg/l	S (0.01 mg/l)	80-120%	S	20%	S	80-120%	S	90%	S (100%)
BOD_5	No Standard	No Standard	EPA 405.1/ SM5210 B; 2 mg/l	S (2 mg/l)	NA	NA	20%	S	NA	NA	90%	S (100%)
Manganese, Total	1 mg/l[G]	0.2 mg/l	EPA 200.8 0.02 mg/l	S (0.02 mg/l)	70-130%	S (80-120%)	20%	S	80-120%	S	90%	S (100%)

Notes
[1] Method Detection Limit (MDL) from SM and EPA.
* Limits are subject to change based upon capabilities of contract labs
[G] State of Illinois General Use Water Quality Standard
[s] Required sensitivity
EPA U.S. EPA Methods for Chemical Analysis of Water and Wastes, March 1983
NA Not Applicable
SM Standard Methods of the Examination of Water and Wastewater, 20th Edition
S QA check is satisfactory, criteria met

This page is blank to facilitate double-sided printing.

Attachment A. QAPP

This page is blank to facilitate double-sided printing.

Quality Assurance Project Plan

for TMDL Sampling Activities
at the following State of Illinois Watersheds:

Macoupin Creek
Hodges Creek
Mauvaise Terre Creek
East Fork Kaskaskia River
North Fork Kaskaskia River
Skillet Fork

Prepared for Illinois Protection Agency

Revised: July, 2005

Project Contact: David Dilks (734) 332-1200, ddilks@limno.com

Limno-Tech, Inc.
Environmental Engineering

Ann Arbor, Michigan

This page is blank to facilitate double sided printing.

APPROVAL SHEET

Signature:		Date:	Aug 17, 2005
Name:	David Dilks		
Title:	Project Administrator, Quality Assurance Officer	Affiliation:	Limno-Tech, Inc.
Signature:		Date:	Aug. 17, 2005
Name:	Penelope Moskus		
Title:	Project Manager	Affiliation:	Limno-Tech, Inc.
Signature:		Date:	10/11/05
Name:	Gregg Good		
Title:	Manager of the IEPA Bureau of Water Surface Water Section	Affiliation:	Illinois Environmental Protection Agency
Signature:		Date:	10/04/2005
Name:	Mike Henebry		
Title:	Bureau of Water QA Officer	Affiliation:	Illinois Environmental Protection Agency
Signature:		Date:	Aug 15, 2005
Name:	David Pott		
Title:	Subconsultant Project Manager	Affiliation:	Baetis Environmental Services, Inc.
Signature:		Date:	
Name:			
Title:		Affiliation:	
Signature:		Date:	
Name:			
Title:		Affiliation:	

This page is blank to facilitate double sided printing.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1 Project Management (Group A)

The purpose of the Quality Assurance Project Plan (QAPP) is to document the necessary procedures required to assure that the project is executed in a manner consistent with applicable United States Environmental Protection Agency (U.S. EPA) guidance documents and with generally accepted and approved quality assurance objectives. In this QAPP, U.S. EPA QAPP Guidance Group A requirements are discussed in this section (Section 1), Group B requirements are discussed in Section 2, Group C requirements are discussed in Section 3 and Group D requirements are discussed in Section 4.

This QAPP was prepared to support surface water sampling activities related to the development of Total Maximum Daily Loads (TMDLs) for impaired water bodies in the following six State of Illinois watersheds:

- Macoupin Creek,
- Hodges Creek,
- Mauvaise Terre Creek,
- East Fork Kaskaskia River,
- North Fork Kaskaskia River and
- Skillet Fork.

This QAPP provides guidance and specifications to assure that:

- proper preventive maintenance, equipment calibration, and approved analytical protocols will be implemented so that all field measurements and sampling analytical results will be valid;
- sampling is conducted using sample tracking systems and chain-of-custody procedures which properly identify samples being collected and ensure the control of those samples from field collection through analysis and data reduction;
- records are produced and retained to document the quality of samples collected and analyzed, the validity of applied procedures, and the completeness of the investigation in relation to the approved scope of the project;
- generated data is validated; and
- calculations, evaluations, and decisions completed or deduced during the execution of the study are accurate, appropriate, and consistent with the objectives of the investigation.

The requirements of this QAPP are applicable to the activities of all participants in the investigation. This QAPP will address all anticipated activities necessary to execute the investigation.

1.1. Distribution List (A3)

Each organization listed on the approval sheet will receive a copy of this quality assurance project plan. Individuals taking part in the project may request additional copies of the Quality Assurance Project Plan (QAPP) from the LTI project manager listed in the following section of this QAPP.

1.2. Project Organization (A4)

Limno-Tech, Inc. (LTI) of Ann Arbor, Michigan, and its subcontractors, Baetis

Environmental Services, Inc. (Baetis) of Chicago, Illinois, Brighton Analytical Laboratories (BAL) of Brighton, Michigan, Animal Disease Laboratory – Illinois Department of Agriculture of Centralia, Illinois and ARDL, Inc. of Mt. Vernon, Illinois will conduct activities on behalf of the Illinois Environmental Protection Agency in support of TMDL development for impaired water bodies. LTI will maintain the technical responsibility for implementing the water quality sampling activities for the following watersheds: Macoupin Creek, Hodges Creek, Mauvaise Terre Creek, North Fork Kaskaskia River and Skillet Fork. Baetis will maintain the technical responsibility for implementing the water quality sampling activities for East Fork Kaskaskia River watershed. Brighton Analytical Laboratories (BAL) of Brighton, Michigan will provide analytical laboratory services for LTI. The Animal Disease Laboratory of Centralia, Illinois and ARDL, Inc. of Mount Vernon, Illinois will provide analytical laboratory services for Baetis.

LTI will coordinate activities with its subcontractors. The staff of LTI, Baetis and the laboratories will report to their respective team leaders and project managers for technical and administrative direction. Each staff member has responsibility for performance of assigned quality control duties in the course of accomplishing identified tasks. The quality control duties include:

- completing the assigned task in a quality manner in accordance with the schedule and with established procedures.
- ascertaining that the work performed is technically correct and meets all aspects of the QAPP.

The roles and responsibilities of LTI and Baetis personnel that will work on this project are presented below and in Table 1:

Table 1 Project Organization/Responsibilities

Role	Personnel	General Responsibilities
Project Administrator, Quality Assurance Officer	David Dilks/LTI	General and QA oversight; Review/approval of all work products
Project Manager	Penelope Moskus/LTI David Pott/Baetis	Project management; Direct all field, data evaluation, and reporting activities
Project Engineer/Scientist	Robert Betz, Chris Cieciek, Cathy Whiting/LTI David Pott/Baetis	Supervise all field sampling, quality assurance, data evaluation, and reporting activities
Assistant Project Engineer/Scientist	Chris Behnke, Nick Bogater, Brian Lord, Cullen O'Brien, Ed Verhamme/LTI Chloe Pott/Baetis	Field and technical support

Responsibilities and duties of the analytical laboratories include the following:

- Perform analytical procedures;
- Supply sampling containers and shipping cartons;
- Maintain laboratory custody of samples;
- Strictly adhere to all protocols in the QAPP;
- Notify LTI project manager in advance of any deviations to QA protocols.

Project Administrator. The project administrator is responsible for the overall administration and staffing of the project. As part of the QA/QC responsibilities, the project administrator will:

- Provide for overall direction of project objectives and activities;
- Provide for QA/QC management of all aspects of the project within the stated scope of responsibility;
- Approve reports and other materials for release to members of the project team and other external organizations.

Project Manager. The project manager is responsible for maintaining a clear definition of and adherence to the scope, schedule, and budget of the project. As a part of this responsibility, the project manager will:

- Serve as the communication link with the project team members and client(s);
- Direct all work performed by the organization and its subcontractors;
- Perform final review of field data reductions, report submittals, and presentations;
- Assure corrective actions are taken for deficiencies noted during project activities;
- Maintain budgetary and schedule surveillance of the work.

Project Engineer/Scientist. The project engineer/scientist is responsible for the implementation of field activities, initial data acquisition, health and safety aspects of field activities, and for the proper selection and execution of procedures that have been accepted for use in the investigation. As part of the QA/QC responsibilities, the project engineer/scientist will:

- Supervise assistant project engineers/scientists, technicians, or subcontractors executing data gathering tasks;
- Supervise the collection of samples so that sampling remains representative of actual field conditions;
- Supervise the regular maintenance of equipment to prevent unnecessary equipment failures and project delays caused thereby;
- Review the effectiveness of procedures and suggest changes that will enhance or more efficiently accomplish the objectives of the investigation;
- Prepare and review field data reductions, reports, submittals, and presentations to assure that data and conclusions accurately reflect observed conditions in the field;
- Assist in the maintenance of budgetary and scheduling surveillance.

Assistant Project Engineer/Scientist. The assistant project engineer/scientist is responsible for the assisting in the implementation of field activities, initial data acquisition, health and safety aspects of field activities, and for the proper selection and execution of procedures that have been accepted for use in the investigation. As part of the QA/QC responsibilities, the assistant project engineer/scientist will:

- Perform data gathering and compilation tasks;

- Assist in supervising technicians and subcontractors;
- Assist in reviewing the effectiveness of procedures and suggest changes that will enhance or more efficiently accomplish the objectives of the investigation;
- Assist in the collection of samples so that sampling remains representative of actual field conditions;
- Perform regular maintenance and calibration of equipment to prevent unnecessary equipment failures and project delays caused thereby;
- Assist in the preparation and review of field data reductions, reports, submittals, and presentations to assure that data and conclusions accurately reflect observed conditions in the field.

1.3. Problem Definition/Background (A5)

The project activities associated with this QAPP will include surface water sampling activities to provide data that will be used to support development of TMDLs for impaired water bodies in the following six State of Illinois watersheds:

- Macoupin Creek,
- Hodges Creek,
- Mauvaise Terre Creek,
- East Fork Kaskaskia River,
- North Fork Kaskaskia River and
- Skillet Fork.

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the 2004 303(d) list (IEPA, 2004), which is available on the web at http://www.epa.state.il.us/water/tmdl/303d-list.html. The Clean Water Act requires that a TMDL be completed for each pollutant listed for an impaired water body. TMDLs are prepared by the States and submitted to the U.S. EPA. In developing the TMDL, a determination is made of the greatest amount of a given pollutant that a water body can receive without exceeding water quality standards and designated uses, considering all known and potential sources. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation.

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams compiled, reviewed and evaluated the sufficiency of available data to support TMDL development for the listed watersheds. For each listed watershed, the data review included:

- confirmation of the impairments identified on the 303(d) list,
- further identification of potential sources causing these impairments,
- identification, description and recommendations for methodologies, procedures and/or models to be used in the development of TMDLs, and
- recommendations for additional data needed to support the modeling, where necessary, along with general data collection plans

The additional data collection work approved by Illinois EPA for the above-bulleted watersheds is presented and described in the following subsection of this QAPP. The data will be used for model development and calibration in support of TMDL development. Stream measurements of flow, dissolved oxygen, BOD, ammonia, water temperature, SOD and diurnal dissolved oxygen will be used to support QUAL2E dissolved oxygen modeling in streams. Coliform bacteria measurements will be used support development of a load-duration curve, and pH and iron measurements will support an empirical approach combined with spreadsheet calculations. Finally, manganese measurements in the Skillet Fork watershed will be collected to help determine its source (e.g., mining or natural background).

1.4. Project/Task Description (A6) and Schedule

Monitoring will be conducted within six watersheds in southern Illinois. Table 2 summarizes the scope of work for each watershed. The sampling sites and coordinates for each watershed are presented in Table 3 and depicted on Figures 1-6. All sampling activities will be conducted in accordance with standard operating procedures (SOPs) presented in Appendix A.

Stream Surveys. Stream sampling surveys will be conducted during low to medium flow conditions, as specified in Table 2. Coliform sampling will also be conducted during wet weather conditions. Survey deployment decisions will be based on real-time streamflows at USGS gages in or near the watershed. Low to medium flow surveys will be targeted for dry conditions and periods when the real-time streamflow of the nearest gage is in the vicinity of the 20th percentile flow value, based on the period of record data.. If necessary, low to medium flow surveys may be conducted at slightly higher flows, when the real-time streamflows are in the vicinity of or less than the 50th percentile flow value. Tributary monitoring will be conducted if the tributaries are flowing. The USGS gages and daily mean flow statistics are presented in Table 4.

Surface Water Quality Sampling. Water quality grab samples and water quality measurements will be collected at mid-stream or at the location where maximum flow is observed, where safely practicable. Grab samples will be collected from bridges, where possible, preferably using weighted bottle, dip or direct samplers attached to a pole or a line. Sampling equipment will be decontaminated between locations using a river water rinse followed by a triple deionized water rinse and generally following the SOP for Equipment Cleaning presented in Appendix A. Water quality samples will be stored in an iced cooler prior to and during overnight express shipment to the analytical laboratory following strict chain-of-custody procedures as specified in the Sample Handling, Packing and Shipping SOP presented in Appendix A. As an exception, E. coliform samples will be delivered directly to the laboratory by sampling personnel or picked up in the field by a laboratory courier in order to meet holding times. The samples will be analyzed for BOD_5, ammonia, nitrate-nitrite, coliform bacteria, total manganese and/or total iron, as specified for the different watershed surveys in Table 2.

Surface Water Measurements. Field water quality measurements (i.e., water temperature, pH, dissolved oxygen (DO)) will be recorded using instruments (e.g., YSI, Hydrolab meters) that are calibrated daily in accordance with manufacturer recommendations. Channel morphometry/stream depth, and water velocity measurements will be conducted in accordance with the SOP for Surface Water Flow Measurements in Appendix A. Locations will be selected for channel morphometry/stream depth and water velocity measurements based on two factors: 1) is it a good site for flow calculation; and 2) are the sites spaced out throughout the watershed. Sediment oxygen demand (SOD) and continuous DO measurements will be conducted in accordance with the SOPs for Sediment Oxygen Demand Measurements and Field Water Quality Measurements, respectively, presented in Appendix A. Locations for SOD measurements will be selected in the field, and will be representative of conditions in the river.

Schedule. An example schedule for implementation of data collection activities is presented in Table 5. Field activities will commence within two weeks after Illinois EPA communicates approval of the QAPP and approval to proceed, subject to the sampling requirements (i.e., discharge level and precipitation conditions) being met for each watershed. It is anticipated that all dry weather low or medium flow events will be conducted before the fall wet weather season. Available USGS surface water discharge gages in or near the watersheds will be monitored to determine the occurrence of appropriate flow levels for field deployment. The schedule will be updated as necessary and will be used by the Project Manager to review overall progress of the project.

Table 2 Scope of Work

Watershed	Waterbody name (ID)	Work Description
Macoupin Creek	Macoupin Creek (DA04, DA05), Briar Creek (DAZN)	1 low-to-medium-flow survey to measure: • DO, temperature, BOD, ammonia, channel morphometry at 12 sites (5 mainstem, 7 tribs) • Depth and velocity at 4 mainstem sites (to be determined in the field) • SOD and continuous DO monitoring at 1 site representative of river (to be determined in field) 1 low-to-medium flow survey to measure: • DO, temperature, BOD, ammonia, channel morphometry at 12 sites (5 mainstem, 7 tribs) • Depth and velocity at 4 mainstem sites (to be determined in the field)
Hodges Creek	Hodges Creek (DAG02)	1 low-to-medium-flow survey to measure: • DO, temperature, BOD, ammonia, channel morphometry at 7 sites (1 mainstem, 6 tribs) • Depth and velocity at 4 sites (Hodges Ck @ Cnty Hwy 24, Otter Ck @ Rte 108 bridge, Otter Cr @ Henry Rd, 1 tributary to be determined in the field) • SOD and continuous DO monitoring at 1 site representative of river (to be determined in field) 1 low-to-medium-flow survey to measure: • DO, temperature, BOD, ammonia, channel morphometry at 7 sites (1 mainstem, 6 tribs) • Depth and velocity at 4 sites (Hodges Ck @ Cnty Hwy 24, Otter Ck @ Rte 108 bridge, Otter Cr @ Henry Rd, 1 tributary to be determined in the field)
Mauvaise Terre Creek	North Fork Mauvaise Terre Creek (DDC)	1 low-to-medium-flow survey to measure: • DO, water temperature, BOD, ammonia, channel morphometry at 4 sites (3 mainstem, 1 trib) • Depth and velocity at 2 sites (NF Mauvaise Terre Ck @ IL Rte 123, NF Mauvaise Terre Ck @ Lisbon Rd) • SOD and continuous DO monitoring at 1 site representative of river (to be determined in field)
East Fork Kaskaskia River	East Fork Kaskaskia River (OK01)	1 low-to-medium flow survey to measure: • BOD, nitrate-nitrite, ammonia at 15 locations (3 IEPA legacy stations, 2 other mainstem stations, 10 tributary stations) • SOD at one location representative of river (to be determined in the field) • DO and water temperature at 35 locations (4 IEPA legacy stations, 7 other mainstem stations, 3 NPDES stations, and 21 tributary stations) • Discharge, stream morphology, depth and velocity at 12 locations (3 IEPA legacy stations, 1 other mainstem station, 3 NPDES stations, 5 tributary stations) • Coliform bacteria at 17 stations (3 IEPA legacy stations, 1 other mainstem station, 3 NPDES stations, 10 tributary stations) 1 wet weather survey to measure: • Coliform bacteria at 17 stations (3 IEPA legacy stations, 1 other mainstem station, 3 NPDES stations, 10 tributary stations)

Watershed	Waterbody name (ID)	Work Description
North Fork Kaskaskia River	North Fork Kaskaskia (OKA01, OKA02)	1 low-to-medium-flow survey to measure: • DO, temperature, BOD, ammonia, channel morphometry at 7 sites (5 mainstem, mouth Louse Run, unnamed trib with discharge from Patoka STP) • Depth and velocity at 3 mainstem sites (to be determined in the field) 1 low-to-medium flow survey to measure: • pH and total Fe at 7 locations (5 mainstem, mouth Louse Run, unnamed trib with discharge from Patoka STP) • SOD and continuous DO monitoring at 1 site representative of river (to be determined in field) • DO, temperature, BOD, ammonia, channel morphometry at 7 sites (5 mainstem, mouth Louse Run, unnamed trib with discharge from Patoka STP) • Depth and velocity at 3 mainstem sites (to be determined in the field)
Skillet Fork	Skillet Fork (CA03, CA05, CA06, CA09), Horse Creek (CAN01), Brush Creek (CAR01), Dums Creek (CAW01)	1 low-to-medium flow survey to measure: • Mn at 10 locations (2 each per segments CA03, CA05, CA06, CAN01, CAR01) • pH at 6 locations (2 each per segments CA03, CA05, CA06) • SOD and continuous DO at 7 sites representative of each stream segment (to be determined in field) • DO, temperature, BOD, ammonia, channel morphometry at 28 sites (12 mainstem, 16 tribs) • Depth and velocity at 6 sites representative of each stream segment (excluding segment CA05 with USGS gage) 1 low-to-medium-flow survey to measure: • DO, temperature, BOD, ammonia, channel morphometry at 28 sites (12 mainstem, 16 tribs) • Depth and velocity at 6 sites representative of each stream segment (excluding segment CA05 with USGS gage)

Table 3 Sampling Locations

Stream	Access	TMDL Station ID	Longitude	Latitude
Macoupin Creek Watershed				
Macoupin Cr	U.S. 67	DA 03	-90.19483079590	39.26235488860
Coop Branch	Victory Rd		-90.09148094130	39.19683004470
Macoupin Cr	Shipman Rd	DA 04	-89.97935149050	39.20104990470
Dry Fork	Lake Catatoga Rd		-89.95550388800	39.19418235490
Honey Cr	Brushy Mound Rd		-89.87360501930	39.24342942380
Briar Cr	Crumystone Rd	DAZN	-89.88056449760	39.26046630510
Macoupin Cr	Illinois Route 4	DA 05	-89.84931859880	39.25961219940
Shaw Point Branch	Sumpter Rd		-89.76970998510	39.31317888700
Macoupin Cr	Coops Mound Rd	DA 11	-89.77338896040	39.31660949520
Horse Cr	Sulphur Springs Rd		-89.71699036180	39.36629309710
Horse Cr	Boston Chapel Rd		-89.71851666130	39.38752831690
Macoupin Cr	2nd Rd		-89.66246194810	39.42305698530
Hodges Creek Watershed				
Hodges Cr	County Highway 24	DAG 03	-90.16966141040	39.26941869650
Joes Cr	Joes Cr Rd		-90.14273781100	39.29107306560
Otter Cr	Illinois Route 108		-90.10025314080	39.30522380070
Solomon Cr	Boyscout Rd		-90.03690323180	39.36116261880
Solomon Cr	not at a bridge		-90.01120398330	39.42342966540
unnamed tributary	near end of Wildcat Rd		-89.96479296510	39.40580948260
East Fork Otter Cr	Henry Rd		-89.81287422150	39.44858595910
Mauvaise Terre Creek Watershed				
N Fork Mauvaise Terre Cr	Lisbon Rd	DDC 11	-90.20582047410	39.74953834210
N Fork Mauvaise Terre Cr	Mobil Rd	DDC 12	-90.18233912890	39.74710985640
unnamed tributary	I-72		-90.15349792340	39.73605259570
N Fork Mauvaise Terre Cr	Illinois Route 123		-90.04261497410	39.77177676000

Stream	Access	TMDL Station ID	Longitude	Latitude
East Fork Kaskaskia River Watershed				
East Fork Kaskaskia River	Gerrish Road	B OK 99	-89.12058888889	38.70354444444
East Fork Kaskaskia River	US 51	B OK 01	-89.10000000000	38.69102222222
Davidson Creek	Ferrydale Road	B OKB 11	-89.09776944444	38.68897222222
Davidson Creek	Seven Hills Road	B OKB 12	-89.04945833333	38.67211388889
Davidson Creek	Hoots Chapel Road	B OKB 13	-89.01400000000	38.66851111111
Barden Creek	Seven Hills Road	B OKBA 11	-89.04880833333	38.68203055556
East Fork Kaskaskia River	County Rd 1600	B OK 11	-89.07460833333	38.70666666667
East Fork Kaskaskia River	Marshall Creek Road	B OK 12	-89.03108888889	38.72515833333
East Fork Kaskaskia River	McNicol Road	B OK 02	-89.01072500000	38.73550000000
Jims Creek	Marshall Creek Road	B OKC 11	-89.03095555556	38.71138333333
Jims Creek	Jims Creek Road	B OKC 12	-89.00461388889	38.70933055556
Jims Creek	Oak Grove Road	B OKC 13	-88.97185555556	38.72206944444
Wills Creek	Alma Hatchery Road	B OKCA 11	-88.98985555556	38.70728611111
Warren Branch	Bilek Road	B OKG 11	-88.94855277778	38.75850555556
Warren Branch	Hicks Road	B OKG 12	-88.93192777778	38.73668055556
unnamed tributary 1	Hester Lane	B OKGZ 11	-88.91284722222	38.72951388889
unnamed tributary 2	Malone Road	B OKGZ 21	-88.92349166667	38.72885833333
East Fork Kaskaskia River	Kinoka Road	B OK 13	-88.94912500000	38.76224444444
unnamed tributary 3	County Road 1425	B OKZ 11	-88.87928611111	38.77494722222
unnamed tributary 4	West Case Street	B OKZ 21	-88.85903888889	38.77711388889
East Fork Kaskaskia River	St Peter Road	B OK 03	-88.84549166667	38.80626111111
East Fork Kaskaskia River	Gentry Road	B OK 14	-88.85922777778	38.80478611111
Lone Grove Branch	Gentry Road	B OKE 11	-88.86239166667	38.81023611111
Lone Grove Branch	County Road 700	B OKE 12	-88.84495555556	38.83899722222
Lone Grove Branch	County Road 800	B OKE 13	-88.83516944444	38.85336111111
unnamed tributary 5	County Road 2200	B OKEZ 11	-88.84451111111	38.85566388889
East Fork Kaskaskia River	Blomberg Road	B OK 15	-88.82674722222	38.80373888889
unnamed tributary 6	Vandeveer Street	B OKFZ 11	-88.82664722222	38.78469166667
Schneider Springs Branch	Illinois Route 37	B OKF 11	-88.81688055556	38.79656667000
East Fork Kaskaskia River	Sullivan Road	B OK 16	-88.80781666667	38.81533333000

Stream	Access	TMDL Station ID	Longitude	Latitude
unnamed tributary 7	local Farina street	B OKZ 31	-88.78804722222	38.82535555556
unnamed tributary 8	local Farina street	B OKZ 41	-88.78504722222	38.82707777778
unnamed tributary 7	Echof Street	B OKZ 32	-88.78126944444	38.83217500000
unnamed tributary 7	Illinois Road 185	B OKZ 33	-88.77479166667	38.83786111000
East Fork Kaskaskia River	Echof Street	B OK 17	-88.79771388889	38.82601111111
North Fork Kaskaskia River Watershed				
North Fork Kaskaskia River	County Road 300	OKA 01	-89.19385616200	38.74162579850
Louse Run	County Road 2150		-89.16621508190	38.73750964400
North Fork Kaskaskia River	County Road 100		-89.16377644200	38.75219332070
unnamed tributary	not at a bridge		-89.11480254660	38.76036325090
North Fork Kaskaskia River	U.S. 51		-89.08657432240	38.77396168120
North Fork Kaskaskia River	not at a bridge		-88.98827934220	38.78507402690
North Fork Kaskaskia River	Hadley Rd		-88.92251900000	38.81332160000
Deer Cr	Boat Dock Rd		-89.10775406760	38.76519444490

Stream	**Access**	**TMDL Station ID**	**Longitude**	**Latitude**
Skillet Fork Watershed				
Skillet Fork	County Highway 1	CA 03	-88.16415217920	38.15479579740
Limekiln Cr	not at a bridge		-88.22938678370	38.16103442950
Sevenmile Cr	not at a bridge		-88.23160843460	38.15357838750
Skillet Fork	County Road 475	CA 02	-88.28406719800	38.16359967360
Skillet Fork	~1 mi south of County Road 500N		-88.49457745840	38.31343869660
Skillet Fork	near Illinois Route 15	CA 05	-88.58337492580	38.35831917750
Puncheon Cr	near County Rd 100E		-88.68415188910	38.37476836780
Horse Cr	County Road 200E	CAN 01	-88.66257719530	38.37677587620
Skillet Fork	County Road 900N		-88.61409624450	38.38777369600
Horse Cr	Malecki Rd		-88.75649378860	38.42393172170
Horse Cr	Moonbeam Ln		-88.81111003440	38.45344064110
Skillet Fork	County Highway 13		-88.65238195360	38.46648093630
Brush Cr	County Highway 27	CAR 01	-88.63489866570	38.47584424840
Skillet Fork	Strt 161 Extension	CA 06	-88.72705842260	38.51960397070
Brush Cr	County Highway 16		-88.60850107560	38.52338314200
Bob Branch	County Road 1900N		-88.59792835420	38.53449893060
Skillet Fork	at end of Seed House Rd		-88.74108667380	38.54880816290
Nickolson Cr	Dago Hill Rd		-88.72201515260	38.55124806790
Fulton Cr	Landmark Rd		-88.76797079850	38.57135034760
Brush Cr	County Road 2200N		-88.59131791570	38.57809407280
Skillet Fork	near end of Blank Rd	CA 08	-88.74828647270	38.59112024710
Dums Cr	Landmark Rd	CAW 04	-88.76750287030	38.65369981820
Skillet Fork	near end of Burkett Rd		-88.73375590070	38.65647408140
Dums Cr	Bee Branch Rd		-88.83988279890	38.66420459560
Skillet Fork	at end of County Road 80E	CA 09	-88.69735030890	38.71610228030
Sutton Cr	County Road 150		-88.68603981220	38.72281392080
Dums Cr	Williams Rd		-88.85472799280	38.73694029780
Skillet Fork	near Krustinger Rd		-88.70500602780	38.74410228390

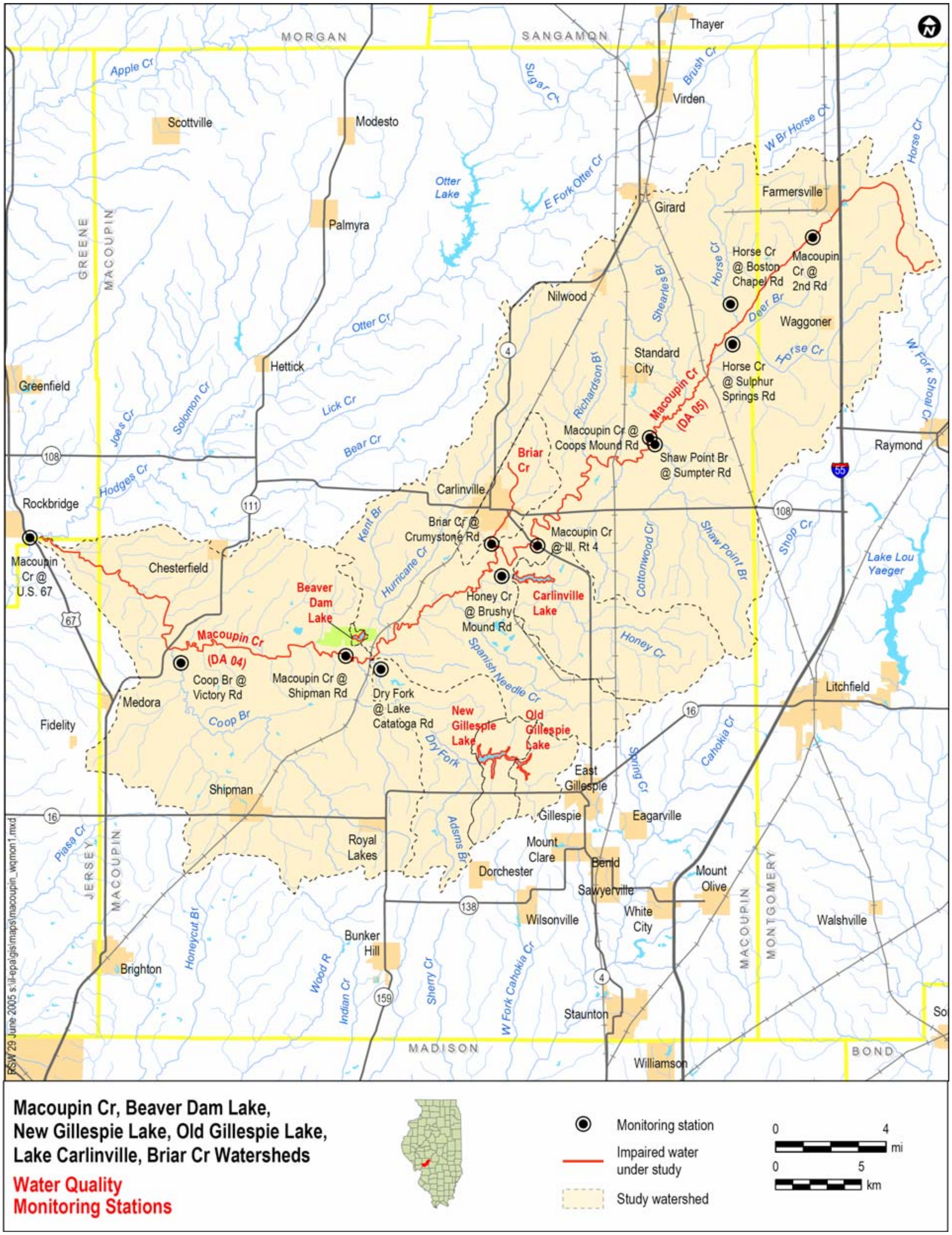


Figure 1. Macoupin Creek Watershed Sampling Locations

This page is blank to facilitate double sided printing.

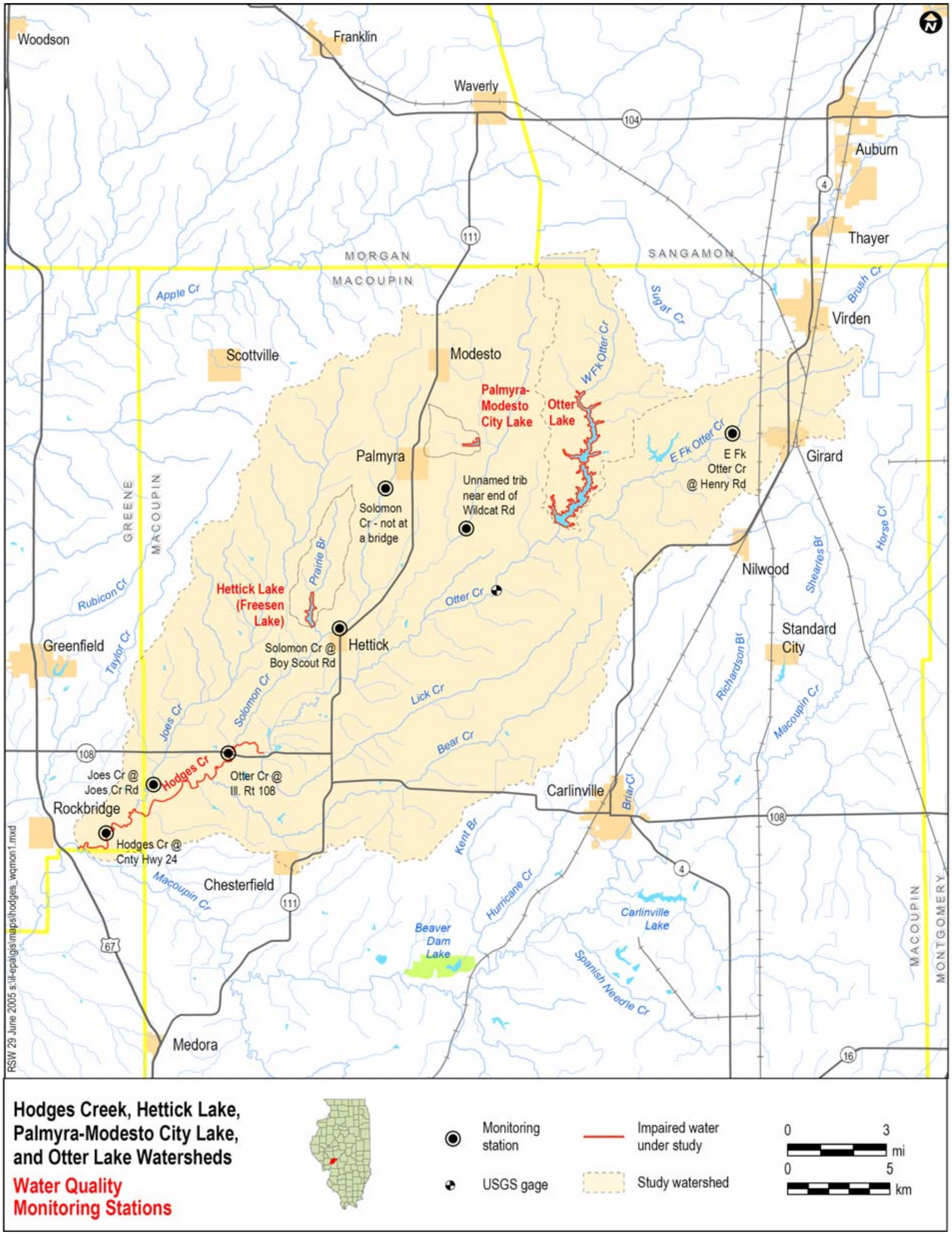


Figure 2. Hodges Creek Watershed Sampling Locations

This page is blank to facilitate double sided printing.

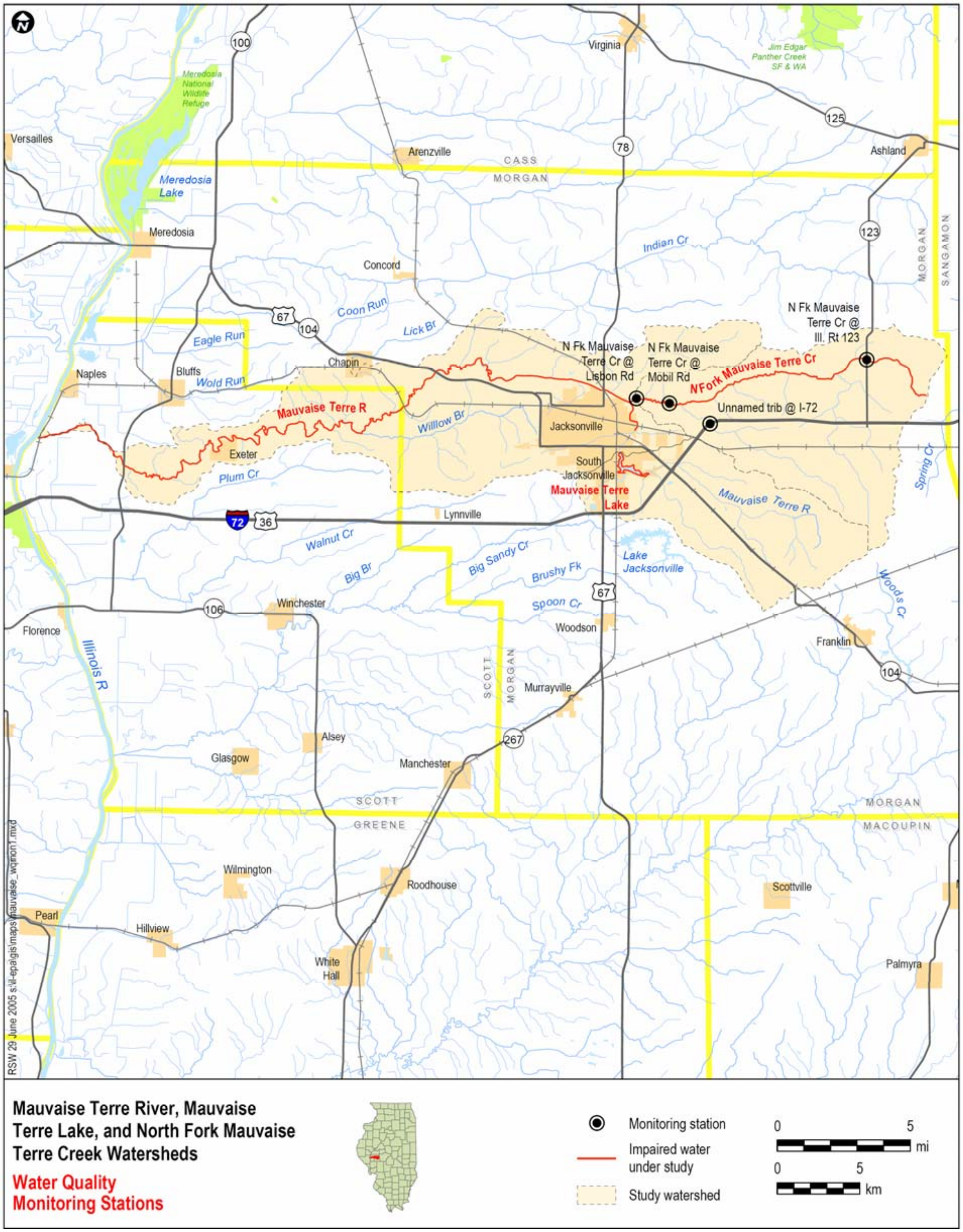


Figure 3. Mauvaise Terre Creek Watershed Sampling Locations

This page is blank to facilitate double sided printing.

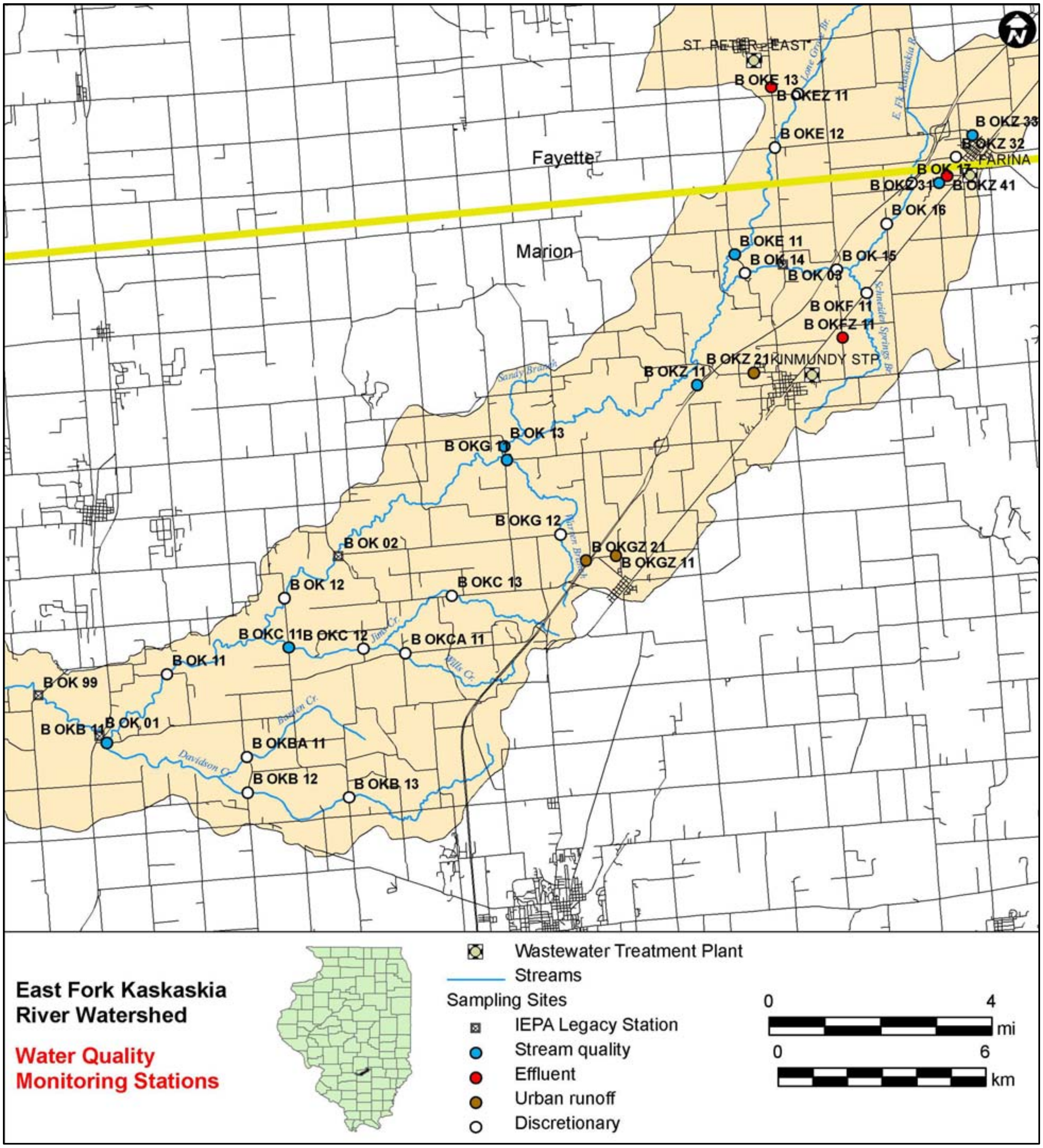


Figure 4. E. Fork Kaskaskia River Watershed Sampling Locations

This page is blank to facilitate double sided printing.

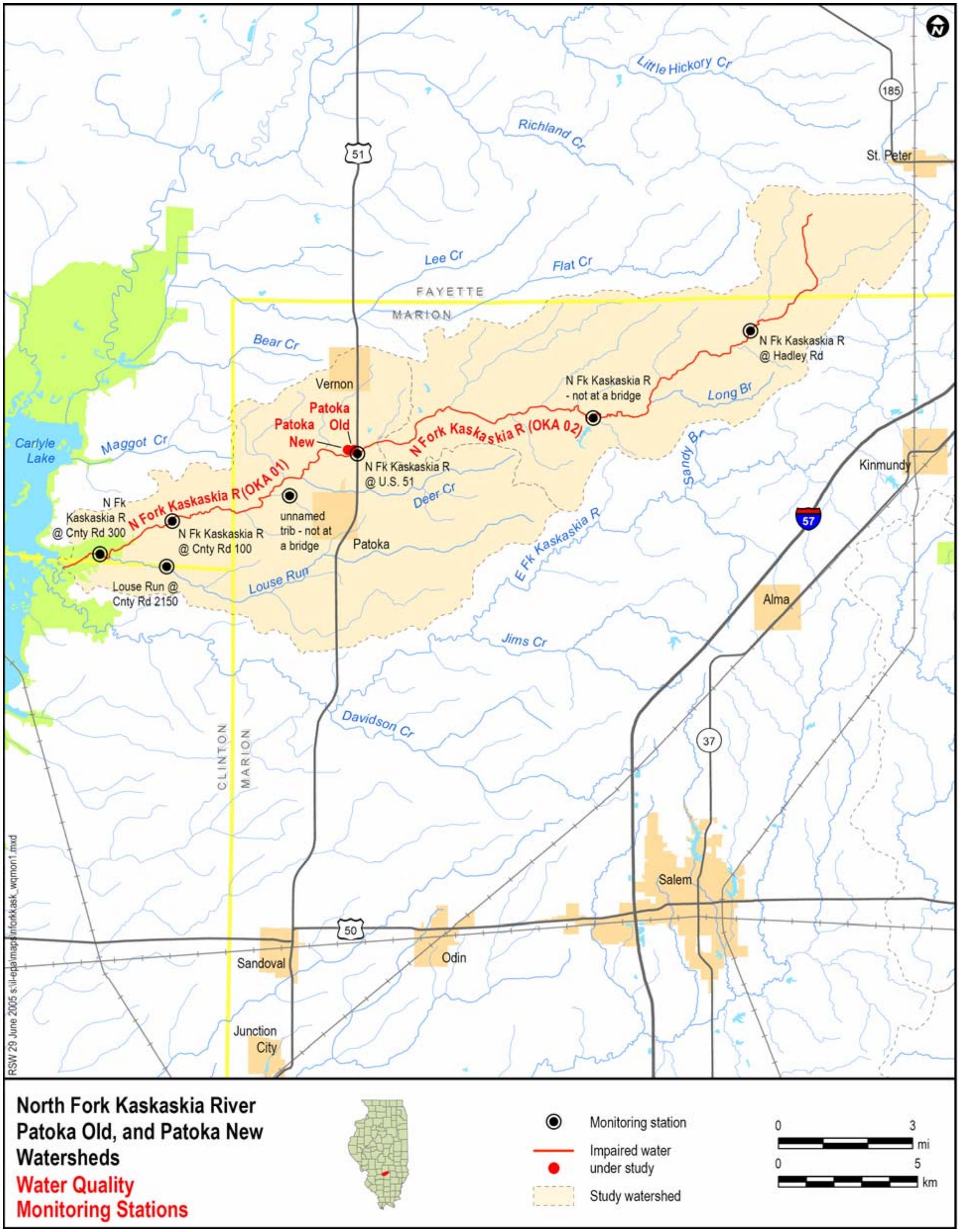


Figure 5. N. Fork Kaskaskia River Watershed Sampling Locations

This page is blank to facilitate double sided printing.

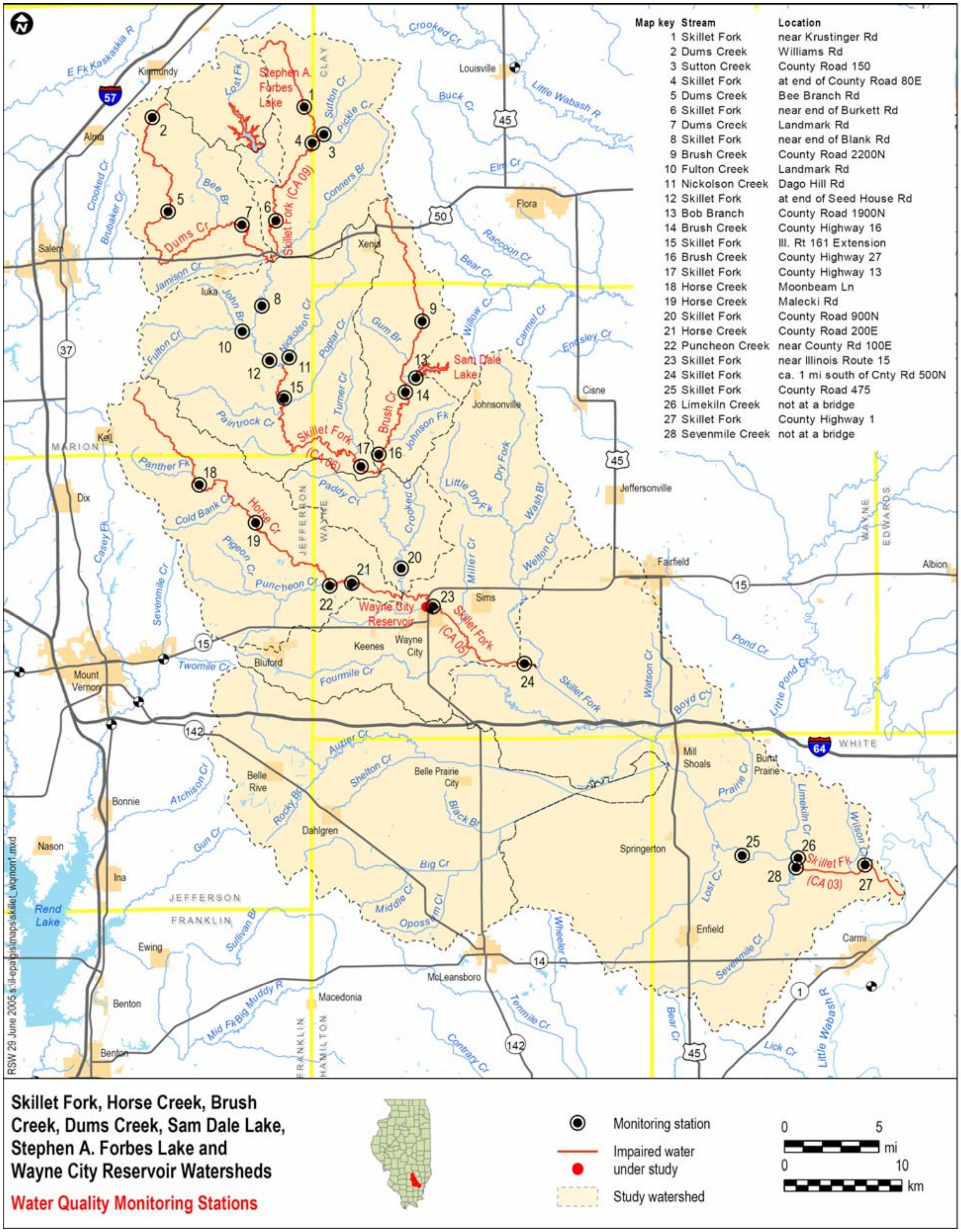


Figure 6. Skillet Fork Watershed Sampling Locations

This page is blank to facilitate double sided printing.

Table 4 USGS Gage Streamflow Statistics

Watershed	Nearest USGS Gage	USGS Gage Number	20th Percentile Flow (cfs)	50th Percentile Flow (cfs)	80th Percentile Flow (cfs)
Mauvaise Terre	Spring Cr at Springfield, IL	05577500	1.2	21	80
Hodges Macoupin	(See Macoupin Cr Gage) Macoupin Cr near Kane, IL	05587000	16	100	465
NF Kaskaskia EF Kaskaskia	(See E Fork Kaskaskia River gage) E Fork Kaskaskia River near Sandoval, IL	05592900	0.5	8.5	54
Skillet Fork	Skillet Fork at Wayne City, IL	03380500	3.9	36	312

Percentile values calculated from USGS website daily mean streamflow values for the period of record
The USGS real-time streamflow values for these gages can be accessed at the following URL:
http://waterdata.usgs.gov/il/nwis/uv?multiple_site_no=05587000%0D%0A05586800%0D%0A05586000%0D%0A05577500%0D%0A05594450%0D%0A05592900%0D%0A03380500%0D%0A&search_site_no_match_type=exact&index_pmcode_00065=3&index_pmcode_00060=4&index_pmcode_00045=5&index_pmcode_00055=&index_pmcode_72019=&sort_key=site_no&group_key=NONE&sitefile_output_format=html_table&column_name=agency_cd&column_name=site_no&column_name=station_nm&column_name=lat_va&column_name=long_va&column_name=state_cd&column_name=county_cd&column_name=alt_va&column_name=huc_cd&period=7&begin_date=&end_date=&format=gif&date_format=YYYY-MM-DD&rdb_compression=file&list_of_search_criteria=multiple_site_no%2Crealtime_parameter_selection

Table 5 Schedule

Event	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Approval to proceed from IL-EPA	**X**							
Macoupin Creek								
Survey 1 - low/medium flow								
Survey 2 - low/medium flow								
Hodges Creek								
Survey 1 - low/medium flow								
Survey 2 - low/medium flow								
Mauvaise Terre Creek								
Survey 1 - low/medium flow								
East Fork Kaskaskia River								
Survey 1 – low/medium flow								
Wet Weather Bacteria Survey		As weather permits						
North Fork Kaskaskia River								
Survey 1 - low/medium flow								
Survey 2 - low/medium flow								
Skillet Fork								
Survey 1 - low/medium flow								
Survey 2 - low/medium flow								

1.5. Quality Objectives and Criteria (A7)

The monitoring information collected will meet the quality objectives and criteria outlined in this section and presented in Table 6. Data quality will be measured for the monitored parameters in terms of minimum measurement criteria, minimum measurement objectives, required detection limits, accuracy, precision and completeness.

Minimum measurement criteria will be established at the lowest analyte concentration required for planned uses of the measurement data. Minimum measurement criteria are State of Illinois water quality standards for general use waters, where applicable. Where no minimum measurement criteria can be identified, the water samples will be analyzed to the lowest concentration readily achievable by the contract laboratory.

The minimum measurement objectives will be set at approximately one-fifth of the minimum measurement criteria shown to ensure that analytes will be measured with reasonable accuracy at the minimum measurement criteria concentrations, and measured to reasonable levels below the minimum measurement criteria. The minimum measurement objective for any analyte will be achieved when the analytical procedure selected for sample analysis can be shown to have a method detection limit (MDL) at or below the minimum measurement objective. Analyte MDLs will be determined from the USEPA analytical methods used (as found in the Code of Federal Regulations (CFR), Volume 40, Part 136, Appendix B). The MDL is defined as the minimum constituent concentration that can be distinguished from a sample with no analyte at a 95 percent confidence level. Since the MDL procedure is based upon precision obtained for a standard greater than the MDL, it also is a measure of method sensitivity at concentrations near the MDL.

For analytes without minimum measurement criteria, the minimum measurement objectives will be understood to be the MDL level that is readily achievable using analytical methods generally employed at the contract laboratory. For field parameters where MDLs are not applicable such as pH, temperature, and dissolved oxygen, the minimum measurement objectives are the sensitivity of the measurement method.

Table 6 Measurement Objectives and Criteria

Parameter	Minimum Measurement Criteria	Minimum Measurement Objectives	Method*; MDL[1]	MS/MSD * Accuracy (% recovery)	MS/MSD * Precision (RPD)	LCS * Accuracy (% recovery)	Completeness
Dissolved Oxygen	NA	0.1 mg/l [s]	Field; NA	NA	NA	NA	90%
Water Temperature	NA	0.1 degree C [s]	Field; NA	NA	NA	NA	90%
pH	NA	0.1 pH unit[s]	Field; NA	NA	NA	NA	90%
Ammonia	15.0 mg/l[G]	3.0 mg/l	EPA 350.1/ 350.3; 0.01/0.03 mg/l	80-120%	20%	80-120%	90%
Nitrate-Nitrite	No Standard	0.05 mg/l	EPA 353.1	80-120%	6%	80-120%	90%
BOD_5	No Standard		EPA 405.1/ SM5210 B; 2 mg/l	N/A	20%	N/A	90%
Iron, Total	0.017 mg/l[G, 2]	0.005 mg/l	EPA 200.8; 0.02 mg/l	70-130%	20%	80-120%	90%
Manganese, Total	1 mg/l[G]	0.2 mg/l	EPA 200.8 0.02 mg/l	70-130%	20%	80-120%	90%
Eschericia coli	No standard	20 counts/100ml	SM 9223 B; 1 count/100ml	NA	NA	Positive	90%

NA = Not Applicable
SM - Standard Methods of the Examination of Water and Wastewater, 20th Edition
s = Required sensitivity
EPA - EPA Methods for Chemical Analysis of Water and Wastes, March 1983
* = Limits are subject to change based upon capabilities of contract labs
1 = Method Detection Limit (MDL) from SM and EPA.
2 = Calculated acute standard based on a minimum water hardness of 100 mg/L as $CaCO_3$
G = State of Illinois General Use Water Quality Standard

1.6. Special Training/Certification (A8)

A variety of professional staff (engineers, scientists and others) will be involved in this monitoring program. Project staff will be assigned duties based on their qualifications to accomplish the task. The Project Manager will determine the appropriateness of an individual to undertake a task.

Training sessions will be carried out for all field staff on proper sampling, sample handling and shipping, and general field procedures prior to conducting the first sampling event. Specific emphasis will be placed on QA/QC issues as well as on health and safety. Field staff will receive a safety briefing conducted by the Field Manager with emphasis on field hazards and materials handling. Training will also include the operation, maintenance and calibration of field equipment, including multi-parameter probes, velocity meters, and all other on-site equipment used throughout the field program. SOPs for program elements will be distributed to appropriate staff and available at all times.

The laboratory Technical Director will be responsible for training and certifications of laboratory personnel. All laboratory personnel will receive appropriate training and have proven proficiency in their designated analytical procedures. Laboratory personnel will be provided copies of the appropriate laboratory procedures, which will be available at all times.

1.7. Documents and Records (A9)

The Project Manager will ensure that the project team has the most current approved version of the QAPP. The project manager is responsible for initiating project files and for overseeing maintenance of the files during the course of the project. All project files will be properly identified by client, project name, project code and file description for all appropriate correspondence, memoranda, calculations, technical work products, and other project-related data. In addition, a quality assurance file will be maintained containing all QA/QC related information. A back up of all computer files containing important project information will also be maintained.

Documents generated by field activities may include staff notes, field logs, equipment logs, field on-site measurement data sheets, field audit reports and chain of custody forms. Documents generated by laboratory activities may include QA/QC documentation, laboratory bench sheets, laboratory results, and laboratory audit reports. These documents will be maintained in the project files.

At the conclusion of the project, all relevant information from the project files and computer disks will be archived. Documents will be retained for a minimum period of three years following archiving.

2 Data Generation and Acquisition (Group B)

The U.S. EPA QAPP Guidance Group B Data Generation and Acquisition elements (B1-B10) are addressed below.

2.1. Sampling Process Design (B1)

The sampling process design is presented in Sections 1.3 and 1.4 of this QAPP, including sampling rationale, locations, media, frequencies, and schedules.

2.2. Sampling Methods (B2)

Standard operating procedures (SOPs) will be employed to provide consistency and reproducibility to the sampling methods used by field personnel. The following sections present or reference the detailed methods for performing sampling activities including related support procedures for equipment cleaning, field measurements, and calibration and maintenance of field instruments. Sample custody procedures are presented in the Sample Handling and Custody Section of this QAPP.

2.2.1. Surface Water Sample Collection

Surface water grab samples will be collected as specified in the Section 1.4 and according to the procedures presented in Appendix A.

2.2.2. Stream Morphometric and Discharge Monitoring

Stream discharge monitoring will be conducted as specified in Section 1.4 and according to the procedures presented in Appendix A.

2.2.3. Field Water Quality Measurements and Monitoring

Instantaneous water quality measurements (e.g. temperature, pH and DO) will be collected using field instruments according to the procedures presented in Appendix A. In-situ monitoring instruments and equipment will be installed in a manner using methods that incorporate the unique requirements of specific locations. The main concern will be the security of the instruments, equipment and generated data. Maintenance, cleaning and/or data download activities for in-situ instruments will be performed at a frequency necessary to assure that representative data are generated and recorded for transfer to the project files.

2.2.4. Cleaning of Equipment and Materials

All reusable equipment and materials used during the field activities will be cleaned prior to use at the site and at specified intervals during the field activities. Cleaning will be performed according to the procedures specified in Section 1.4 and as presented in Appendix A to avoid the introduction of any chemical constituents or cross-contamination to the soils or groundwater. Equipment and materials that may be used during the investigation include water and/or sediment sample collection devices.

Equipment cleaning will be performed using water from a source approved by the project manager. If needed, a designated cleaning or decontamination area will be used or constructed so that all water generated during cleaning operations will be contained for proper disposal.

2.3. Sample Handling and Custody (B3)

Sample handling will be performed so as to collect, store, submit to the laboratory and analyze representative samples using methods as specified in Section 1.4 and according to the procedures presented in Appendix A. Sample containers, volumes, preservatives and holding times are summarized in Table 7. Laboratory sample custody will be performed in accordance with the laboratory's Quality Assurance Manual

2.4. Analytical Methods (B4)

The following section details aspects of the analytical requirements, ensuring that appropriate analytical methods are employed. Table 6 summarizes the analytical methods to be used by the contract laboratory. Table 7 displays the required container type, sample volume, preservation, and holding time for each parameter according to the previously referenced methods. The laboratory will provide sample containers from a commercial supplier. All sample containers will be new and pre-cleaned by the supplier. In addition, the contract laboratory will provide sample labels for each bottle and add the required preservative for each parameter, where feasible.

The analytical data results and intra-laboratory QA/QC results will be submitted by the contract laboratory to the Field Manager or other designated contact person within a specified time frame from the completion of each sampling event.

Table 7 Guidelines for Sample Container Preparation and Preservation

Parameter	Container	Recommended Sample Volume	Preservation	Holding Time
Coliform Bacteria	Pre-Sterilized Polyethylene or Glass	200 ml	Add $Na_2S_2O_7$ [1] Refrigerate to 4°C	6 hours[2]
NH_3 and nitrate-nitrite	Polyethylene or Glass	1000 ml	Add H_2SO_4, pH<2 Refrigerate to 4°C	28 days
BOD_5	Polyethylene or Glass	1000 ml	Refrigerate to 4°C	48 hours
Iron	Polyethylene or Glass	500 ml	Add HNO_3, pH<2 Refrigerate to 4°C	180 days
Manganese	Polyethylene or Glass	500 ml	Add HNO_3, pH<2 Refrigerate to 4°C	180 days

1. Sodium Thiosulfate ($Na_2S_2O_7$) prevents continuation of bacteriocidal action.
2. The maximum allowable holding time for bacteria samples is 30 hours with a regulatory goal of 6 hours when practical.

2.5. Quality Control (B5)

All field operations personnel are responsible for ensuring that proper procedures are followed for sample collection and handling, sample preservation, and sample custody of the delivered samples to the designated laboratory. If noncompliance issues arise, an investigation and corrective action report prepared by the responsible supervising field personnel will be submitted to the Project Manager. The accuracy and precision of all data measurements must be quantifiable. Analytical procedures used for data analysis must be performed according to approved standard methods. Data measurements should be recorded in a controlled environment in which a quality control program can be maintained.

Field quality will also be assessed through the collection of field duplicate samples and equipment rinse blank samples. Field duplicates will be collected at a frequency of one for every group of 10 samples. Rinse blank samples will be collected at a frequency of one for each day of sampling or one for every group of 20 samples.

The contract laboratory is responsible for implementing its QA/QC Manual, which is an internal quality assurance plan for laboratory procedures. The contract lab is responsible for the accuracy and reliability of analytical methods and final data reports. If noncompliance issues arise, an investigation and corrective action report will be prepared and submitted from the Laboratory Manager to the Project Manager. The contract lab is responsible for providing data qualifiers and/or case narratives to inform the Project Manager of any analytical exceptions that fall outside of routine method protocols. Analytical quality control will be performed in accordance with the laboratory QA/QC Manual, the specified analytical methods, and as discussed under the Quality Objectives and Criteria Section of this QAPP.

2.6. Instrument/Equipment Testing, Inspection, and Maintenance (B6)

All field and laboratory instruments/equipment shall be routinely maintained according to manufacturer instructions and accepted procedures associated with the selected analytical methods, SOPs and the laboratory's QA/QC Manual, as applicable. Field instruments and equipment shall be tested and inspected prior to sampling events. An adequate supply of spare parts shall be maintained as necessary for equipment maintenance.

2.7. Instrument/Equipment Calibration and Frequency (B7)

Calibration procedures for field and laboratory instruments/equipment will follow manufacturer instructions and accepted procedures associated with the selected analytical methods, SOPs and the laboratory's QA/QC Manual, as applicable. In order to maintain field precision and accuracy, the instruments will be calibrated to known standards.

2.8. Inspection/Acceptance of Supplies and Consumables (B8)

All supplies and consumables for field and laboratory activities will be inspected by the field operations teams and laboratory managers, respectively, to guarantee their usability. Supplies or consumables found to be deficient for the needs of the project will not be used.

2.9. Non-direct Measurements (B9)

Non-direct measurements will not be used in implementation of the monitoring program.

2.10. Data Management (B10)

Data generated through field and laboratory activities will be used for developing models and reports. Reporting formats will vary depending on the purpose for which the data has been assembled, but will include such items as field books, field calibration and measurement records, electronic data downloaded from field instruments, laboratory analytical results and QC reports. The Project Manager or designee has the responsibility of maintaining all documents and data generated during field programs and received from the laboratory. The Laboratory Technical Director has the same responsibility for laboratory data and information.

Field and laboratory documents will be kept in the project files. All electronic files will be backed up on a regular basis. At the conclusion of the project all relevant information, project files and electronic data will be turned over to the Project Manager. Paper and electronic files will be retained for a minimum period of three years following archiving.

3 Assessment and Oversight (Group C)

The U.S. EPA QAPP Guidance Group C Assessment and Oversight elements are addressed in this section.

3.1. Assessment and Response Actions (C1)

The sampling team will be evaluated to determine if sampling protocol is followed. Quality control and noncompliance issues related to field activities will require an investigation and corrective action conducted under the supervision of the Project Manager.

Laboratories contracted for data analysis shall maintain internal quality assurance programs described in their quality assurance plans. When the possibility of quality control problems or noncompliance issues arise that may affect the usability of data, an investigation and corrective action will be conducted by the Laboratory Technical Director and communicated to the Project Manager.

3.2. Reports to Management (C2)

Periodic summary reports will be prepared by the Project Engineer in charge of Quality Assurance, if necessary, to inform the Project Manager of the project status. The reports will include:

- Periodic assessment of measurement data accuracy, precision, and completeness;
- Results of performance audits and/or systems audits;
- Significant Quality Assurance/Quality Control problems and recommended corrective action;
- Status of corrective action implementation to any problems previously identified.

This page is blank to facilitate double sided printing.

4 Data Validation and Usability (Group D)

The U.S. EPA QAPP Guidance Group D Data Validation and Usability elements are addressed in this section. The purpose of these elements is to determine if the data meet the project's Data Quality Objectives (validation) and to evaluate the data against the method, procedural and/or contractual requirements (verification). Data validation, verification, and usability assessment will be conducted as outlined in this QAPP.

The data generated from the sampling program will be subjected to a multi-tiered review process described below. This process includes:

- A review of the data at the bench and field levels;
- A secondary review of field records by the Field Manager and analytical results within the laboratory by the lab QA/QC Manager to verify the data against method and SOP requirements;
- A review of the verified data by the Project Manager or designee for reasonableness and to identify obvious data anomalies;
- A validation by an objective third party, if necessary; and
- An assessment of the data by project team members for its usability to meet the project goals.

4.1. Data Review, Verification and Validation (D1)

All environmental measurement data collected by project staff will be subjected to quality control checks before being utilized in the interpretive reporting. A data generation system that incorporates reviews at several steps in the process is designed to protect the integrity of the data and reduce the number of data that do not meet the Data Quality Objectives (DQOs) or the project goals. This section describes the requirements of each review step that will be used in this project.

4.1.1. Data Verification Requirements

Data verification will occur at the field and laboratory level. This section describes the requirements of the data verification.

Field Activities Data Verification. The Field Manager will be responsible for ensuring that the samples are collected and handled according to the specified procedures. Sample collection verification will include confirming that the samples were collected with the proper equipment at the appropriate locations with the appropriate frequency. Sample handling verification will include confirming that the samples were stored in the appropriate containers with the correct preservative, that the samples were stored at the proper temperature during transport from the field to the laboratory, and that all of the appropriate information is logged on the chain-of-custody records.

Lab Activities Data Verification. The laboratory QA/QC Manager will be responsible for verification of laboratory-generated data, although the laboratory SOPs for each method may require some components of the verification to also be conducted at the bench level. Laboratory verification will include assessing that the procedures used to generate the data are consistent with the method requirements as specified in the laboratory's SOPs and that the QA/QC requirements for each method are met. Examples of method requirements include verifying the calibration and data reduction procedures. However, these requirements vary by analyte and are presented in more detail in the laboratory QA/QC Manual.

4.1.2. Data Review Requirements

The Field Manager will perform data reviews that consist of screening the field data sheets and laboratory data sheets according to established criteria listed in this section. If the established screening criteria are not met, an additional review of available laboratory data (e.g., quality control checks, relevant laboratory bench sheets) may be conducted. Investigation of the issue will be documented and the data will be discarded or flagged appropriately, identifying the limitations of the data.

Field Data Sheet Reviews. The following criteria may be used to screen the physical parameter measurements recorded by the field crews:

- temperature readings – check for reasonableness of values
- pH readings – check for reasonableness of values
- dissolved oxygen readings –compare concentrations to percent saturation

Laboratory Data Sheet Reviews. The following criteria will be used to screen the analytical measurements performed by the contract laboratory:

- equipment blanks –values should be less than detection limits
- method blanks –values should be less than detection limits
- field blanks – are values less than detection limits
- review of all analytical results – check for reasonableness of values

4.1.3. Data Validation Requirements

Data validation is typically performed by someone independent of the project activity and not associated with the organization responsible for producing the dataset. However, the data validator needs to be familiar with both the data validation requirements and the project objectives. A scientist/engineer not directly involved in the project administration, project management, field or laboratory operations will conduct the data validation. There are four requirements in the data validation process as follows:

- Inspect the data verification and review records to ensure that no oversights were made during that process.
- Evaluate the data against the project DQOs. If data do not meet one or more of the DQOs, the data validation process will include an investigation into causes and an assessment of the impact of the noncompliant data on project objectives.
- Evaluate the data in the context of the project's overall objectives.
- Communicate the data validation results to the rest of the project team.

4.2. Verification and Validation Methods (D2)

All environmental measurement data and samples collected by project staff will be subjected to quality control prior to being entered into the project database. This is a multi-step process where the laboratory QA/QC Manager will have primary responsibility for verifying the data and a third party, preferably one who is not involved in data collection or analysis, conducts the data validation. These steps are described in more detail in the following sections.

4.2.1. Data Verification

This section describes the procedures that will be utilized in this project for verifying the data against method, procedural and/or contractual requirements.

Field Activities Data Verification. Individual crew leaders will verify the completion of their field data sheets and chain-of-custody forms. In addition, crew leaders will also verify the proper calibration and operation of their multi-parameter instruments. At the completion of each monitored event, the Field Manager will review all field data sheets, calibration sheets, and chain-of-custody forms for accuracy and completeness. The Field Manager will also verify that monitoring QA objectives for all accuracy, precision, completeness, and adherence to the required collection techniques are being met.

Laboratory Analytical Results Verification. Individual analysts will verify the completion of the appropriate analytical test and required bench sheets. The laboratory Technical Director or designee will review calculations and inspect laboratory bench sheets and log books daily to verify their accuracy, completeness, and adherence to the specified analytical method protocols. Calibration and QC data will be examined daily by the individual analyst. The laboratory Technical Director or designee will verify that all instrument systems are operating within control limits and that QA objectives for accuracy, precision, completeness, and adherence to the required detection limits are being met.

A summary of reportable QA/QC results and any non-conformance issues will be included in the laboratory deliverable to the Field or Project Manager.

4.2.2. Data Validation

This section describes the process that will be used to validate the data generated for this project. The first requirement is to inspect the data verification results and review records to ensure that no oversights were made during that process. A complete set of field and laboratory information will be provided to the data validator for this task.

The primary objective of the data validation in this project is to evaluate the data conformance with the project DQOs. These DQOs include criteria for accuracy, precision, completeness, and compliance with required detection limits. The components described under the Data Management Section of this QAPP will provide the necessary information to make this evaluation. The following must be reviewed as part of the measurement data and analytical data validation activities:

- field measurement data,
- field sample collection information,
- sample custody records,
- laboratory analytical results,
- data review information and/or laboratory case narrative,
- quality control data.

The data validator will conduct a systematic review of the data for compliance with the established quality control criteria based on duplicate, replicate, spiked, control, and blank data results provided by the laboratory. In addition, quality assurance evaluations of data accuracy, precision, and completeness will be performed on the field measurement data and the laboratory analytical results for each monitored event. The data validation qualifiers listed in Table 8 will be used when validating the data:

Table 8 Data Validation Qualifiers

Qualifier	Definition
U	The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.
J	The associated value is an estimated quantity.
R	The data are unusable (note: analyte may or may not be present)
UJ	The material was analyzed for, but was not detected. The associated value is an estimated level.
B	Chemical was detected in the field blank at a concentration equal to or greater than the ML, or greater than one-fifth the level in the associated sample, whichever is greater.
D	Out of control field duplicate based on RPD control limit

If quality control checks or objectives were not met, an investigation of the non-conformance may be initiated by the data validator with the project team personnel, such as the Field Manager, the laboratory QA/QC Manager, and the Project Manager. The non-conformance will be documented and the affected data set will be flagged appropriately, identifying any limitations.

Another objective of the data validation is to evaluate the data within the context of the project goals. These goals include providing datasets that can be used to develop model inputs, to calibrate and validate the models, and to ensure consistency among different sources of data. Suitable datasets for the modeling portion of this project will be based on the data quality assessment described above as well as an assessment of the spatial and temporal extent of the sample collection. Comparability with other sources of data will be evaluated by comparing and, if necessary, plotting the data with previously collected data to identify outliers or anomalous values.

The data validation results will be communicated to the project team in the form of a summary table that lists the validation tasks and the associated results and conclusions. If the validated dataset includes non-compliant data, this data will be addressed in a memo that accompanies the summary table. Data qualifiers assigned to the data during validation will be maintained in the project database to ensure communication of validation results with current and future data users.

4.3. Reconciliation with User Requirements (D3)

Once all field measurements and analytical data have been reviewed, quality control measures assessed, and any problems addressed, the measurement and analytical data will be assessed by the Project Manager or designee.

The assessment of the information generated from the monitoring program will be initiated by entering all analytical data and field measurement data into the project database. Other data (such as precipitation, flow data, velocity data, stage data, field notes, and information on any sampling anomalies) may be appended. All of these data will be evaluated and any relationships or correlations will be noted. The compilation of all information surrounding a sampling and/or monitoring event will be available to facilitate reconciliation with user requirements.

This page is blank to facilitate double sided printing.

5 References

Illinois Environmental Protection Agency (IEPA). 2004. Illinois 2004 Section 303(d) List. Bureau of Water, Watershed Management Section. November 2004. IEPA/BOW/04-005 [online] http://www.epa.state.il.us/water/watershed/reports/303d-report/303d-2004.pdf

United States Environmental Protection Agency (EPA), 1998. *EPA Guidance for Quality Assurance Project Plans*, EPA QA/G-5. Washington , DC.

United States Environmental Protection Agency (EPA), 2002. *Guidance on Environmental Verification and Data Validation*. EPA QA/G-8. Washington, DC.

This page is blank to facilitate double sided printing.

Appendix A

This page is blank to facilitate double sided printing.

I. Introduction

This standard operating procedure (SOP) is applicable to the collection of representative liquid samples, both aqueous and non-aqueous, from streams, rivers, lakes, ponds, lagoons, and surface impoundments. It includes samples collected from depth, as well as samples collected from the surface. These typically applicable procedures have been adapted from the U.S. EPA Environmental Response Team Surface Water Sampling SOP No. 2013, dated 11/17/94 and may be varied or changed as required, dependent upon site conditions or equipment and procedural limitations. The actual procedures used should be documented in the field notes, especially if changes are made.

There are two primary interferences or potential problems with representative surface water sampling. These include cross contamination of samples and improper sample collection. Following proper decontamination procedures and minimizing disturbance of the sample site will eliminate these problems as follows:

- Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Refer to the Equipment Cleaning SOP.
- Improper sample collection can involve using contaminated equipment, disturbance of the stream or impoundment substrate, and sampling in an obviously disturbed area.

In order to collect a representative sample, the hydrology and morphometry of a stream or impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons or impoundments, flow patterns in streams, and appropriate sampling locations and depths. In addition, water quality indicator data may be collected, if necessary, in impoundments to determine if stratification is present. Measurements such as dissolved oxygen, pH, temperature, and redox potential can indicate if strata exist which would affect analytical results. Measurements should be collected at sufficiently sized intervals (e.g., 1 meter) from the substrate to the surface using the appropriate instrument (e.g., Hydrolab).

II. Materials

The following materials shall be available, as required, during surface water sampling. Back-up field instruments/equipment should be available, if required.

- Personal protective equipment (as necessary);
- Cleaning equipment (as required in the Standard Operating Procedure for Equipment Cleaning);
- Appropriate sampling apparatus and accessories (e.g., Kemmerer, weighted bottle, or Dip sampler, sample containers, sampling line, weights, messengers);
- Appropriate sample bottles, preservatives (if required) and sample bottle labels;
- Ziploc^{R}-type bags;
- Insulated coolers, ice, and appropriate packing material;
- Chain of Custody records and custody seals;
- Field data sheets, field log book, waterproof pen, camera and film;

- Decontamination equipment;
- Maps/plot plan, survey stakes/flags/buoys and anchors;

III. Preparations

- Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.
- Obtain the necessary sampling and monitoring equipment to suit the task. Consider sample volume, depth, deployment circumstances (shore, wading, boat, currents), type of sample, sampler composition materials, and analyses to be conducted.
- Decontaminate or pre-clean equipment and ensure that it is in working order.
- Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
- Perform a general site survey.
- Use stakes, flagging, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. If also collecting sediment samples, this procedure may disturb the bottom and cause interferences with collection of representative water samples.

IV. General Sample Collection Procedures

1. Record pertinent data on the field log (see attached Surface Water Sampling Field Log, or equivalent).

2. Label all sample containers with the date, time, site location, sampling personnel, and other requested information.

3. Don appropriate personal protective equipment (as necessary).

4. For coliform bacteria samples, use a sterile sample bottle and store the bottle cap in a sterile plastic bag to prevent contamination during sampling.

5. Clean all sampling equipment prior to sample collection according to the procedures in the Standard Operating Procedure for Equipment Cleaning.

6. At designated surface water sampling locations, thoroughly rinse the sampler in the water body prior to collecting the first sample.

7. For samples requiring field filtering, use a pump and in-line disposable filter, if possible to collect the sample directly into the sample container.

8. If field preservation is required, place appropriate preservative into the sample container prior to sample collection. Note the preservative and preservative column on the sample container and sampling log.

9. If any quality control samples are specified, they will be collected in the following manner:

- Duplicate samples should be collected at the same time or immediately following one another in accordance with the above procedures. If blind duplicate samples are specified, one of the duplicate samples should be labeled so that it does not identify the other sample of the duplicate pair to the laboratory on the chain-of-custody (COC). For example, one sample of the duplicate pair would be labeled following the normal protocol, while the second would be labeled with a sample ID of "DUPLICATE" and a blank line placed in the location, date and time boxes of the sample label. It is important that the duplicate pair samples are identified separately in the field notes with information including location, sample ID (as entered on the sample container label and COC), sample date and time so that analytical results can be paired after received from the laboratory.
- Rinse (or equipment) blanks should be collected from a final distilled/deionized water rinse of the specified sampling equipment after that piece of equipment has been cleaned in accordance with appropriate specified cleaning procedures.
- Field blanks, such as samples of water or reagents used to clean sampling equipment, should be collected directly into the sample bottle from the appropriate source container.

10. Record sample collection information on the field log and store the samples in an iced cooler as described in the Standard Operating Procedure for the Shipping and Handling of Samples.

11. Handle, pack, and ship samples according to the procedures in Standard Operating Procedure for the Shipping and Handling of Samples.

V. Equipment-Specific Sample Collection Procedures

Kemmerer Bottle. A Kemmerer bottle may be used in most situations where site access is from a boat or structure such as a bridge or pier, and where samples at depth are required. Sampling procedures are as follows:

1. Use a properly cleaned Kemmerer bottle. Set the sampling device so that the sampling end pieces (upper and lower stoppers) are pulled away from the sampling tube (body), allowing the substance to be sampled to pass through this tube.

2. Lower the pre-set sampling device to the pre-determined depth. Avoid bottom disturbance.

3. When the Kemmerer bottle is at the required depth, send down the messenger, closing the sampling device.

4. Retrieve the sampler and discharge from the bottom drain the first 10-20 mL to clear any potential contamination of the valve.

5. Transfer the sample to the appropriate sample container, as necessary, and cap securely.

Weighted Bottle Sampler. A weighted bottle sampler may be used in situations similar to those outlined for the Kemmerer bottle, but for near surface samples. Sampling procedures are as follows:

1. Use a thoroughly cleaned weighted bottle sampler with clean and/or disposable sample containers. For coliform bacteria samples, use a sterile sample bottle with the special sample bottle holder and store the bottle cap in a sterile plastic bag to prevent contamination.

3. Upon arrival at each field site, thoroughly rinse the sampler in the stream prior to collecting the first sample.

4. At the designated sampling location, carefully lower the weighted bottle sampler, allowing the sampler to fully submerse and fill with water. Coliform samples will be collected just below the surface of the stream at the center of flow.

5. Retrieve the sampler, transfer the sample to the appropriate sample container, as necessary, and cap securely.

Dip Sampler

A dip sampler is useful in situations where a sample is to be recovered from locations (e.g., outfall pipe, sump manhole, along a pond or lagoon bank) where direct access is limited. The long handle (or line if sampling from a bridge or other structure directly above the water body) on such a device allows access from a safe location. Sampling procedures are as follows:

1. Assemble the device in accordance with the manufacturer's instructions.

2. Thoroughly clean the sampler prior to use and use only clean sample containers.

3. Upon arrival at each field site, thoroughly rinse the sampler in the stream prior to collecting the first sample.

4. Extend the device to the sample location and fill the sample container by dipping and/or submersion.

5. Retrieve the sampler, transfer the sample to the appropriate sample container, as necessary, and cap securely.

Direct Method

For streams, rivers, lakes, and other surface waters, the direct method may be used to collect water samples from the surface directly into the sample bottle. This method may not be appropriate for sampling lagoons or other impoundments where contact with contaminants is a concern. When using the direct method, do not use pre-preserved sample bottles as the collection method may dilute the concentration of preservative necessary for proper sample preservation. The procedures are as follows:

1. Using adequate protective clothing, access the sampling station by appropriate means.

2. For shallow stream stations, collect the sample under the water surface while pointing the sample container upstream. The container must be upstream of the collector. Avoid disturbing the substrate.

3. For lakes and other impoundments, collect the sample under the water surface avoiding surface debris and boat wakes.

VI. Disposal Methods

If required, all water generated during equipment cleaning procedures will be collected and contained on site for determination of proper treatment or disposal. In addition, personal protective equipment (e.g., gloves, disposable clothing) and other disposable equipment resulting from cleaning and sampling procedures will be placed in plastic bags and appropriately contained for proper disposal.

This page is blank to facilitate double sided printing.

SURFACE WATER SAMPLING FIELD LOG

Project Name: Project Code: Page __ of __

Date	Time	Sample ID	Sample Location	Equipment Used	Samplers	Comments

Notes:

This page is blank to facilitate double sided printing.

I. Introduction

This standard operating procedure (SOP) is applicable to the collection of representative data (stream dimensions and water velocity) for use in determining discharge in streams and open channels. These typically applicable procedures have been adapted from the USGS *Techniques in Water Resources Investigations*, Book 3, Chapter A8: Discharge Measurements at Gaging Stations (http://water.usgs.gov/pubs/twri/twri3a8/pdf/TWRI_3-A8.pdf) and the *Open Channel Profiling Handbook*, January 1989 (Rev. May 1, 1990), Marsh-McBirney, Inc. The procedures herein may be varied or changed as required, dependent upon site conditions or equipment and procedural limitations. The actual procedures used should be employed in consultation of the more detailed procedures found in the USGS discharge measurement guidance document and the actual procedures used should be documented in the field notes, especially any changes made.

II. Materials

The following materials shall be available, as required, during collection of surface water flow data. Back-up field instruments/equipment should be available, if required.

- Personal protective equipment (as necessary);
- Boat and/or waders;
- Cleaning equipment (see the Standard Operating Procedure for Equipment Cleaning);
- Flowmeter/velocimeter and appropriate accessories (e.g., Marsh-McBirney Flo-Mate 2000, Pigmy-Gurly velocimeter, profiling/wading rod, boat/bridge board with suspension cable and weight, operation manuals);
- Protractor and compass;
- Measuring tape and/or measuring wheel;
- Field data sheets, field log book, waterproof pen, camera and film;
- Maps/plot plan, survey stakes/flags/buoys and anchors;

III. Preparations

- Determine the extent of the sampling effort, the methods to be employed, and the types and amounts of equipment and supplies needed.
- Obtain the necessary sampling and monitoring equipment to suit the task. Consider stream morphometry (width, depths, channels) and deployment circumstances (bridges, shoreline, wading, boats, obstructions, currents).
- Decontaminate or pre-clean equipment and ensure that it is in working order.
- Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
- Perform a general site survey.
- Use stakes, flagging, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

IV. Flow Measurement Procedures

The methods of determining cross-sectional area and velocity must be selected prior to the field event. Data required for use in calculation of stream flow includes measurements of cross-sectional area (water depth and transect segment width), water velocity, flow angle, and transect angle. The mid-section method of computing cross-sectional area for discharge measurements is recommended by USGS and there are a number of different methods for measuring velocity. The two methods of velocity measurement that follow are frequently used for normal stream conditions:

- Six tenths Depth Method (0.6 depth below the water surface) uses observed velocity at this depth as the mean velocity in the vertical. This method gives extremely reliable results whenever the water depth is between 0.3 and 2.5 feet. It is also quicker to measure so is good for times of rapidly changing water level (stage).
- Two Point Method (0.2 and 0.8 depth below the water surface) averages velocities observed at these relative depths at each location and this average is used as the same mean velocity in the vertical. This method gives more consistent and accurate results than any of the other methods except the vertical-velocity curve method. The two point method is generally not used at depths less than 2.5 feet because the current meter settings would be too close to the water surface and stream bed for dependable results.

Flow measurement data collection using wading techniques are preferred by USGS, if conditions permit. Wading measurements offer the advantage over measurements from bridges (or other techniques such as cableways, not discussed herein) in that it is usually possible to select the best of several available cross-sections for the measurement.

When a stream cannot be waded, bridges may be used to obtain flow measurements (though cableway measurements are usually better, if available). No set rule can be given for choosing between the upstream or downstream side of the bridge to collect flow data. The advantages of using the upstream side of the bridge are:

- Hydraulic characteristics at the upstream side of bridge openings usually are more favorable.
- Approaching drift can be seen and be more easily avoided.
- The streambed at the upstream side of the bridge is not likely to scour as badly as at the downstream side.

The advantages of using the downstream side of the bridge are:

- Vertical angles are more easily measured because the sounding line will move away from the bridge.
- The flow lines of the stream may be straightened out by passing through a bridge opening with piers (see points under step 2 below).

To accomplish flow data collection using the methods selected, a transect of measurement stations across a stream is set up and marked before collecting section depth, width, and velocity data using the following steps:

1. Follow appropriate safety procedures and use personal protective equipment as necessary.
2. Select the transect site location following as many of the following considerations as possible:

- The channel should have as much straight run as possible – at least such that the length upstream from the profile should be twice the downstream length.
- The channel should be free of flow disturbances. Look for protruding pipe joints, sudden changes in diameter, contributing sidestreams, outgoing sidestreams, or obstructions.
- The flow should be free of swirls, eddies, vortices, backward flow, or dead zones.
- Avoid areas immediately downstream from sharp bends or obstructions.
- Avoid converging or diverging flow (approach to a flume) and vertical drops.
- Avoid areas immediately downstream from a sluice gate or where the channel empties into a body of stationary water.

3. Determine the width of the stream starting and ending at the stream's edges. Use a measuring wheel on a bridge or string a measuring tape between stakes if wading or in a boat.

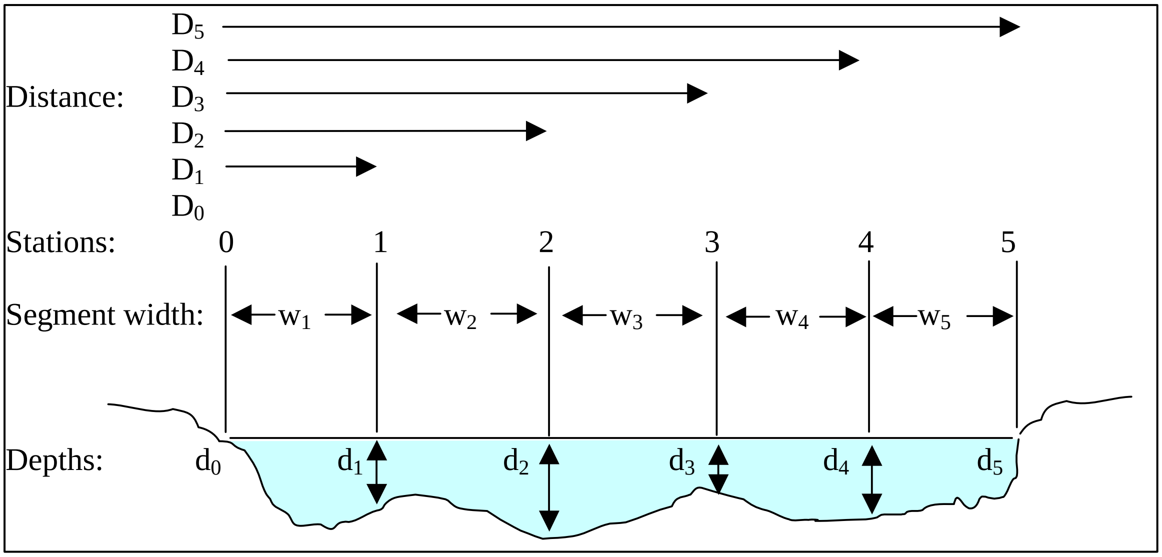
4. Record the angle of the transect with respect to the stream channel and direction of flow. The transect should most preferably be at right angles to the direction of flow to avoid having to correct for the angle of the transect when calculating discharge.

5. Mark/record the partial section locations (measurement recording stations) of the measurement transect. These should be spaced so that no partial section contains more than 10 percent of the total flow. The ideal measurement would have less than 5 percent of the flow in any one partial section. Equal width partial sections across the transect are not recommended. Make the width of the partial sections less as depths and velocities become greater.

6. Assemble the appropriate equipment for the velocity and depth measurements.

7. Prepare the measurement note sheets to include the following information:
   - Name of stream and exact location of transect site.
   - Date, party, type of meter suspension, type of meter.
   - Measurement data (depth, width, position location, velocity, flow angle, time measurements were started and ended).
   - Bank of stream that was the starting point. Identify the stream bank by either LEW or REW (left edge of water or right edge of water, respectively) when facing downstream.
   - Gage height measurement and corresponding times.
   - Other pertinent information regarding site conditions and accuracy of the measurement.

8. Begin recording depth, width (transect distance) and velocity measurements at each station of the transect, successively, according to the remaining steps below and in reference to the figure that follows.



w = width of segment
D = distance from stream's edge
d = depth of water

9. Record distance (D1, D2, D3 …) from steam's edge at initial station (measurement point 0) to each successive station (1, 2, 3, …).
10. Record the water depth (d0, d1, d2, d3, …) at each measurement point, including the edge of the water at each end of the transect.
11. Measure velocity (0.2 depth & 0.8 depth – or – 0.6 depth below water surface) at each station and record the reading and associated meter depth position (0.2, 0.6, 0.8). Follow manufacturer instructions for operation of the meter.

    Note: If wading, stand in a position that least affects the velocity of the water passing the meter sensor (sufficiently downstream or to the side of the sensor – approximately an arm's length). Avoid standing in the water if feet and legs would occupy a considerable percentage of the cross section of a narrow stream (use a plank or other support). Keep the wading rod in a vertical position and the velocity sensor parallel to the direction of flow.
12. Measure and record the angle of flow with respect to the transect and direction of flow, especially if the flow is not at right angles to the transect.

V. Discharge Calculation

The USGS-preferred midpoint method of determining discharge uses the products of the partial areas of the stream cross-section (segment) and their respective average velocities (Q = A * V). It is assumed that the velocity measurement at each station represents the mean velocity in a partial rectangular area. The area extends laterally from half the distance from the preceding station to half the distance to the next and vertically from the water surface to the sounded depth. The cross-section is defined by depths at the station locations (d_1, d_2, …, d_n). There are two cases in the calculation, as follows:

For segments in the middle of the transect:

$Q_{middle\text{-}segment} = (D_{n+1} - D_{n-1})/2 * d_n * V_n$

For segments at the end of the transect:

$Q_{first\text{-}end\text{-}segment} = (D_{n+1} - D_n)/2 * d_n * V_n$
$Q_{last\text{-}end\text{-}segment} = (D_n - D_{n-1})/2 * d_n * V_n$

- Q = A * V (discharge = area * velocity; where)
- A = w * d (area = width * depth; where)
- $w = D_{n-1} - D_{n+1}$ or $D_{n+1} - D_n$ or $D_n - D_{n-1}$
(segment width = distance between alternate or adjacent stations; and)

Sum the segment discharges to get the total discharge for the river at a particular location

VI. Other considerations for less than ideal site conditions:

Non-perpendicularity:

Ideally, the cross-section is perpendicular to the stream channel, which has a straight run of sufficient length, and the stream flow is perpendicular to the cross-section. However, this is not always possible in the real world.

Angle of flow measurements should be collected and incorporated into the discharge calculation when flow is not perpendicular to the stream cross-section (insufficient straight run length of channel, presence of swirls, eddies, etc.).

Calculation of discharge should consider only the velocity component vector that is parallel to the stream channel (perpendicular to the ideal cross-section). This can be obtained by multiplying the velocity reading by the cosine of the flow angle (V * cos(a)). If the cross-section measurements are taken from a bridge that is not perpendicular to the stream channel, then correction for the angle of the bridge is also necessary.

Backwater and reverse flow:

Backwater areas or areas to shallow to measure are usually assigned a velocity of zero. Velocity values in areas of flow reversal (from eddies, or lake seiche effects near river mouths) must be assigned the opposite sign (if downstream velocities are positive, upstream velocities are negative).

This page is blank to facilitate double sided printing.

Flow Monitoring Datasheet

Site: ____________________

Crew: ____________________ Date: ____________________

Staff Gage Reading (ft): ____________ Begin Time: ____________________

Tape Down (ft): ____________ End Time: ____________________

Equipment Used:

Transect Starting Point is on (circle one): left bank facing downstream right bank facing downstream

Bridge measurements are from (circle one): upstream side downstream side

Distance Starting Point to Nearest Edge of Water (ft): ____________

Distance Ending Point to Nearest Edge of Water (ft): ____________

Depth at Left Edge of Water (facing downstream): ____________

Depth at Right Edge of Water (facing downstream): ____________

Observations:

Transect Point No.	Transect Tape Reading (ft)	Water Depth (ft)	0.8D Velocity (ft/s) (if Depth >2.5 ft)	0.2D Velocity (ft/s) (if Depth >2.5 ft)	0.6D Velocity (ft/s) (if Depth <2.5 ft)	Angle coeff.	Notes

This page is blank to facilitate double sided printing.

I. Introduction

The equipment cleaning procedures described in this document include pre-field, in-field, and post-field cleaning of sampling equipment. The sampling equipment may consist of surface water sampling devices; water testing instruments; or other activity-specific sampling equipment. All non-disposable sampling equipment will be cleaned after completion of each sampling event. If appropriate, cleaning procedures will be monitored through the analysis of rinse blank samples as described in the project QAPP. Equipment cleaning areas will be located within or adjacent to a specific work area as necessary.

II. Materials

The following materials will be available during equipment cleaning, as needed:

- Personal protection equipment (as necessary);
- Distilled/deionized water;
- Non-phosphate detergent (Alconox, Liquinox, or equivalent);
- Tap water;
- Appropriate cleaning solvent (e.g., methanol, nitric acid);
- High-pressure hot water/steam cleaning unit;
- Wash basins;
- Brushes;
- Polyethylene sheeting;
- Aluminum foil;
- Plastic overpack drum, garbage can, or stainless steel tubes (for bladder or other pumps);
- Large heavy-duty garbage bags;
- Spray bottles (to hold tap water, distilled/deionized water, methanol, or nitric acid); and
- Disposable and/or heavy duty reusable (PVC, latex or nitrile) gloves.

III. Storage of Equipment

All cleaned sampling equipment will be stored in a clean environment and, if appropriate, the equipment will be covered/sealed with aluminum foil.

IV. Safety Procedures During Equipment Cleaning

1. Personnel will wear the following personal protection equipment as necessary, when cleaning sampling equipment (e.g., Kemmerer sampler, split-spoon sampler, trowels) and larger equipment (e.g., drill rig, augers):

   - Safety glasses, goggles, or a splash shield; and
   - PVC, latex, or nitrile outer gloves,

- Coated Tyvek® disposable coveralls or rainsuit, optional for small equipment cleaning; and
- Chemical resistant over boots, optional for small equipment cleaning.

2. All solvent rinsing if required, will be conducted in an adequately ventilated area.

3. All solvents transported into the field will be stored and packaged in appropriate containers with care taken to avoid exposure to extreme heat.

4. Handling of solvents will be consistent with the manufacturer's Material Safety Data Sheets (MSDS).

V. Field Cleaning Procedures

Cleaning Station

If a designated field equipment cleaning station location is required, it will be established to conduct all cleaning at each work area of the Site. The field equipment cleaning station will be located away from the immediate work area to minimize adverse impacts from work activities on the cleaning procedures, but close enough so the sampling teams can minimize equipment handling and transport.

Cleaning of Smaller Sampling Equipment

Cleaning of smaller sampling equipment (e.g., Kemmerer samplers, sample composite vessels, split-spoon samplers, bailers, trowels) will be conducted according to the following sequential procedure:

- Non-phosphate detergent (Alconox, Liquinox, or equivalent) and tap water wash;
- Tap water rinse;
- Solvent rinse, if required (e.g., methanol for organic constituent analysis, nitric acid for inorganic constituent analysis); and
- Triple distilled/deionized water rinse.

The first step, non-phosphate detergent and tap water scrub, is intended to remove all visible particulate matter and residual oil and grease. This may be preceded by a steam cleaning to facilitate soils removal. The tap water rinse is necessary to remove all soapy residues. The need for a specific solvent used for the solvent rinse, if required in the QAPP, will depend upon what the sample will be analyzed for. The final rinse of distilled/deionized water will be repeated three times. The equipment will then be allowed to air dry.

Collection and Disposal of used Solvents, Residuals and Rinse Solutions

All solvents, residuals, and rinse waters generated during the cleaning of equipment on-site will be collected, containerized, and stored on-site until arrangements can be made for proper disposal.

This page is blank to facilitate double sided printing.

I. Introduction

This standard operating procedure (SOP) is applicable to the collection of representative sediment oxygen demand (SOD) data from streams, rivers, lakes, ponds, lagoons, and surface impoundments. These typically applicable procedures have been adapted from the Ohio EPA Sediment Sampling Guide and Methodologies (OEPA, 2001), and may be varied or changed as required, dependent upon site conditions or equipment and procedural limitations. The actual procedures used should be documented in the field notes, especially if changes are made.

In order to collect representative SOD data, the hydrology and morphometry of a stream or impoundment should be determined prior to sampling. This will aid in determining appropriate sampling locations (see Section II).

SOD is measured using a dark chamber (resembling a large, inverted bowl) that isolates a known area of sediment and a known volume of water. A pump and tubing are used to form a closed system loop to circulate the volume of water over the area of sediment and ensure complete mixing. A dissolved oxygen (DO) probe in the chamber provides a continuous display of the DO concentration inside the chamber, which is recorded every five minutes for two hours or until the DO drops by 2 mg/L.

By using a dark chamber, photosynthesis does not affect the DO of the water in the chamber, and respiration and SOD are the only influences in the DO chamber. The effects of respiration are quantified by filling a blank SOD chamber or dark bottle with a known volume of water from the same location as the measurement chamber and measuring the DO at the beginning and end of the SOD test. The change in DO in the blank chamber or dark bottle provides an estimate of the amount of DO consumed by algal respiration in the water column.

The rate of change of DO in the chamber is determined by plotting the DO recorded in the chamber every five minutes. A regression analysis is then performed on the dataset. The rate of change of DO in the chamber is equal to the slope of the regression. The respiration rate measured in the dark bottle is subtracted from this rate. The corrected value is then divided by the area of the underlying sediment, resulting in an SOD value expressed as grams of oxygen consumed per square meter per day (g/m2/day) at the ambient temperature. To provide for standardization, temperatures are usually corrected to 20 degrees Celsius using a temperature correction factor.

II. Site Selection

SOD should be evaluated when any of the following conditions exist:

- Reaches having extensive low velocity pools (less than 0.25 fps).
- Reaches having diurnal DO swings greater than 100%.
- Reaches having extensive sludge deposits.

Sites should be selected based on a field evaluation that includes:

- Stream velocity; less than 0.25 fps (Velz, 1970), i.e., pools.
- Discharger location.

- Accessibility.
- Presence and extent of sludge deposits. Sludge deposits present the greatest impact of sediment types on instream DO. Sites for SOD measurement should include sludge deposits, if present, or locations with hydraulic characteristics conducive to sludge deposition.

III. Materials

The following materials shall be available, as required, during SOD surveys. Back-up field instruments/equipment should be available, if required.

- Personal protective equipment (as necessary).
- Cleaning equipment (as required in the Standard Operating Procedure for Equipment Cleaning).
- SOD chambers (benthic respirometer) and accessories (mixing pump with tubing and fittings, battery with connecting cables, rheostat for adjusting pump velocity).
- DO Meters – YSI Model 56 DO meter for each chamber, YSI Model 57 DO meter for algal production outside chamber, chart recorder.
- Primary productivity bottles, rope.
- Turbidimeter and accessories.
- Pyranograph and photometer with submersible sensor.
- Sediment sampling equipment (scoop, ponar dredge, etc.).
- Field data sheets, field log book, waterproof pen, camera and film.
- Miscellaneous supplies: Maps/plot plan, extra rope, bungee cords, survey stakes/flags/buoys, anchors and safety equipment.

IV. Preparations

- Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.
- Decontaminate or pre-clean equipment and ensure that it is in working order.
- Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
- Perform a general site survey.
- Use stakes, flagging, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. If also collecting sediment samples, this procedure may disturb the bottom and cause interferences with collection of representative water samples.

V. SOD Instrument Setup and Measurement Procedures

Benthic Respirometer – Instrument Setup

1. Measure and record on SOD data sheet: water velocity at 0.2 feet above sediments, SOD chamber number.

2. Calibrate DO meter. Record DO concentration near water surface.

3. Place chamber in sediments. If sediments are disturbed, wait several minutes before proceeding.

4. Purge all air from the mixing pump and tubing by running the pump for a sufficient time period with tubing ends under water.

5. Attach the mixing pump inlet and outlet tubing to the SOD chamber fittings. Turn on pump to begin mixing water and verify that no air is trapped within chamber.

6. Insert the DO probe in the chamber. Verify that no air bubbles are introduced inside the chamber via the probe.

7. If possible, regulate water velocity within chamber to approximate stream velocity near the sediments outside the chamber. If a rheostat is used in-line with the pump, the rheostat settings will need to be calibrated to velocity using the pump and tubing, a bucket and a flowmeter.

8. Install a similar respirometer next to the first one, but seal the bottom with a plastic lid, excluding all sediment (for quality control “blank” measurements). This chamber will measure the respiration oxygen demand of the water column, to be subtracted from the DO change measured by the first SOD chamber. If only one chamber is available, use the DO change measured in the dark productivity bottles to make this correction.

9. Start the DO meter.

10. Record the starting time, date, site data, meter number and, if using a non-auto-recording DO meter, manually record the DO and temperature readings on the SOD field data sheet. Write the values at 5 minute intervals initially, and alter the interval depending on the rate of oxygen uptake.

11. Retrieve chamber after DO concentration has decreased by 2 mg/l or after two hours.

VI. Calculations

The following equation is used to determine the SOD:

SOD = 1.44 * (V/A)*(b1-b2)   where:

SOD	=	sediment oxygen demand, in g/m2/day
1.44	=	conversion factor, converts results to g/m2/day
V	=	volume of chamber, in liters
A	=	area of chamber, in square meters (A=p*r2)
b1	=	rate of change of DO inside the SOD chamber, in mg/L/minute
b2	=	rate of change of DO inside the “blank” SOD chamber or dark productivity bottles, in mg/L/minute

To facilitate the comparison of results among different sites, the SOD should be converted to 20^{o}C by using the following equation:

SOD20 = SODT/(1.065T-20)   where:

SODT	=	SOD at original temperature, in g/m2/day

SOD20	=	SOD at 20^{o}C, in g/m2/day
T	=	Ambient temperature, in ^{o}C

VII Disposal Methods

If required, all water generated during equipment cleaning procedures will be collected and contained for determination of proper treatment or disposal. In addition, personal protective equipment (e.g., gloves, disposable clothing) and other disposable equipment resulting from cleaning and sampling procedures will be placed in plastic bags and appropriately contained for proper disposal.

VIII. References

Ohio EPA. 2001. Sediment Sampling Guide and Methodologies, 2nd Edition. Division of Surface Water, Columbus, Ohio. Nov. 2001

Velz, Clarence. 1970. Applied Stream Sanitation. Wiley Interscience. New York, NY.

I. Introduction

Water quality parameters, such as water temperature, dissolved oxygen and pH are routinely measured during surface water investigations. Instantaneous measurements may be recorded using individual probes or multi-sensor sondes, as available and appropriate for each situation. These probes should be calibrated daily using manufacturer procedures. Collection of continuous data is most commonly performed using a data sonde with internal batteries and memory capacity that can be deployed for extended periods to record data over a range of conditions. The primary limiting factor for extended deployment duration is usually degradation of data quality because of biofouling of the sensor surfaces. The rate of biofouling is related to productivity of the water where monitoring is being conducted. In general, a sonde should be downloaded, checked for reading stability (drift), and recalibrated at a frequency of no more than seven to ten days. An initial check within this time period may allow for modification of subsequent visits, depending on the magnitude of drift observed. The calibration and maintenance log for the above referenced meters is included as an attachment to this Standard Operating Procedure.

II. Materials

The following materials, as required, shall be available for installation of and field visits to the continuous monitoring station(s):

- Personal protective equipment (as necessary);
- Perforated PVC housing(s) for extended deployment installations;
- Fence post(s) and pounder for extended deployment installations;
- Attachment hardware for extended deployment installations;
- Data probes or sonde;
- Manufacturer's operating manuals for each instrument;
- Calibration solutions appropriate for each instrument;
- Tools and equipment necessary for field maintenance of instruments;
- Laptop computer for setup and downloading sondes (as necessary);
- Clean container;
- pH calibration buffer solution within and bracketing expected range of measurements;
- Cleaning equipment (as required in the Standard Operating Procedure for Equipment Cleaning);
- Distilled/deionized water; and
- Appropriate forms and field notebook.

III. Procedures for Instantaneous Field Water Quality Measurements

1. Calibrate and operate all meters in accordance with manufacturer’s operating manuals.
2. For in-situ surface water measurements place probe(s) at the designated location in the water body, allow instrument readings to stabilize, and record the readings for each parameter:
3. If measuring ex-situ samples, collect a water sample from the designated location in the designated container, insert probes into container and record readings (especially temperature

and pH readings) as soon as possible after collecting the sample to minimize inaccuracies from the changing temperature of the sample as it equilibrates to ambient temperature.

4. Rinse probes off in distilled/deionized water, if required.
5. Log results and observations in field notebook.

IV. Procedures for Extended Sonde Deployment and Continuous Measurements

Installation. Installation of the data sonde is accomplished using a perforated PVC housing attached to a fence post or other structure, if present and appropriate. The goal of the installation is to place the sensors in a location that is representative of the water column (e.g. mid-channel, mid-depth, middle of flow volume). It is important to consider water level fluctuations, obstructions, and debris that may be present during wet or dry weather conditions and plan the installation accordingly to maximize the collection of accurate data. After an appropriate location is identified, install the perforated PVC housing in the stream channel.

Data Sonde Set-up and Calibration. The dissolved oxygen and pH sensors are calibrated according to manufacturer specifications prior to installation. Temperature is usually a factory-calibrated parameter. A logging file is created in the sonde for the storage of data according to manufacturer specifications. Start date and time is specified to ensure that data logging occurs when the sonde is deployed. Specify the sampling interval/data recording frequency. After calibration and logging file set-up, remove calibration chamber and attach the weighted strainer. Place the sonde into the protective housing. Secure the cap to the housing. Record deployment time in field notes.

Field Maintenance. The data sonde should be maintained at a minimum frequency of every seven to ten days. The current readings should be checked to evaluate drift, the logging file should be downloaded, the sonde should be cleaned and recalibrated, and the sonde should be redeployed. Each of these activities is described below.

The readings being reported by the sensors are checked for drift by comparing to known values. Dissolved oxygen is compared to a winkler titration and pH readings are compared to calibration solutions. The procedure is as follows:

1. Collect a water sample using a 5-gallon bucket, taking care to minimize turbulence. Keep sample out of direct sunlight.

2. Remove sonde from housing, connect to laptop, and place sensors in sample bucket. NOTE: take care to minimize disturbance to sensors;

3. Record current dissolved oxygen reading;

4. Conduct a Winkler titration to determine dissolved oxygen concentration of sample. Perform this step with an aliquot of the water collected in step 1 and as near as possible to the same time the sonde DO reading is recorded. Treat both sample aliquots identically otherwise, collect;

5. Calculate relative percent difference (RPD) between Winkler and sonde dissolved oxygen readings using the formula noted below. The acceptance criterion for this comparison is an RPD of 20% or less.

$$RPD = \left| \frac{(Abs(Winkler\ D.O. - Sonde\ D.O.))}{(Winkler\ D.O. + Sonde\ D.O\ /\ 2)} \right| *100$$

6. Record result in the field notebook;
7. Repeat process for the pH sensors;
8. Download logging file to laptop;
9. Gently clean the sensors to remove biofilms according to manufacturer specifications;
10. Recalibrate sensors;
11. Set up logging file;
12. Redeploy sonde, record date and time in field notes.

This page is blank to facilitate double sided printing.

FIELD INSTRUMENT CALIBRATION AND MAINTENANCE LOG
Temperature, pH and Dissolved Oxygen Meters

Instrument	Temperature	pH	D.O.
Manufacturer			
Model			
Identification No.			

Date	Time	Initials	Temp	pH			D.O.	Battery	Comments
			°C	4	7	10		Check	

.

This page is blank to facilitate double sided printing.

I. Handling

1. Fill in sample label (see attachment). Use indelible waterproof marking pen and include:
   - Sample Identification code (if possible, should reflect site name, sample location and sample interval)
   - Sample type (e.g., soil, sediment, water, vapor);
   - Project code;
   - Analysis required;
   - Date sampled;
   - Time sampled;
   - Name or initials of person who collected the sample;
   - Mode of collection (composite or grab); and
   - Preservation added, if applicable.
2. Check the caps on the sample containers so that they are tightly sealed.
3. Cover the label and sample container cap with clear packing tape to secure the label and cap onto the container, if necessary.
4. Place a signed custody seal label (see attachment) over the cap such that the cap cannot be removed without breaking the custody seal, if required.

II. Packing

1. If using a laboratory-supplied transpack, follow the laboratory's instructions for packing. Generally, repack the transpack in the same way in which the empty containers were received. If using a standard cooler, follow the instructions below.
2. Using packaging tape, secure the outside and inside the drain plug at the bottom of the cooler that is used for sample transport.
3. Place 1 to 2 inches of vermiculite or other cushioning material at the bottom of the cooler.
4. Place the sealed container upright in the cooler.
5. Place additional cushioning material around the sides of each sample container.
6. Place frozen gel cold packs on top of sample containers. If ice is used, repackage ice in small Ziploc® - type plastic bags and place loosely in the cooler. Do not pack cold packs or ice so tightly that it may prevent the addition of sufficient cushioning material.
7. Fill the remaining space in the cooler with vermiculite or other cushioning material.

8. Place the chain-of-custody forms (see attachment) in a large Ziploc® type bag and tape the forms to the inside of the cooler lid.

9. Close the cooler lid and fasten with packaging tape.

10. Wrap strapping or packaging tape around both ends of the cooler at least twice.

11. Mark the cooler on the outside with the following information: return address, "Fragile" labels (see attachment) on the top and on one side, and arrows indicating "This Side Up" (see attachment) on two adjacent sides.

12. Place custody seal evidence tape (see attachment) over front right and back left of the cooler lid and cover with clear plastic tape.

III. Shipping

1. Environmental samples will be shipped according to 40 CFR 761.65 (i)(3) and in accordance with current and applicable D.O.T. standards.

2. All samples will be delivered by an express carrier, allowing for sufficient time for analysis to be performed within the applicable holding time periods.

3. The following chain-of-custody procedures will apply to sample shipping:

   - Relinquish the sample containers to the laboratory via express carrier. The signed and dated forms should be taped inside the top of the cooler. The express carrier will not be required to sign the chain-of-custody forms.
   - When the samples are received by the laboratory, the laboratory personnel shall complete the chain-of-custody forms by signing and dating to acknowledge receipt of samples. The internal temperature of the shipping container is measured and recorded. The sample identification numbers on the containers are then checked to ensure that they are consistent with the chain of custody forms

Sample Shipping Label

	Limno-Tech, Inc. **734-332-1200**
Client/Source:	☐ **Grab** ☐ **Composite**
Site Name:	**Date:**
Sample #	**Time:**
Analysis:	**Preservatives:**
	Collected by:

Sample Custody Seal Label

Limno-Tech, Inc. **501 Avis Drive** **Ann Arbor, MI 48108**	Sealed by: ______________________ Date: _________Time: ______________

This page is blank to facilitate double sided printing.

Sample Chain of Custody Form

Limno-Tech, Inc.
Excellence in Environmental Engineering Since 1975

Check Originating Office

☐ Corporate Office
501 Avis Drive
Ann Arbor, MI 48108
(734) 332-1200 (phone)
(734)332-1212 (fax)

☐ Kalamazoo Field Office
2980 Business One Drive
Kalamazoo, MI 49001
(616) 226-0190 (phone)
(616) 226-0192 (fax)

CHAIN OF CUSTODY RECORD

Proj. No.	Project Name

Samplers: *(Signature)*

Sta. No.	Date	Time	COMP	GRAB	Station Location	Number of Containers							Remarks

Relinquished by: *(Signature)*	Date	Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date	Time	Relinquished by: *(Signature)*
Relinquished by: *(Signature)*	Date	Time	Received by: *(Signature)*	Relinquished by: *(Signature)*	Date	Time	Relinquished by: *(Signature)*
Relinquished by: *(Signature)*	Date	Time	Received for Laboratory by: *(Signature)*	Date	Time	Remarks:	

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

This page is blank to facilitate double sided printing.

Mauvaise Terre Creek Watershed
Final Approved TMDL

Prepared for Illinois Environmental Protection Agency

September 2006

Mauvaise Terre Creek (IL_DD-04): Fecal Coliform

Mauvaise Terre Lake (IL_SDL): Total Phosphorus, Manganese, Nitrate

This page is blank to facilitate double sided printing.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

This page is blank to facilitate double sided printing.

INTRODUCTION

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the 2006 303(d) list, which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (USEPA, 1991).

Mauvaise Terre Creek (IL_DD-04) and Mauvaise Terre Lake (IL_SDL) are listed on the 2006 Illinois Section 303(d) List of Impaired Waters (IEPA, 2006) as waterbodies that are not meeting their designated uses. As such, they have been targeted as high priority waterbodies for TMDL development. This document presents the TMDLs designed to allow these waterbodies to fully support their designated uses. The report covers each step of the TMDL process and is organized as follows:

- Problem Identification
- Required TMDL Elements
- Watershed Characterization
- Description of Applicable Standards and Numeric Targets
- Development of Water Quality Model
- TMDL Development
- Public Participation and Involvement
- Adaptive Implementation Process

This page is blank to facilitate double sided printing.

1 PROBLEM IDENTIFICATION

The impairments in waters of the Mauvaise Terre Creek Watershed addressed in this report are summarized below, with the parameters (causes) that they are listed for, and the impairment status of each designated use, as identified in the 303(d) list (IEPA, 2006). TMDLs for Mauvaise Terre Creek and Mauvaise Terre Lake are included in this report. TMDLs for North Fork Mauvaise Terre Creek (IL_DDC) for dissolved oxygen and manganese will be conducted after additional data needed for the analysis have been collected. While TMDLs are currently only being developed for pollutants that have numerical water quality standards (indicated below with bold font), many controls that are implemented to address TMDLs for these pollutants will reduce other pollutants as well. For example, any controls to reduce phosphorus loads from watershed sources (stream bank erosion, runoff, etc.) would serve to reduce not only phosphorus, but also sediment loads to Mauvaise Terre Lake, as phosphorus Best Management Practices (BMPs) are often the same or similar to sediment BMPs. Furthermore, any reduction of phosphorus loads, either through implementation of watershed controls or dredging of lake sediments, is expected to work towards reducing algae concentrations, as phosphorus is the nutrient most responsible for limiting algal growth.

Mauvaise Terre Creek	
Assessment Unit ID	IL_DD-04
Size (length)	36.71
Listed For	**Fecal Coliform**
Use Support[1]	Aquatic life (F), Fish consumption (F), Primary contact (N), Secondary contact (X), Aesthetic quality (X)

[1] F = fully supporting, N=not supporting, X = not assessed

Mauvaise Terre Lake	
Assessment Unit ID	IL_SDL
Size (Acres)	172
Listed For	**Manganese, Phosphorus, Nitrate,** total suspended solids, aquatic algae
Use Support[1]	Aquatic life (N), Fish consumption (F), Public and food processing water supplies (N), Primary contact (X), Secondary contact (X), Aesthetic quality (N),

[1] F = fully supporting, N=not supporting, X = not assessed

This page is blank to facilitate double sided printing.

2 REQUIRED TMDL ELEMENTS

USEPA Region 5 guidance for TMDL development requires TMDLs to contain eleven specific components. Each of those components is summarized below, by waterbody.

Mauvaise Terre Creek (IL_DD-04)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Mauvaise Terre Creek, HUC 0713001104. The pollutant of concern addressed in this TMDL is fecal coliform. Potential sources contributing to the listing of Mauvaise Terre Creek include: runoff from pastureland and animal feeding operations, private sewage disposal systems, municipal point sources, and combined sewer overflows. Mauvaise Terre Creek is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006).

2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The IEPA guidelines (IEPA, 2006) for identifying fecal coliform as a cause of impairment in streams state that fecal coliform is a potential cause of impairment of the primary contact use if the geometric mean of all samples collected during May through October (minimum five samples) is greater than 200 cfu/100 ml, or if greater than 10% of all samples exceed 400 cfu/100 ml (cfu = colony forming units). For the Mauvaise Terre Creek TMDL for fecal coliform, the target is set at meeting 200 cfu/100 ml across the entire flow regime during May-October.

3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** A load capacity calculation was completed to determine the maximum fecal coliform loads that will maintain compliance with the fecal coliform standard for May through October under a range of flow conditions:

Flow Percentile Range	Median Observed Mauvaise Terre Creek Flow (cfs)	Load Capacity (cfu/day)
60-100	1.56	7.63E+09
30-60	35.1	1.72E+11
0-30	139	6.81E+11

4. **Load Allocations (LA):** Load allocations designed to achieve compliance with the above TMDL are calculated for the May-October period by the following equation:

$$\text{Load allocation} = \text{load capacity} - \text{MOS} - \Sigma\text{WLAs}$$

Flow Percentile Range	Median Observed Mauvaise Terre Creek Flow (cfs)	Load Allocation (LA) (cfu/day)
60-100	1.56	0
30-60	35.1	1.13E+11
0-30	139	5.65E+11

5. **Wasteload Allocations (WLA):** The WLA for the three point source dischargers of fecal coliform in the Mauvaise Terre Creek watershed was calculated from the current permitted flows and a fecal coliform concentration consistent with the TMDL target (200 cfu/100 ml). The WLA for these facilities equals 5.84E+10 cfu/day, during periods of no CSO discharge and applies at the point where the segment impairment begins. The Jacksonville STP CSOs have a combined WLA of 5.72E+10 cfu/day during periods when the CSOs are discharging. This is calculated using reported flow volumes per overflow event and a fecal coliform concentration consistent with the TMDL target (200 cfu/100ml). This number may be refined as the results from a proposed monitoring study are reported.

6. **Margin of Safety:** The TMDL contains an implicit margin of safety for fecal coliform, through the use of multiple conservative assumptions. The TMDL target (no more than 200 cfu/100 ml at any time) is more conservative than the more restrictive portion of the fecal coliform water quality standard (geometric mean of 200 cfu/100 ml for all samples collected May through October). An additional implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no decay of bacteria that enter the river, and therefore represents an upper bound of expected concentrations for a given pollutant load.

7. **Seasonal Variation:** The TMDL was conducted with an explicit consideration of seasonal variation. The approach used for the TMDL evaluated seasonal loads because only May through October water quality data were used in the analysis, consistent with the specification that the standard only applies during this period. The fecal coliform standard will be met regardless of flow conditions in the applicable season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur at any given point in the season where the standard applies.

8. **Reasonable Assurances:** In terms of reasonable assurances for point sources, Illinois EPA has the NPDES permitting program for treatment plants, stormwater permitting and CAFO permitting. The permits for the point source dischargers in the watershed will be modified if necessary as part of the permit review process (typically every 5 years), to ensure that they are consistent with the applicable wasteload allocation.

In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

- Convene local experts familiar with nonpoint sources of pollution in the watershed
- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability.

Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.

9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan will be prepared as part of the implementation plan.
10. **Transmittal Letter:** A transmittal letter has been prepared and is included with the TMDL.
11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (listed in the Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. In March 2005, a public meeting was conducted in Jacksonville, Illinois to present the results of the Stage 1 characterization work. In July 2006, a second public meeting was conducted in Jacksonville, Illinois to present the TMDL. Another meeting will be held at a later date to present the implementation plan.

Mauvaise Terre Lake (IL_SDL)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Mauvaise Terre Lake, HUC 0713001104. The pollutants of concern addressed in this report are **total phosphorus, manganese, and nitrate**. Potential sources contributing to the listing of Mauvaise Terre Lake include: lake bottom sediments, recreational activities (i.e., golf courses) and agricultural sources for total phosphorus, natural background sources for manganese, and agricultural runoff and recreational activities (i.e., golf courses) for nitrate. Mauvaise Terre Lake is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006).
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The water quality standard for **total phosphorus** to protect aquatic life and aesthetic quality uses in Illinois lakes is 0.05 mg-P/l. For the Mauvaise Terre Lake phosphorus TMDL, the target is set at the water quality criterion for total phosphorus of 0.05 mg-P/l.

   The water quality standard for **manganese** in Illinois waters designated as public and food processing water supplies is 150 ug/l. For the Mauvaise Terre Lake TMDL, the target is set at the water quality criterion for manganese of 150 ug/l.

   The water quality standard for **nitrate** in Illinois waters that serve as public and food processing water supplies is 10 mg-N/l. For the Mauvaise Terre Lake nitrate TMDL, the target is set at the water quality criterion for nitrate of 10 mg-N/l.
3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** The water quality model BATHTUB was applied to determine that the maximum phosphorus load that will maintain compliance with the phosphorus standard is 60.8 kg-P/month (2.03 kg-P/day).

   A load capacity calculation was completed to determine the maximum manganese and nitrate loads that will maintain compliance with their respective water quality standards for a range of flow conditions. This calculation is based on flow multiplied by the water quality standard of 150 ug/l for manganese, and 10 mg/l for nitrate.

Mauvaise Terre River Flow (cfs)	Allowable Manganese Load (kg/day)	Allowable Nitrate Load (kg-N/day)
0.5	0.18	12.2
1	0.37	24.5
2	0.73	48.9
5	1.84	122.3
10	3.67	244.7
20	7.34	489.4
30	11.01	734.1
40	14.68	978.7
50	18.35	1223.4

4. **Load Allocations (LA):** The Load Allocation designed to achieve compliance with the above TMDL is as follows:

   Total phosphorus: 54.72 kg-P/month (1.827 kg-P/day)
   Manganese and nitrate (see table below)

Mauvaise Terre River Flow (cfs)	Manganese LA (kg/day)	Nitrate LA (kg-N/day)
0.5	0.17	11.0
1	0.33	22.0
2	0.66	44.0
5	1.65	110.1
10	3.30	220.2
20	6.61	440.4
30	9.91	660.6
40	13.21	880.9
50	16.52	1101.1

5. **Wasteload Allocations (WLA):** There are no point source dischargers in the Mauvaise Terre Lake watershed; therefore the wasteload allocation is not calculated.

6. **Margin of Safety:** The TMDL contains an explicit margin of safety (MOS) of 10% for total phosphorus. The phosphorus value was set to reflect the uncertainty in the BATHTUB model predictions. The resulting MOS for total phosphorus is 6.08 kg-P/month (0.203 kg-P/day).

   The manganese and nitrate TMDLs contain an implicit Margin of Safety and an explicit MOS. The implicit MOS is provided via the use of a conservative model to define load capacity. The model assumes no loss of manganese or nitrate that enters the lake, and therefore represents an upper bound of expected concentrations for a given pollutant load. The TMDLs also contain an explicit margin of safety of 10%. This 10% margin of safety was included in addition to the implicit margin of safety to address potential uncertainty in the effectiveness of load reduction alternatives. This margin of safety can be reviewed in the future as new data are developed.

The following table provides the MOS for manganese and nitrate:

Mauvaise Terre River Flow (cfs)	Manganese MOS (kg/day)	Nitrate MOS (kg-N/day)
0.5	0.02	1.2
1	0.04	2.4
2	0.07	4.9
5	0.18	12.2
10	0.37	24.5
20	0.73	48.9
30	1.10	73.4
40	1.47	97.9
50	1.84	122.3

7. **Seasonal Variation:** The TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for the phosphorus TMDL is designed to accommodate the evaluation of monthly loads. The monthly loading analysis is appropriate due to the short nutrient residence time. The monthly duration for the loading was determined based on a calculation of a phosphorus residence time in Mauvaise Terre Lake on the order of weeks.

   The load capacity calculations for manganese and nitrate take into account seasonal variations by specifying target loads for the entire range of flow conditions that are possible to occur in any given year.

8. **Reasonable Assurances:** There are no point source dischargers in the watershed, so reasonable assurances are not discussed for point source dischargers.

   In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

   - Convene local experts familiar with nonpoint sources of pollution in the watershed
   - Ensure that they define priority sources and identify restoration alternatives
   - Develop a voluntary implementation plan that includes accountability.

   Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.

9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan will be prepared as part of the implementation plan.

10. **Transmittal Letter:** A transmittal letter has been prepared and is included with this TMDL.

11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (listed in the Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. A public meeting was conducted in Jacksonville, Illinois in March 2005 to present the results of the Stage 1 characterization work. A second public meeting was conducted in Jacksonville, Illinois in July 2006 to present the TMDL. Another meeting will be held at a later date to present the implementation plan.

This page is blank to facilitate double sided printing.

3 WATERSHED CHARACTERIZATION

The Stage 1 Report presents and discusses information describing the Mauvaise Terre Creek watershed to support the identification of sources contributing to the listed impairments as applicable. The Stage 1 Report is divided into four sections, called Quarterly Progress Reports. The watershed characterization is discussed in the First Quarterly Progress Report. Watershed characterization activities were focused on gaining an understanding of key features of the watershed, including geology and soils, climate, land cover, hydrology, urbanization and population growth, point source discharges and watershed activities.

The impaired waterbodies addressed in this report are in the Mauvaise Terre Creek watershed, located in Morgan and Scott counties in west-central Illinois. The two waterbodies of concern are Mauvaise Terre Lake (IL_SDL) and Mauvaise Terre Creek downstream of Town Brook (IL_DD-04). Mauvaise Terre Lake lies in Morgan County, while Mauvaise Terre Creek flows through both Morgan and Scott Counties. Mauvaise Terre Lake was constructed by damming the upper part of Mauvaise Terre Creek (above the North Fork). The lake has a surface area of 172 acres and serves as a source of drinking water for Jacksonville and several surrounding communities. Most of the water supply, however, comes from wells located 26 miles from the Jacksonville (City of Jacksonville, 2004). Mauvaise Terre Lake is approximately "L" shaped, with an arm extending west from the inlet, and a second arm extending north to the dam. Mauvaise Terre Lake is connected near the corner of the "L" to a smaller lake called Morgan Lake.

Figure 1 shows a map of the watershed, and includes some key features such as waterways, impaired waterbodies, public water intakes and other key features. The map also shows the locations of point source discharges that have a permit to discharge under the National Pollutant Discharge Elimination System (NPDES).

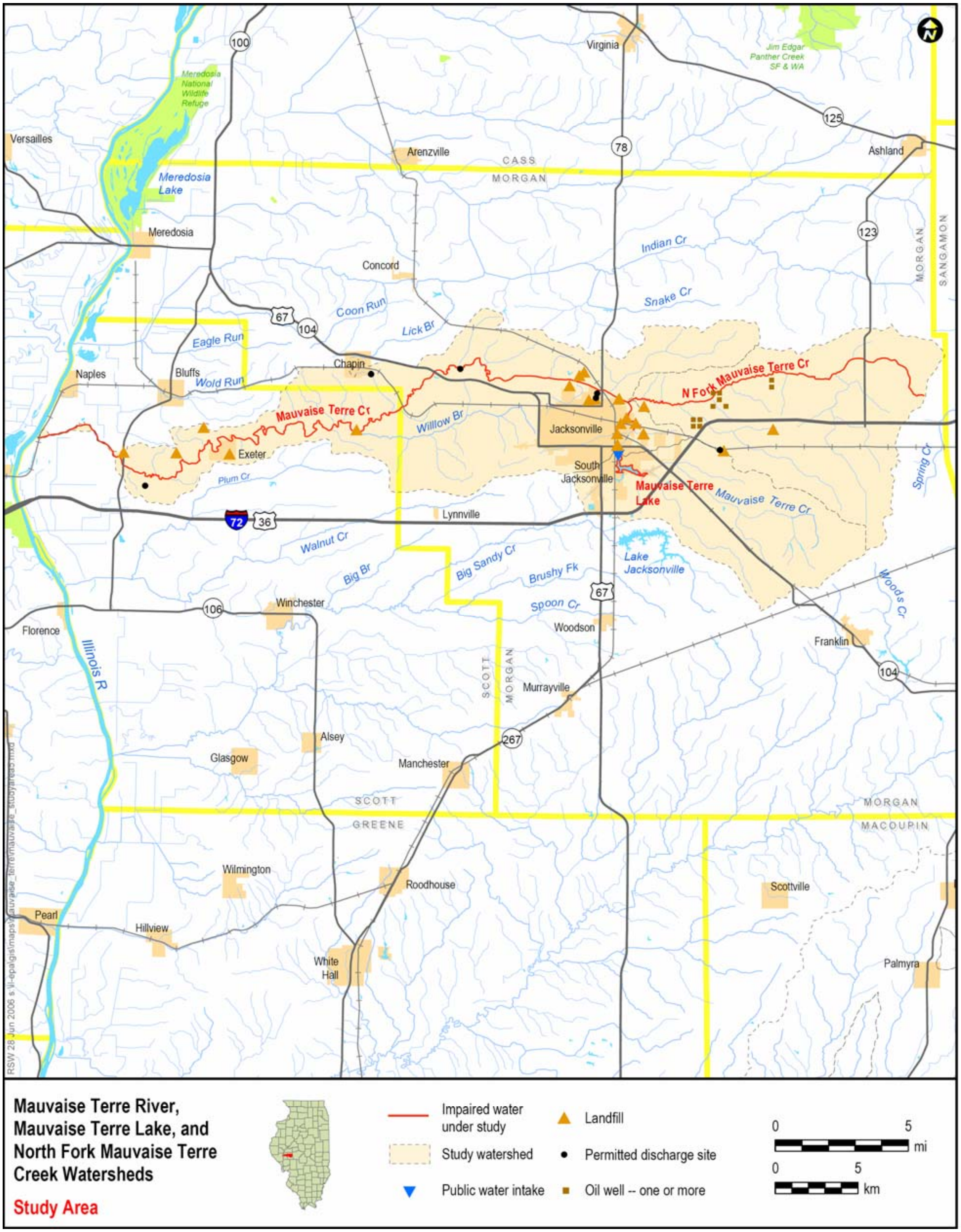


Figure 1. Mauvaise Terre Creek Watershed

4 DESCRIPTION OF APPLICABLE STANDARDS AND NUMERIC TARGETS

A water quality standard includes the designated uses of the waterbody, water quality criteria to protect designated uses, and an antidegradation policy to maintain and protect existing uses and high quality waters. Water quality criteria are sometimes in a form that are not directly amenable for use in TMDL development and may need to be translated into a target value for TMDLs. This section discusses the applicable designated uses, use support, criteria and TMDL targets for waterbodies in the Mauvaise Terre Creek watershed that are addressed in this report.

4.1 DESIGNATED USES AND USE SUPPORT

Water quality assessments in Illinois are based on a combination of chemical (water, sediment and fish tissue), physical (habitat and flow discharge), and biological (macroinvertebrate and fish) data. Illinois EPA conducts its assessment of water bodies using a set of seven designated uses: aquatic life, aesthetic quality, indigenous aquatic life (for specific Chicago-area waterbodies), primary contact (swimming), secondary contact, public and food processing water supply, and fish consumption (IEPA, 2006). For each water body, and for each designated use applicable to the water body, Illinois EPA's assessment concludes one of two possible "use-support" levels:

- Fully Supporting (the water body attains the designated use); or
- Not Supporting (the water body does not attain the designated use).

Water bodies assessed as "Not Supporting" for any designated use are identified as impaired. Waters identified as impaired based on biological (macroinvertebrate, macrophyte, algal and fish), chemical (water, sediment and fish tissue), and/or physical (habitat and flow discharge) monitoring data are placed on the 303(d) list. Potential causes and sources of impairment are also identified for impaired waters (IEPA, 2006).

Following the U.S. EPA regulations at 40 CFR Part 130.7(b)(4), the Illinois Section 303(d) list was prioritized on a watershed basis. Illinois EPA watershed boundaries are based on the USGS ten-digit hydrologic units to provide the state with the ability to address watershed issues at a manageable level and document improvements to a watershed's health (IEPA, 2006).

4.2 WATER QUALITY CRITERIA

Illinois has established water quality criteria and guidelines for allowable concentrations of total phosphorus, manganese, nitrate and fecal coliform under its CWA Section 305(b) program, as summarized below. A comparison of available water quality data to these criteria is provided in the Stage 1 Report.

4.2.1 Total Phosphorus

The IEPA guidelines (IEPA, 2006) for identifying total phosphorus as a cause of impairment in lakes greater than 20 acres in size, state that phosphorus is a potential cause of impairment of the aesthetic quality use if there is at least one exceedance of the applicable standard (0.05 mg/L) during the most recent year of data from the Ambient

Lake Monitoring Program or the Illinois Clean Lakes Program. The available data support the listing of phosphorus as a cause of impairment in Mauvaise Terre Lake, as discussed in the Stage 1 Report.

4.2.2 Manganese

The water quality standard for manganese in Illinois waters designated as public and food processing water supplies is 150 ug/l. The public and food processing water supply guidelines for inland lakes indicate impairment if more than 10% of the observations measured since 1999 exceed 150 ug/L. The available data confirm that the listing of Mauvaise Terre Lake for manganese is appropriate based on IEPA's guidelines, as discussed in the Stage 1 Report.

4.2.3 Nitrate

The IEPA guidelines (IEPA, 2006) for identifying nitrate as a cause of impairment in waterbodies used for public and food processing water supply, state that nitrate is a potential cause of impairment of the public and food processing water supply use if more than 10% of the observations exceed the applicable nitrate standard (10 mg-N/l) for raw water. The available data support the listing of nitrate as a cause of impairment in Mauvaise Terre Lake, as discussed in the Stage 1 Report.

4.2.4 Fecal Coliform

The IEPA guidelines (IEPA, 2006) for identifying fecal coliform as a cause of impairment in streams state that fecal coliform is a potential cause of impairment of the primary contact use if the geometric mean of all samples collected during May through October (minimum five samples) is greater than 200/100 ml, or if greater than 10% of all samples exceed 400/100 ml. The available data support the listing of fecal coliform as a cause of impairment in Mauvaise Terre Creek (IL_DD-04), as discussed in the Stage 1 Report.

4.3 DEVELOPMENT OF TMDL TARGETS

The TMDL target is a numeric endpoint specified to represent the level of acceptable water quality that is to be achieved by implementing the TMDL. Where possible, the water quality criterion for the pollutant of concern is used as the numeric endpoint. When appropriate numeric standards do not exist, surrogate parameters must be selected to represent the designated use.

4.3.1 Total Phosphorus

For the Mauvaise Terre Lake phosphorus TMDL, the target is set at the water quality criterion for total phosphorus of 0.05 mg-P/l.

4.3.2 Manganese

For the Mauvaise Terre Lake manganese TMDL, the target is set at the water quality criterion for manganese of 150 ug/l.

4.3.3 Nitrate

For the Mauvaise Terre Lake nitrate TMDL, the target is set at the water quality criterion for nitrate of 10 mg-N/l.

4.3.4 Fecal Coliform

For Mauvaise Terre Creek (IL_DD-04) fecal coliform TMDL, the target was set at 200 cfu/100 ml.

This page is blank to facilitate double sided printing.

5 DEVELOPMENT OF WATER QUALITY MODELS

Water quality models are used to define the relationship between pollutant loading and resulting water quality. The TMDL for phosphorus is based upon the BATHTUB model. The TMDLs for fecal coliform, manganese and nitrate utilize a Load Duration Curve method in addition to a Load Capacity Calculation. The development of the BATHTUB model and the Load Duration Curve Approach are described in this section. The load capacity calculation is described in Section 6. Section 5 includes information on:

- Model selection
- Modeling approach
- Model inputs
- Model calibration (only for BATHTUB)/Analysis (for load duration)

5.1 BATHTUB MODEL

The BATHTUB water quality model was used to define the relationship between external phosphorus loads and the resulting concentrations of total phosphorus in Mauvaise Terre Lake.

5.1.1 Model Selection

A detailed discussion of the model selection process for the Mauvaise Terre Creek watershed is provided in the Stage 1 Report.

Of the models discussed , the BATHTUB model (Walker, 1985) was selected to address phosphorus impairments to Mauvaise Terre Lake. The BATHTUB model was selected because it does not have extensive data requirements (and can therefore be applied with existing data), yet still provides the capability for calibration to observed lake data. BATHTUB has been used previously for several reservoir TMDLs in Illinois, and has been cited as an effective tool for lake and reservoir water quality assessment and management, particularly where data are limited (Ernst et al., 1994).

BATHTUB was used to predict the relationship between phosphorus load and resulting in-lake phosphorus concentrations.

5.1.2 Modeling Approach

The approach selected for the phosphorus TMDL is based upon discussions with IEPA and the Scientific Advisory Committee. The approach consists of using existing empirical data to define current loads to the lake, and using the BATHTUB model to define the extent to which these loads must be reduced to meet water quality standards. This approach corresponds to Alternative 1 in the detailed discussion of the model selection process provided in the Stage 1 Report. Implementation plans for agricultural sources will require voluntary controls, applied on an incremental basis. The approach taken for these TMDLs, which requires no additional data collection and can be conducted immediately, will expedite these implementation efforts.

Determination of existing loading sources and prioritization of restoration alternatives may be conducted by local experts as part of the implementation process (see Section 8). Based upon their recommendations, a voluntary implementation plan can be developed that includes both accountability and the potential for adaptive management.

5.1.3 Model Inputs

This section provides an overview of the model inputs required for BATHTUB application, and how they were derived. The following categories of inputs are required for BATHTUB:

- Model Options
- Global Variables
- Reservoir Segmentation
- Tributary Loads

5.1.3.1 Model Options

BATHTUB provides a multitude of model options to estimate nutrient concentrations in a reservoir. Model options were entered as shown in Table 1, with the rationale for these options discussed below. No conservative substance was being simulated, so this option was not needed. The second order available phosphorus option was selected for phosphorus, as it is the default option for BATHTUB. Nitrogen was not simulated, because phosphorus is the nutrient of concern. Similarly, transparency and chlorophyll a are not simulated.

The Fischer numeric dispersion model was selected, which is the default approach in BATHTUB for defining mixing between lake segments. Phosphorus calibrations were based on lake concentrations. No nitrogen calibration was required. The use of availability factors was not required, and estimated concentrations were used to generate mass balance tables.

Table 1. BATHTUB Model Options for Mauvaise Terre Lake

MODEL	MODEL OPTION
Conservative substance	Not computed
Total phosphorus	2nd order, available phosphorus
Total nitrogen	Not computed
Chlorophyll-a	Not computed
Transparency	Not computed
Longitudinal dispersion	Fischer-numeric
Phosphorus calibration	Concentrations
Nitrogen calibration	None
Error analysis	Not computed
Availability factors	Ignored
Mass-balance tables	Use estimated concentrations

5.1.3.2 Global Variables

The global variables required by BATHTUB consist of:

- The averaging period for the analysis
- Precipitation, evaporation, and change in lake levels
- Atmospheric phosphorus loads

BATHTUB is a steady state model, whose predictions represent concentrations averaged over a period of time. A key decision in the application of BATHTUB is the selection of the length of time over which inputs and outputs should be modeled. The length of the appropriate averaging period for BATHTUB application depends upon the nutrient residence time, which is the average length of time that phosphorus spends in the water column before settling or flushing out of the lake. Guidance for the BATHTUB model recommends that the averaging period used for the analysis be at least twice as large as nutrient residence time for the lake of interest. For lakes such as Mauvaise Terre Lake, which have a nutrient residence time on the order of weeks, a monthly averaging period is recommended. The averaging period used for this analysis was set to the monthly period.

Precipitation inputs were taken from the observed long-term annual average precipitation data and scaled for the monthly simulation period. This resulted in a total monthly precipitation value of 3.3 inches. Evaporation was set equal to precipitation and there was no assumed increase in storage during the modeling period, to represent steady state conditions. The values selected for precipitation and change in lake levels have little influence on model predictions. Atmospheric phosphorus loads were specified using default values provided by BATHTUB.

5.1.3.3 Reservoir Segmentation

BATHTUB provides the capability to divide the reservoir under study into a number of individual segments, allowing prediction of the change in phosphorus concentrations over the length of the reservoir. The segmentation scheme selected for Mauvaise Terre Lake was designed to provide one segment for each of the primary lake sampling stations. The lake was divided into the segments as shown in Figure 2. The areas of segments and watersheds for each segment were determined by Geographic Information System (GIS).

BATHTUB requires that a range of inputs be specified for each segment. These include segment surface area, length, total water depth, and depth of thermocline and mixed layer. Segment-specific values for segment depths were calculated from lake monitoring data, while segment lengths and surface areas were calculated using GIS. A complete listing of all segment-specific inputs is provided in Attachment 1.

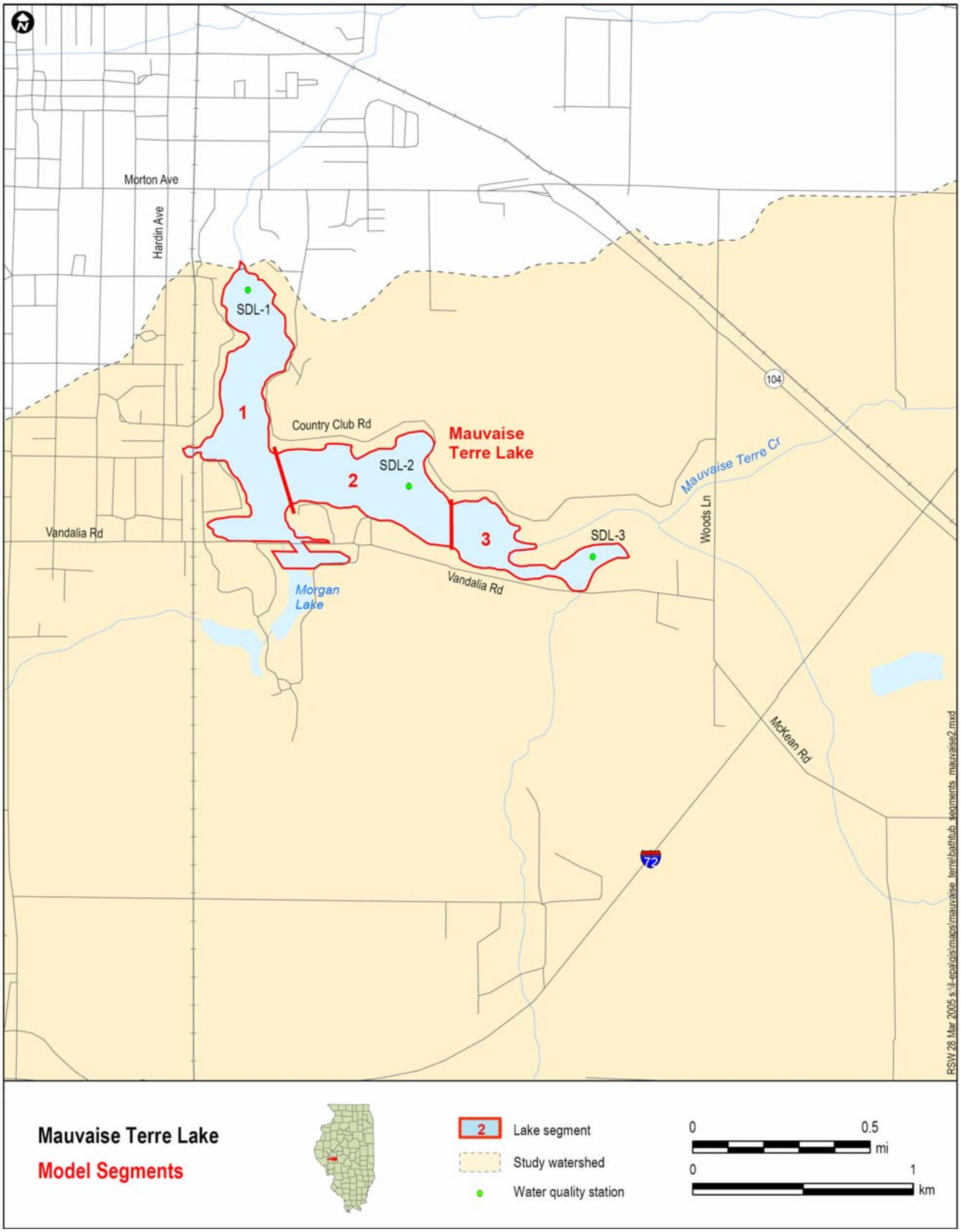


Figure 2. Mauvaise Terre Lake Segmentation Used in BATHTUB

5.1.3.4 Tributary Loads

BATHTUB requires information describing tributary flow and nutrient concentrations into each reservoir segment. The approach used to estimate flows is described below. Total phosphorus concentrations for each major lake tributary were based upon springtime measurements taken near the headwaters of the lake. Concentrations for small tributaries were set equal to the assumed concentration for the major tributary. A complete listing of all segment-specific flows and tributary concentrations is provided in Attachment 1.

Flows to each segment were estimated using observed flows at USGS gaging stations adjusted through the use of drainage area ratios as follows:

Flow into segment = Flow at USGS gage x Segment-specific drainage area ratio

$$\text{Drainage area ratio} = \frac{\text{Drainage area of watershed contributing to model segment}}{\text{Drainage area of watershed contributing to USGS gage}}$$

The USGS gage on Spring Creek at Springfield, IL (#05577500) was used in this analysis.

Segment-specific drainage area ratios were calculated using the watershed boundaries provided in GIS.

5.1.4 BATHTUB Calibration

BATHTUB model calibration consists of:

1. Applying the model with all inputs specified as above
2. Comparing model results to observed phosphorus data
3. Adjusting model coefficients to provide the best comparison between model predictions and observed phosphorus data.

The BATHTUB model was initially applied with the model inputs as specified above. Observed data for the year 1992 were used for calibration purposes, as this year provided the most robust data set. The August in-lake data from this year were used for calibration, as these data best reflect the steady state conditions assumed for the BATHTUB model.

Model results in segments 1, 2, and 3 initially under-predicted the observed phosphorus data. Phosphorus loss rates in BATHTUB reflect a typical “net settling rate” (i.e. settling minus sediment release) observed over a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data were corrected during the calibration process via the addition of an internal phosphorus load of 170 $mg/m^2/day$ in segment 3 to reflect resuspension of phosphorus from the lake bottom sediments in this segment. The resulting predicted lake average total phosphorus concentration was 275.4 ug/l, compared to an observed average of 277.1 ug/l. This comparison represents an acceptable model calibration. A complete listing of all the observed data used for calibration purposes, as well as a comparison between model predictions and observed data, is provided in Attachment 1.

5.2 LOAD DURATION CURVE APPROACH

A load duration curve approach was used in the manganese and nitrate analysis for Mauvaise Terre Lake. A load duration curve approach was also used in the fecal coliform analysis for Mauvaise Terre Creek. A load duration curve is a graphical representation of observed pollutant load compared to maximum allowable load over a range of flow conditions. The load duration curve provides information to:

- Help identify the issues surrounding the problem and differentiate between point and nonpoint source problems, as discussed immediately below;
- Address frequency of deviations (how many samples lie above the curve vs. those that plot below); and
- Aid in establishing the level of implementation needed, by showing the magnitude by which existing loads exceed standards for different flow conditions.

5.2.1 Model Selection

The load duration curve approach was selected for fecal coliform, manganese and nitrate because it is consistent with the selected level of TMDL implementation for this TMDL and it can be applied with the existing data. The load duration curve approach identifies broad categories of sources over the entire range of flows, and the extent of control required from these source categories to attain water quality standards.

5.2.2 Approach

The load duration curve approach uses stream flows for the period of record to gain insight into the flow conditions under which exceedances of the water quality standard occur. A load-duration curve is developed by: 1) ranking the daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results; 2) translating the flow duration curve (produced in step 1) into a load duration curve by multiplying the flows by the TMDL target; and 3) plotting observed pollutant loads (measured concentrations times stream flow) on the same graph. Observed loads that fall above the load duration curve exceed the maximum allowable load, while those that fall on or below the line, do not exceed the maximum allowable load. An analysis of the observed loads relative to the load duration curve provides information on whether the pollutant source is point or nonpoint in nature. A more complete description of the load duration curve approach is provided in the Stage 1 Report.

5.2.3 Data Inputs

The load duration curve approach requires a long-term flow record and concentration measurements that are paired to flows. Data used for the load duration curve approach are discussed below.

5.2.3.1 Manganese and Nitrate

Manganese data are available for a single location (SDL-1) in the lake, which was monitored in 2002. All available manganese data were used in the analysis. These data were collected by IEPA between April and October 2002 as part of IEPA's ambient water quality monitoring program.

Nitrate data are available for three locations in Mauvaise Terre Lake between 1992 and 202. All available nitrate data collected by the IEPA at the most upstream lake station (SDL-3) between 1992 and 2002 were used in the analysis. The data were collected as part of IEPA's ambient water quality monitoring program.

The load duration curve approach requires a matching of flows to water quality data for the recent period. Daily flows were not available for Mauvaise Terre Lake for recent years. Instead, daily average flows measured at the USGS gage on nearby Spring Creek at Springfield, Illinois (05577500) were used in the analysis. Flows are available for the period 1948-2004. The flows measured on Spring Creek were adjusted for the size of the drainage area (i.e., they were multiplied by 0.3 because the watershed for the lake is 70% smaller than the watershed for the Spring Creek gage).

5.2.3.2 Fecal coliform

Fecal coliform data collected by IEPA between 1990 and 2004 were used in the analysis. The data were collected as part of IEPA's ambient water quality monitoring program. Only data for the months of May-October were used because the water quality standard applies during this period.

The load duration curve approach requires a matching of flows to water quality data for the recent period. Daily flows were not available for Mauvaise Terre Creek for recent years. Instead, daily average flows measured at the USGS gage on nearby Spring Creek at Springfield, Illinois (05577500) were used in the analysis. Flows are available for the period 1948-2004. The flows measured on Spring Creek were adjusted for the size of the drainage area (i.e., they were multiplied by 1.3 because the watershed for IL_DD-04 is 30% larger than the watershed for the Spring Creek gage).

5.2.4 Analysis

Load duration curves were developed for manganese, nitrate and fecal coliform, to characterize pollutant problems over the entire flow regime and gain an understanding of manganese and nitrate impairments in Mauvaise Terre Lake and fecal coliform impairments in Mauvaise Terre Creek.

5.2.4.1 Manganese

A flow duration curve was generated by ranking daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results. A load duration curve for manganese was generated by multiplying the flows in the duration curve by the water quality standard of 150 ug/l for manganese. This is shown with a solid line in Figure 3. Observed pollutant loads (measured concentrations multiplied by corresponding stream flow), were plotted at triangles on the same graph. The worksheet for this analysis is provided in Attachment 2.

The load duration curve for manganese shows that elevated concentrations are observed only at low flows. This indicates that groundwater/natural sources are likely contributors to manganese exceedances.

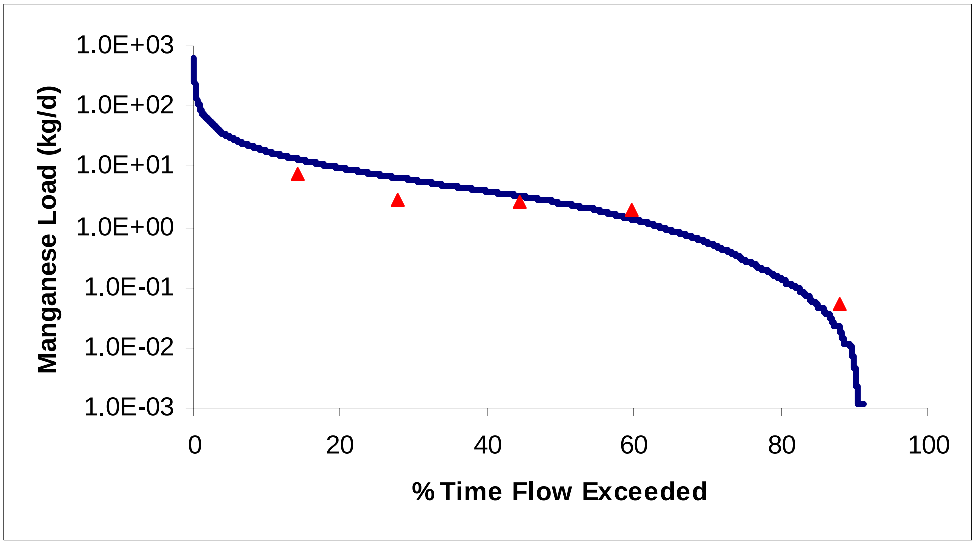


Figure 3. Manganese load duration curve for Mauvaise Terre Lake with observed loads (triangles)

5.2.4.2 Nitrate

A flow duration curve was generated by ranking daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results. A load duration curve for nitrate was generated by multiplying the flows in the duration curve by the water quality standard of 10 mg-N/l for nitrate. This is shown with a solid line in Figure 4. Observed pollutant loads (measured concentrations multiplied by corresponding stream flow), were plotted on the same graph. The worksheet for this analysis is provided in Attachment 3.

The load duration curve shows that nitrate loads at higher flows fall above the curve, indicating that nonpoint sources are significant contributors to nitrate exceedances. During lower flows, nitrate loads fall below the curve, indicating compliance with the standard during drier conditions. This information can be used to look at potential implementation opportunities. Because it will not be feasible to eliminate all nonpoint source loadings of nitrate in the watershed, the implementation plan (addressed in a separate report) will need to define practical activities that will reduce loadings as much as is feasible and practical.

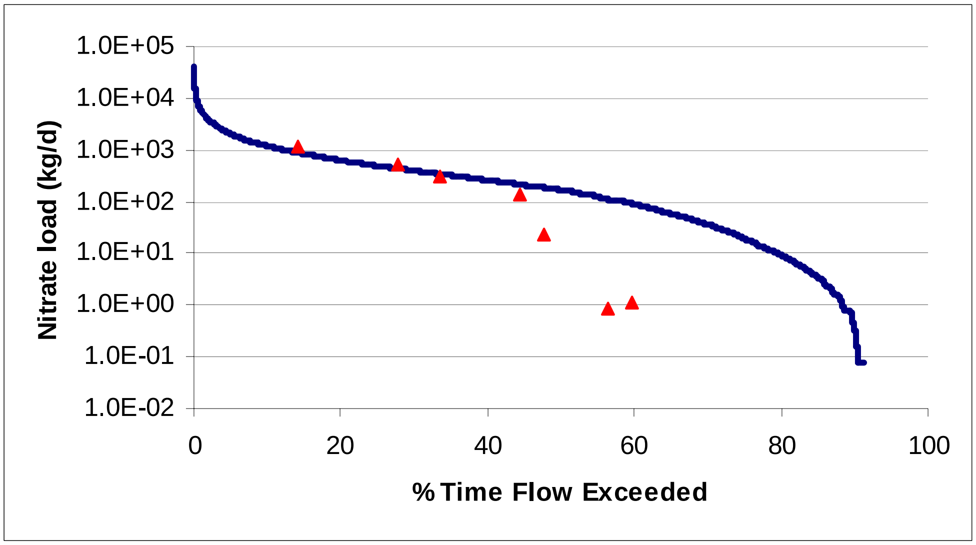


Figure 4. Nitrate load duration curve for Mauvaise Terre Lake with observed loads (triangles)

5.2.4.3 Fecal coliform

A flow duration curve was generated by ranking daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results. A load duration curve for fecal coliform was generated by multiplying the flows in the duration curve by the TMDL target of 200 cfu/100 ml for fecal coliform bacteria. This is shown with a solid line in Figure 5. Observed pollutant loads (measured concentrations multiplied by corresponding stream flow), were plotted on the same graph. The worksheet for this analysis is provided in Attachment 4.

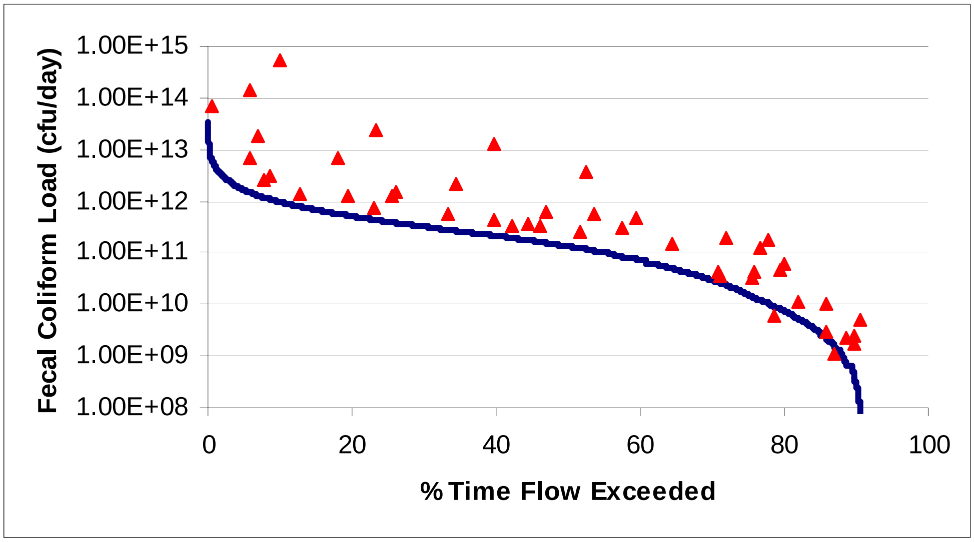


Figure 5. Fecal coliform load duration curve for Mauvaise Terre Creek with observed loads (triangles)

Fecal coliform concentration data are available for a wide range of flows and exceedances are observed over the range of flows examined. This indicates that wet and dry weather sources are significant contributors to fecal coliform exceedances in this segment.

This page is blank to facilitate double sided printing.

6 TMDL DEVELOPMENT

This section presents the development of the total maximum daily load for the impaired waterbodies in Mauvaise Terre Creek watershed. It begins with a description of how the total loading capacity was calculated, and then describes how the loading capacity is allocated among point sources, non-point sources, and the margin of safety. A discussion of critical conditions and seasonality considerations is also provided.

6.1 PHOSPHORUS (MAUVAISE TERRE LAKE)

The BATHTUB model was developed to define the relationship between phosphorus loads and resulting phosphorus concentrations in Mauvaise Terre Lake and to calculate the loading capacity.

6.1.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards.

The loading capacity was determined by running the BATHTUB model repeatedly, reducing the tributary nutrient concentrations for each simulation until model results demonstrated attainment with the TMDL target. The maximum tributary concentration that results in compliance with water quality standards was used as the basis for determining the lake's loading capacity. The tributary concentration was then converted into a loading rate through multiplication with the tributary flow.

Initial BATHTUB load reduction simulations indicated that Mauvaise Terre Lake phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional sediment phosphorus source for scenarios where the tributary phosphorus concentrations were less than 100 ug-P/l. The resulting tributary phosphorus load that led to compliance with water quality standards was 60.8 kg-P/month (2.03 kg-P/day). This allowable load corresponds to an approximately 57% reduction from existing tributary loads (estimated as 142.8 kg-P/month or 4.76 kg-P/day). Loads are expressed on a monthly basis because model results indicate that the phosphorus residence time in Mauvaise Terre Lake is on the order of several weeks. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.

6.1.2 Allocation

A TMDL consists of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

Since no point sources are located in the Mauvaise Terre Lake watershed, the WLA will be set to zero. The remainder of the loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a loading capacity of 60.8 kg-P/month (2.03 kg-P/day) and an explicit margin of safety of 10% (discussed below) results in a load allocation for Mauvaise Terre Lake of 54.72 kg-P/month (1.827 kg-P/day).

6.1.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Critical conditions were taken into account in the development of this TMDL. The critical environmental conditions for Mauvaise Terre Lake correspond to the middle to late summer period, when observed phosphorus concentrations in the lake are highest. The BATHTUB model simulations upon which this TMDL is based were conducted to represent this critical middle to late summer period.

6.1.4 Seasonality

These TMDLs were conducted with an explicit consideration of seasonal variation. The BATHTUB model was applied to evaluate phosphorus over a range of seasonal periods, with TMDL results being based upon the most critical period as described above.

6.1.5 Margin of Safety

The phosphorus TMDL contains an explicit margin of safety of 10%. The 10% margin of safety is considered an appropriate value based upon the generally good agreement between the BATHTUB water quality model predicted values and the observed values. Since the model reasonably reflects the conditions in the watershed, a 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL, based upon the data available. The resulting explicit phosphorus load allocated to the margin of safety is 6.08 kg-P/month (0.203 kg-P/day).

6.2 MANGANESE (MAUVAISE TERRE LAKE)

A load capacity calculation approach was applied to support development of a manganese TMDL for Mauvaise Terre Lake.

6.2.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards. The loading capacity was defined over a range of specified flows based on expected flows for the watershed. The allowable loading capacity was computed by multiplying flow by the water quality standard (150 ug/l for manganese). The manganese loading capacity is presented in Table 2. The percent reduction in manganese load was calculated by comparing the observed and allowable manganese loads over a range of flows. The observed manganese load was calculated from observed in-lake concentrations (averaged by flow class) and flows estimated from the Spring Creek gage near Springfield. A 53% reduction from current manganese loads is required for Mauvaise Terre River flows less than 5 cfs.

Table 2. Manganese Loading Capacity

Mauvaise Terre River Flow (cfs)	Manganese Loading Capacity (kg/day)
0.5	0.18
1	0.37
2	0.73
5	1.84
10	3.67
20	7.34
30	11.01
40	14.68
50	18.35

6.2.2 Allocation

A TMDL consists of waste load allocations (WLAs) for point sources, load allocations (Las) for nonpoint sources, and a margin of safety (MOS).

Because there are no point sources located in the Mauvaise Terre Lake watershed, the WLA for manganese is set at zero. The remainder of the loading capacity is given to the load allocation for nonpoint sources and the margin of safety (Table 3). The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall manganese load.

Table 3. Manganese TMDL Allocation[1]

Mauvaise Terre River Flow (cfs)	Manganese Loading Capacity (kg/day)	Manganese LA (kg/day)	Manganese MOS (kg/day)
0.5	0.18	0.17	0.02
1	0.37	0.33	0.04
2	0.73	0.66	0.07
5	1.84	1.65	0.18
10	3.67	3.30	0.37
20	7.34	6.61	0.73
30	11.01	9.91	1.10
40	14.68	13.21	1.47
50	18.35	16.52	1.84

[1] Due to rounding, numbers may not add up exactly.

6.2.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Critical conditions were taken into account in the development of this TMDL. Manganese naturally occurs in soils; therefore, surface runoff contains manganese that is transported into the lake via rain events. TMDL development based on the load duration curve approach considers the entire range of flows that could occur in any given year; which includes flow from rain events. Therefore critical conditions were addressed during TMDL development.

6.2.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. By specifying the allowable loading capacity as a function of stream flow, the TMDL considers all possible seasonal variation.

6.2.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be either implicit (e.g., incorporated into the TMDL analysis through conservative assumptions), or explicit (e.g., expressed in the TMDL as a portion of the loading), or expressed as a combination of both. The manganese TMDL contains an explicit margin of safety of 10% to address potential uncertainty in the effectiveness of load reduction calculations. A relatively low margin of safety was chosen by IEPA because the load duration curve (LDC) analysis, used to develop the loadings, provides good information on the relationship between pollutant loadings and the receiving water quality. The LDC method has few assumptions in it, compared to more complex models. It provides a simple context for evaluating monitoring data across the entire range of flow conditions (i.e. a period of 56 years from 1948-2004), thus reducing the uncertainty in the flows (and related loads). Since duration curves calculated loads at various flows and used the WQS as the TMDLs target, the method allowed IEPA to have a better understanding of when the exceedences occurred in the waterbody and under what conditions. This will help reduce uncertainty in the effectiveness of the implementation efforts, and the likelihood of meeting the appropriate WQS/designated use.

6.3 NITRATE (MAUVAISE TERRE LAKE)

A load capacity calculation approach was applied to support development of a nitrate TMDL for Mauvaise Terre Lake.

6.3.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards. The loading capacity for nitrate was defined over a range of specified flows based on expected flows for the watershed. The allowable loading capacity was computed by multiplying flow by the water quality standard (10 mg-N/l for nitrate). The nitrate loading capacity is presented in Table 4.

The percent reduction in nitrate load was calculated by comparing the observed and allowable nitrate loads over a range of flows. The observed nitrate load was calculated from observed in-lake concentrations and flows estimated from the Spring Creek gage near Springfield. To calculate the observed nitrate loads, the observed in-lake nitrate concentrations were regressed against the flows and this relationship was applied to calculate observed nitrate loads for the flows presented in Table 4. No reduction is needed at lower watershed flows, as the observed load is less than the allowable loading capacity. At higher flows (i.e., 50 cfs), a 57% reduction in nitrate is required.

Table 4. Nitrate Loading Capacity

Mauvaise Terre River Flow (cfs)	Nitrate Loading Capacity (kg/day)
0.5	12.2
1	24.5
2	48.9
5	122.3
10	244.7
20	489.4
30	734.1
40	978.7
50	1,223.4

6.3.2 Allocation

A TMDL consists of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and a margin of safety (MOS).

Because there are no point sources located in the Mauvaise Terre Lake watershed, the WLA for nitrate is set at zero. The remainder of the loading capacity is given to the load allocation for nonpoint sources and the margin of safety (Table 5). The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall nitrate load.

Table 5. Nitrate TMDL Allocation[1]

Mauvaise Terre River Flow (cfs)	Nitrate Loading Capacity (kg-N/day)	Nitrate LA (kg-N/day)	Nitrate MOS (kg-N/day)
0.5	12.2	11.0	1.2
1	24.5	22.0	2.4
2	48.9	44.0	4.9
5	122.3	110.1	12.2
10	244.7	220.2	24.5
20	489.4	440.4	48.9
30	734.1	660.6	73.4
40	978.7	880.9	97.9
50	1223.4	1101.1	122.3

[1]Due to rounding, numbers may not add up.

6.3.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Critical conditions were taken into account in the development of this TMDL. Nitrate in this watershed was shown to be significantly higher in spring. TMDL development based on the load duration curve approach considers the entire range of flows that could occur in any given year; which includes spring. Therefore critical conditions were addressed during TMDL development.

6.3.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. By specifying the allowable loading capacity as a function of stream flow, the TMDL considers all possible seasonal variation.

6.3.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be either implicit (e.g., incorporated into the TMDL analysis through conservative assumptions), or explicit (e.g., expressed in the TMDL as a portion of the loading), or expressed as a combination of both. The nitrate TMDL contains an explicit margin of safety of 10% to address potential uncertainty in the effectiveness of load reduction calculations. A relatively low margin of safety was chosen by IEPA because the load duration curve (LDC) analysis, used to develop the loadings, provides good information on the relationship between pollutant loadings and the receiving water quality. The LDC method has few assumptions in it, compared to more complex models. It provides a simple context for evaluating monitoring data across the entire range of flow conditions (i.e. a period of 56 years from 1948-2004), thus reducing the uncertainty in the flows (and related loads). Since duration curves calculated loads at various flows and used the WQS as the TMDLs target, the method allowed IEPA to have a better understanding of when the exceedences occurred in the waterbody and under what conditions.

6.4 FECAL COLIFORM (MAUVAISE TERRE CREEK)

A load capacity calculation approach was applied to support development of a fecal coliform TMDL for Mauvaise Terre Creek.

6.4.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards. The loading capacity was defined over the range of observed flow conditions. The allowable loading capacity was computed by multiplying flow by the TMDL target (200 cfu/100 ml). The fecal coliform loading capacity is presented in Table 6.

Table 6. Mauvaise Terre Creek Fecal Coliform Loading Capacity

Flow Percentile Range	Median Observed Mauvaise Terre Creek Flow (cfs)	Load Capacity (cfu/day)[1]
60-100	1.56	7.63E+09
30-60	35.1	1.72E+11
0-30	139	6.81E+11

The maximum fecal coliform concentrations were examined for different flow intervals (Table 7) and compared to the 200 cfu/100 ml target to estimate the percent reduction needed to meet the water quality target. An approximately 99% reduction in fecal coliform loading is required to meet the TMDL target over the range of flows observed in the creek. Exceedances of the target were previously illustrated in Figure 5.

Table 7. Required Reductions in Existing Loads under Different Flow Conditions

Flow Percentile Interval	Mauvaise Terre Creek Flow (cfs)	Maximum fecal concentration (cfu/100 ml)	Percent reduction to meet target
60-100	0 - 14	110,000	99.8%
30-60	14 - 65	20,000	99.0%
0-30	65-6916	15,700	98.7%

6.4.2 Allocation

A TMDL consists of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

There are three NPDES permitted point source dischargers of fecal coliform in the Mauvaise Terre Creek watershed. The WLA for these point sources was calculated using their permitted flow rates and a concentration consistent with meeting the TMDL target (200 cfu/100 ml) at the point where the segment impairment begins. Wasteload allocations for these facilities are presented in Table 8. The total WLA for these three facilities equals 5.84E+10.

In addition to the dischargers presented in Table 8, the Jacksonville STP also has a permit for three combined sewer overflows (CSO) that may discharge during wet weather: outfall 002, outfall 003, and outfall 004 (a treated combined sewage outfall). The WLA for the CSOs is calculated based on the reported 2003 average overflow volume per event for the three overflows and a concentration of 200 cfu/100 ml, consistent with the TMDL target. The WLA for the CSOs equals 5.72E+10 cfu/day and applies at the point where the segment impairment begins, not at the end of the pipe. This number may be refined as the results from a monitoring study proposed by Jacksonville are reported.

Table 8. Permitted Dischargers and WLAs

NPDES ID	Facility Name	Disinfection exemption ?	Average design flow (MGD)	Permit expiration date	WLA (cfu/day)[1]
IL0055085	Marnico Village	Year-round	0.041	2-28-08	3.11E+08
ILG580166	Chapin STP	Year-round	0.1	12-31-07	7.58E+08
IL0021661	Jacksonville STP	No	7.57	10-31-09	5.73E+10

[1]This WLA applies at the point where the segment impairment begins and not at the end of pipe.

The remainder of the loading capacity is given to the load allocation for nonpoint sources as presented in Table 9. The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall fecal coliform load.

Table 9. Fecal Coliform TMDL for Mauvaise Terre Creek (IL_DD-04)[1]

Flow Percentile Range	Median Obs. Mauvaise Terre Creek Flow (cfs)	Load Capacity (cfu/day)	Observed Load (cfu/day)[3]	Wasteload Allocation (WLA) (cfu/day)[2]	CSO WLA (cfu/day)[4]	Load Allocation (LA) (cfu/day)	Percent Reduction for CSOs
60-100	1.56	7.63E+09	5.99E+11	7.63E+09	0	0	0
30-60	35.1	1.72E+11	1.72E+13	5.84E+10	0	1.13E+11	0
0-30	139	6.81E+11	3.74E+14	5.84E+10	5.72E+10	5.65E+11	99.6%

[1] An implicit margin of safety is used in this TMDL

[2] A lower WLA is used during the unique case where all of the stream flow is from the treatment plant flow.

[3] Observed load calculated using maximum fecal concentration and median observed flows

[4] For purposes of this table, CSOs discharge only during high flows

As shown in Table 9, a 99% reduction in CSO loads is required during higher flows, when CSOs are discharging. This percent reduction is based on measured Jacksonville CSO flows and fecal concentrations. No WLA reduction is required at lower flows, as the Chapin and Marinco Village facilities have disinfection exemptions and the

Jacksonville STP is in compliance with its permit limits, which are consistent with meeting water quality standards.

6.4.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Critical conditions were taken into account in the development of this TMDL. The standard for fecal coliform only applies during May 1 through October 31 when humans will be in contact with the water. Water quality data and streamflow data from May 1 through October 31 were used in the load duration curve. Therefore critical conditions were addressed during TMDL development.

6.4.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The approach used for the TMDL evaluated seasonal loads because only May through October water quality data were used in the analysis, consistent with the specification that the standard only applies during this period. The fecal coliform standard will be met regardless of flow conditions in the applicable season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur at any given point in the season where the standard applies.

6.4.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be either implicit (e.g., incorporated into the TMDL analysis through conservative assumptions), or explicit (e.g., expressed in the TMDL as a portion of the loading), or expressed as a combination of both. The fecal coliform TMDL contains an implicit margin of safety, through the use of multiple conservative assumptions. First, the TMDL target (no more than 200 cfu/100 ml at any point in time) is more conservative than the more restrictive portion of the fecal coliform water quality standard (geometric mean of 200 cfu/100 ml for all samples collected May through October). An additional implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no decay of bacteria that enter the river, and therefore represents an upper bound of expected concentrations for a given pollutant load. This margin of safety can be reviewed in the future as new data are developed.

This page is blank to facilitate double sided printing.

7 PUBLIC PARTICIPATION AND INVOLVEMENT

The TMDL process included numerous opportunities for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in Summer 2004 to notify stakeholders about the upcoming TMDLs, and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (see Stage 1 Report). As quarterly progress reports were produced during the first stage of the TMDL process, the Agency posted them to their website for public review.

In January 2005, a public meeting was announced for presentation of the Stage 1 findings. This announcement was mailed to everyone on the previous TMDL mailing list and published in local newspapers. The public meeting was held at 6:30 pm on Tuesday, March 1, 2005 at the Jacksonville Municipal Building in Jacksonville, Illinois. In addition to the meeting's sponsors, nine (9) individuals attended the meeting. Attendees registered and listened to an introduction to the TMDL Program from Illinois EPA and a presentation on the Stage 1 findings by Limno-Tech, Inc. (LTI). This was followed by a general question and answer session.

In July 2005, a public meeting was announced for presentation of the Stage 3 findings. This announcement was mailed to everyone on the previous TMDL mailing list and published in local newspapers. The public meeting was held at 6:00 pm on Wednesday, July 26, 2006 at the Jacksonville Municipal Building in Jacksonville, Illinois. In addition to the meeting's sponsors, nine (9) individuals attended the meeting. Attendees registered and listened to a presentation on the Stage 3 findings by Limno-Tech, Inc. (LTI). This was followed by a general question and answer session.

A responsiveness summary is included in Attachment 5. This responsiveness summary addresses substantive questions and comments received during the public comment period.

This page is blank to facilitate double sided printing.

8 ADAPTIVE IMPLEMENTATION PROCESS

The approach to be taken for TMDL implementation is based upon discussions with Illinois EPA and its Scientific Advisory Committee. The approach consists of the following steps:

1. Use existing data to define overall existing pollutant loads, as opposed to developing a watershed model that might define individual loading sources.
2. Apply relatively simple models (e.g. BATHTUB) to define the load-response relationship and define the maximum allowable pollutant load that the lake can assimilate and still attain water quality standards
3. Compare the maximum allowable loading capacity to the existing load to define the extent to which existing loads must be reduced in order to meet water quality standards
4. Develop a voluntary implementation plan that includes both accountability and the potential for adaptive management.
5. Carry out adaptive management through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented, as well as progress towards attaining water quality standards.

This approach is designed to accelerate the pace at which TMDLs are being developed for sites dominated by nonpoint sources, which will allow implementation activities (and water quality improvement) to begin sooner. The approach also places decisions on the types of nonpoint source controls to be implemented at the local level, which will allow those with the best local knowledge to prioritize sources and identify restoration alternatives. Finally, the adaptive management approach to be followed recognizes that models used for decision-making are approximations, and that there is never enough data to completely remove uncertainty. The adaptive process allows decision-makers to proceed with initial decisions based on modeling, and then to update these decisions as experience and knowledge improve.

Steps 1-3 correspond to TMDL development and have been completed, as described in Section 5 of this document. Steps 4 and 5 correspond to implementation.

This page is blank to facilitate double sided printing.

REFERENCES

Ernst, M. R., W. Frossard, and J. L. Mancini. 1994. Two Eutrophication Models make the Grade. *Water Environment and Technology* 6 (11), pp 15-16.

Illinois Environmental Protection Agency (IEPA), 2006. Illinois Integrated Water Quality Report and Section 303(d) list-2006. Illinois EPA Bureau of Water. April 2006. IEPA/BOW/04-005 http://www.epa.state.il.us/water/watershed/reports/303d-report/2006/303d-report.pdf

U.S. Environmental Protection Agency (EPA), 1991. *Guidance for Water Quality-based Decisions: The TMDL Process.* EPA 440/4-91-001. Office of Water, Washington, DC.

Walker, W. W., 1985. *Empirical Methods for Predicting Eutrophication in Impoundments; Report 3, Phase III: Model Refinements*. Technical Report E-81-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

This page is blank to facilitate double sided printing.

Attachment 1

This page is blank to facilitate double sided printing.

Mauvaise Terre Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 4 Area-Wtd Mean

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	275.4		97.4%	277.1		97.4%
CHL-A MG/M3				63.4		99.3%
SECCHI M				0.3		4.0%
ANTILOG PC-1				5079.5		99.0%
ANTILOG PC-2				8.4		69.2%
TURBIDITY 1/M	2.1		91.7%	2.1		91.7%
ZMIX * TURBIDITY	2.8		44.0%	2.8		44.0%
ZMIX / SECCHI				5.4		58.0%
CHL-A * SECCHI				18.3		79.5%
CHL-A / TOTAL P				0.2		60.3%
FREQ(CHL-a>10) %				99.5		99.3%
FREQ(CHL-a>20) %				93.4		99.3%
FREQ(CHL-a>30) %				80.7		99.3%
FREQ(CHL-a>40) %				66.0		99.3%
FREQ(CHL-a>50) %				52.4		99.3%
FREQ(CHL-a>60) %				41.0		99.3%
CARLSON TSI-P	85.0		97.4%	85.1		97.4%
CARLSON TSI-CHLA				71.2		99.3%
CARLSON TSI-SEC				78.3		96.0%

Segment: 1 Near Dam

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	237.4		96.2%	260.0		97.0%
CHL-A MG/M3				68.0		99.5%
SECCHI M				0.3		6.6%
ANTILOG PC-1				4428.2		98.6%
ANTILOG PC-2				10.1		80.5%
TURBIDITY 1/M	1.2		78.4%	1.2		78.4%
ZMIX * TURBIDITY	2.7		41.6%	2.7		41.6%
ZMIX / SECCHI				6.4		69.5%
CHL-A * SECCHI				23.3		87.9%
CHL-A / TOTAL P				0.3		67.5%
FREQ(CHL-a>10) %				99.7		99.5%
FREQ(CHL-a>20) %				95.2		99.5%
FREQ(CHL-a>30) %				84.4		99.5%
FREQ(CHL-a>40) %				70.7		99.5%
FREQ(CHL-a>50) %				57.4		99.5%
FREQ(CHL-a>60) %				45.7		99.5%
CARLSON TSI-P	83.0		96.2%	84.3		97.0%
CARLSON TSI-CHLA				72.0		99.5%
CARLSON TSI-SEC				75.4		93.4%

Mauvaise Terre Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 2 Middle

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	284.3		97.6%	250.0		96.7%
CHL-A MG/M3				53.0		98.8%
SECCHI M				0.3		2.8%
ANTILOG PC-1				4624.9		98.8%
ANTILOG PC-2				6.8		53.9%
TURBIDITY 1/M	2.6		95.1%	2.6		95.1%
ZMIX * TURBIDITY	3.4		54.6%	3.4		54.6%
ZMIX / SECCHI				5.2		55.9%
CHL-A * SECCHI				13.5		65.2%
CHL-A / TOTAL P				0.2		54.9%
FREQ(CHL-a>10) %				99.1		98.8%
FREQ(CHL-a>20) %				89.7		98.8%
FREQ(CHL-a>30) %				72.8		98.8%
FREQ(CHL-a>40) %				55.7		98.8%
FREQ(CHL-a>50) %				41.4		98.8%
FREQ(CHL-a>60) %				30.5		98.8%
CARLSON TSI-P	85.6		97.6%	83.8		96.7%
CARLSON TSI-CHLA				69.5		98.8%
CARLSON TSI-SEC				79.7		97.2%

Segment: 3 Upper Pool

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	355.4		98.7%	370.0		98.8%
CHL-A MG/M3				71.0		99.6%
SECCHI M				0.2		1.4%
ANTILOG PC-1				7556.6		99.6%
ANTILOG PC-2				6.9		55.2%
TURBIDITY 1/M	3.2		97.0%	3.2		97.0%
ZMIX * TURBIDITY	1.9		26.5%	1.9		26.5%
ZMIX / SECCHI				3.0		21.6%
CHL-A * SECCHI				14.3		68.5%
CHL-A / TOTAL P				0.2		48.7%
FREQ(CHL-a>10) %				99.8		99.6%
FREQ(CHL-a>20) %				95.8		99.6%
FREQ(CHL-a>30) %				86.0		99.6%
FREQ(CHL-a>40) %				73.1		99.6%
FREQ(CHL-a>50) %				60.1		99.6%
FREQ(CHL-a>60) %				48.5		99.6%
CARLSON TSI-P	88.8		98.7%	89.4		98.8%
CARLSON TSI-CHLA				72.4		99.6%
CARLSON TSI-SEC				83.0		98.6%

Mauvaise Terre Lake

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 Near Dam**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Trib 1	1.2	10.3%	181.6	2.9%	155
PRECIPITATION			0.3	2.8%	9.5	0.2%	30
TRIBUTARY INFLOW			1.2	10.3%	181.6	2.9%	155
ADVECTIVE INFLOW			9.9	86.9%	2808.6	44.4%	284
NET DIFFUSIVE INFLOW			0.0	0.0%	3320.5	52.5%	
***TOTAL INFLOW			11.4	100.0%	6320.2	100.0%	556
ADVECTIVE OUTFLOW			11.1	97.2%	2623.2	41.5%	237
***TOTAL OUTFLOW			11.1	97.2%	2623.2	41.5%	237
***EVAPORATION			0.3	2.8%	0.0	0.0%	
***RETENTION			0.0	0.0%	3697.0	58.5%	

Hyd. Residence Time = 0.0633 yrs
Overflow Rate = 34.8 m/yr
Mean Depth = 2.2 m

Component: TOTAL P **Segment: 2 Middle**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
2	1	Trib 2	0.1	1.4%	21.7	0.4%	155
PRECIPITATION			0.2	2.3%	6.9	0.1%	30
TRIBUTARY INFLOW			0.1	1.4%	21.7	0.4%	155
ADVECTIVE INFLOW			9.7	96.3%	3461.3	67.6%	355
NET DIFFUSIVE INFLOW			0.0	0.0%	1629.8	31.8%	
***TOTAL INFLOW			10.1	100.0%	5119.7	100.0%	506
ADVECTIVE OUTFLOW			9.9	97.7%	2808.6	54.9%	284
***TOTAL OUTFLOW			9.9	97.7%	2808.6	54.9%	284
***EVAPORATION			0.2	2.3%	0.0	0.0%	
***RETENTION			0.0	0.0%	2311.1	45.1%	

Hyd. Residence Time = 0.0309 yrs
Overflow Rate = 42.8 m/yr
Mean Depth = 1.3 m

Component: TOTAL P **Segment: 3 Upper Pool**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
3	1	Trib 3	0.5	4.6%	69.9	0.7%	155
4	1	Trib 4	9.3	94.1%	1439.9	15.4%	155
PRECIPITATION			0.1	1.3%	3.8	0.0%	30
INTERNAL LOAD			0.0	0.0%	7808.5	83.8%	
TRIBUTARY INFLOW			9.7	98.7%	1509.7	16.2%	155
***TOTAL INFLOW			9.9	100.0%	9322.0	100.0%	945
ADVECTIVE OUTFLOW			9.7	98.7%	3461.3	37.1%	355
NET DIFFUSIVE OUTFLOW			0.0	0.0%	4950.3	53.1%	
***TOTAL OUTFLOW			9.7	98.7%	8411.6	90.2%	864
***EVAPORATION			0.1	1.3%	0.0	0.0%	
***RETENTION			0.0	0.0%	910.4	9.8%	

Hyd. Residence Time = 0.0079 yrs
Overflow Rate = 77.3 m/yr
Mean Depth = 0.6 m

Mauvaise Terre Lake

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 0.08 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	Trib 1	9.4	1.2	0.00E+00	0.00	0.12
2	1	2	Trib 2	1.1	0.1	0.00E+00	0.00	0.12
3	1	3	Trib 3	3.6	0.5	0.00E+00	0.00	0.12
4	1	3	Trib 4	74.8	9.3	0.00E+00	0.00	0.12
PRECIPITATION				0.7	0.7	0.00E+00	0.00	1.02
TRIBUTARY INFLOW				89.0	11.1	0.00E+00	0.00	0.12
***TOTAL INFLOW				89.7	11.7	0.00E+00	0.00	0.13
ADVECTIVE OUTFLOW				89.7	11.1	0.00E+00	0.00	0.12
***TOTAL OUTFLOW				89.7	11.1	0.00E+00	0.00	0.12
***EVAPORATION					0.7	0.00E+00	0.00	

Overall Mass Balance Based Upon Component: **Predicted TOTAL P** — **Outflow & Reservoir Concentrations**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	Trib 1	181.6	1.9%	0.00E+00		0.00	155.0	19.2
2	1	2	Trib 2	21.7	0.2%	0.00E+00		0.00	155.0	19.2
3	1	3	Trib 3	69.9	0.7%	0.00E+00		0.00	155.0	19.3
4	1	3	Trib 4	1439.9	15.1%	0.00E+00		0.00	155.0	19.2
PRECIPITATION				20.3	0.2%	0.00E+00		0.00	29.5	30.0
INTERNAL LOAD				7808.5	81.8%	0.00E+00		0.00		
TRIBUTARY INFLOW				1713.0	18.0%	0.00E+00		0.00	155.0	19.2
***TOTAL INFLOW				9541.8	100.0%	0.00E+00		0.00	812.9	106.4
ADVECTIVE OUTFLOW				2623.2	27.5%	0.00E+00		0.00	237.4	29.3
***TOTAL OUTFLOW				2623.2	27.5%	0.00E+00		0.00	237.4	29.3
***RETENTION				6918.6	72.5%	0.00E+00		0.00		

Overflow Rate (m/yr)	16.4	Nutrient Resid. Time (yrs)	0.0312
Hydraulic Resid. Time (yrs)	0.0978	Turnover Ratio	2.7
Reservoir Conc (mg/m3)	275	Retention Coef.	0.725

Mauvaise Terre Lake

Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Velocity km/yr	Dispersion--------> Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	Near Dam	0	11.1	0.0633	34.8	18.3	71.0	10.6	0.0
2	Middle	1	9.9	0.0309	42.8	26.6	167.0	10.9	70.8
3	Upper Pool	2	9.7	0.0079	77.3	86.2	448.2	29.3	69.6

Morphometry

Seg	Name	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	Near Dam	0.3	2.2	2.2	1.2	0.7	0.3	4.2
2	Middle	0.2	1.3	1.3	0.8	0.3	0.3	2.9
3	Upper Pool	0.1	0.6	0.6	0.7	0.1	0.2	3.7
Totals		0.7	1.6			1.1		

Mauvaise Terre Lake

Segment & Tributary Network

--------Segment:	1	Near Dam		
Outflow Segment:	0	Out of Reservoir		
Tributary:	1	Trib 1	Type:	Monitored Inflow
--------Segment:	2	Middle		
Outflow Segment:	1	Near Dam		
Tributary:	2	Trib 2	Type:	Monitored Inflow
--------Segment:	3	Upper Pool		
Outflow Segment:	2	Middle		
Tributary:	3	Trib 3	Type:	Monitored Inflow
Tributary:	4	Trib 4	Type:	Monitored Inflow

Mauvaise Terre Lake
Description:
Single reservoir (172 acres)
3 segments

Global Variables	Mean	CV
Averaging Period (yrs)	0.0833	0.0
Precipitation (m)	0.0846	0.0
Evaporation (m)	0.0846	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.50
Total N	1000	0.50
Ortho P	15	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	0	NONE
Error Analysis	0	NOT COMPUTED
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Near Dam	0	1	0.318	2.2	1.16	2.2	0	0	0	1.215452	0	0	0	0	0	0	0
2	Middle	1	1	0.231	1.32	0.82	1.32	0	0	0	2.612008	0	0	0	0	0	0	0
3	Upper Pool	2	1	0.126	0.61	0.68	0.61	0	0	0	3.175495	0	0	0	169.67	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	260	0	0	0	68	0	0.343	0	0	0	0	0	0	0	0	0
2	0	0	250	0	0	0	53	0	0.254	0	0	0	0	0	0	0	0	0
3	0	0	370	0	0	0	71	0	0.202	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
2	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
3	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Mauvaise Terre Lake
Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Trib 1	1	1	9.431433	1.1713	0	0	0	155	0	0	0	0	0	0	0
2	Trib 2	2	1	1.130026	0.1403	0	0	0	155	0	0	0	0	0	0	0
3	Trib 3	3	1	3.630549	0.4509	0	0	0	155	0	0	0	0	0	0	0
4	Trib 4	3	1	74.80244	9.2894	0	0	0	155	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.025	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Attachment 2

This page is blank to facilitate double sided printing.

Data for Manganese Load Duration Curves

Flow (cfs)	% of Time Exceeded	Manganese load (kg/day)
0.0	100.00	0.00
0.0	99.99	0.00
0.0	99.45	0.00
0.0	98.95	0.00
0.0	98.45	0.00
0.0	97.95	0.00
0.0	97.45	0.00
0.0	96.95	0.00
0.0	96.45	0.00
0.0	95.95	0.00
0.0	95.45	0.00
0.0	94.95	0.00
0.0	94.45	0.00
0.0	93.95	0.00
0.0	93.45	0.00
0.0	92.95	0.00
0.0	92.45	0.00
0.0	91.95	0.00
0.0	91.45	0.00
0.0	90.95	0.00
0.0	90.46	0.00
0.0	89.96	0.01
0.0	89.46	0.01
0.0	88.96	0.01
0.0	88.46	0.01
0.1	87.96	0.02
0.1	87.46	0.02
0.1	86.96	0.03
0.1	86.46	0.04
0.1	85.96	0.04
0.1	85.46	0.05
0.1	84.96	0.05
0.2	84.46	0.06
0.2	83.96	0.07
0.2	83.46	0.07
0.2	82.96	0.08
0.3	82.46	0.09
0.3	81.96	0.10
0.3	81.46	0.11
0.3	80.96	0.12
0.4	80.46	0.13
0.4	79.96	0.14
0.4	79.46	0.15
0.4	78.96	0.16
0.5	78.46	0.18
0.5	77.96	0.19
0.5	77.46	0.20
0.6	76.96	0.21
0.6	76.46	0.24
0.7	75.96	0.25
0.7	75.46	0.27
0.8	74.96	0.29
0.9	74.46	0.32

Observed Data

Date	Flow (cfs)	Mn (ug/l)	Percentile	Manganese load (kg/day)
4/11/2002	35.65	90	14.3	7.85
6/7/2002	17.66	67	27.9	2.90
7/10/2002	8.67	120	44.5	2.55
8/15/2002	3.53	220	59.6	1.90
10/17/2002	0.05	420	88.1	0.05

Data for Manganese Load Duration Curves

Flow (cfs)	% of Time Exceeded	Manganese load (kg/day)
0.9	73.96	0.34
1.0	73.46	0.37
1.1	72.96	0.39
1.1	72.47	0.41
1.2	71.97	0.44
1.3	71.47	0.46
1.3	70.97	0.49
1.4	70.47	0.52
1.5	69.97	0.54
1.6	69.47	0.59
1.7	68.97	0.61
1.7	68.47	0.64
1.8	67.97	0.67
1.9	67.47	0.71
2.0	66.97	0.73
2.1	66.47	0.77
2.2	65.97	0.80
2.3	65.47	0.84
2.4	64.97	0.87
2.5	64.47	0.92
2.6	63.97	0.94
2.7	63.47	1.00
2.9	62.97	1.05
3.0	62.47	1.10
3.1	61.97	1.14
3.2	61.47	1.18
3.2	60.97	1.18
3.5	60.47	1.30
3.5	59.97	1.30
3.9	59.47	1.41
3.9	58.97	1.41
4.2	58.47	1.53
4.2	57.97	1.53
4.5	57.47	1.65
4.5	56.97	1.65
4.5	56.47	1.65
4.8	55.97	1.77
4.8	55.47	1.77
5.1	54.97	1.89
5.1	54.48	1.89
5.5	53.98	2.00
5.8	53.48	2.12
5.8	52.98	2.12
6.1	52.48	2.24
6.1	51.98	2.24
6.4	51.48	2.36
6.4	50.98	2.36
6.7	50.48	2.47
6.7	49.98	2.47
7.1	49.48	2.59
7.1	48.98	2.59
7.4	48.48	2.71
7.4	47.98	2.71
7.7	47.48	2.83
7.7	46.98	2.83

Data for Manganese Load Duration Curves

Flow (cfs)	% of Time Exceeded	Manganese load (kg/day)
8.0	46.48	2.95
8.3	45.98	3.06
8.3	45.48	3.06
8.7	44.98	3.18
9.0	44.48	3.30
9.0	43.98	3.30
9.3	43.48	3.42
9.3	42.98	3.42
9.6	42.48	3.54
10.0	41.98	3.65
10.0	41.48	3.65
10.3	40.98	3.77
10.6	40.48	3.89
10.6	39.98	3.89
10.9	39.48	4.01
11.2	38.98	4.12
11.6	38.48	4.24
11.6	37.98	4.24
11.9	37.48	4.36
12.2	36.98	4.48
12.5	36.48	4.60
12.5	35.99	4.60
12.8	35.49	4.71
13.2	34.99	4.83
13.5	34.49	4.95
13.5	33.99	4.95
13.8	33.49	5.07
14.1	32.99	5.19
14.5	32.49	5.30
14.8	31.99	5.42
15.1	31.49	5.54
15.4	30.99	5.66
15.7	30.49	5.77
16.1	29.99	5.89
16.7	29.49	6.13
17.0	28.99	6.25
17.3	28.49	6.36
17.7	27.99	6.48
18.0	27.49	6.60
18.6	26.99	6.84
18.9	26.49	6.95
19.3	25.99	7.07
19.6	25.49	7.19
19.9	24.99	7.31
20.6	24.49	7.54
21.2	23.99	7.78
21.5	23.49	7.90
22.2	22.99	8.13
22.5	22.49	8.25
23.1	21.99	8.49
23.8	21.49	8.72
24.4	20.99	8.96
25.0	20.49	9.19
25.7	19.99	9.43
26.3	19.49	9.66

Data for Manganese Load Duration Curves

Flow (cfs)	% of Time Exceeded	Manganese load (kg/day)
27.3	18.99	10.02
27.9	18.49	10.25
28.6	18.00	10.49
29.2	17.50	10.72
30.5	17.00	11.20
31.5	16.50	11.55
32.4	16.00	11.90
33.4	15.50	12.26
34.4	15.00	12.61
35.3	14.50	12.96
36.6	14.00	13.43
37.9	13.50	13.91
39.2	13.00	14.38
40.5	12.50	14.85
41.7	12.00	15.32
43.4	11.50	15.91
45.0	11.00	16.50
46.9	10.50	17.21
48.8	10.00	17.91
50.7	9.50	18.62
53.3	9.00	19.56
55.6	8.50	20.39
58.1	8.00	21.33
61.0	7.50	22.39
64.2	7.00	23.57
68.4	6.50	25.10
72.6	6.00	26.63
77.7	5.50	28.52
83.5	5.00	30.64
90.2	4.50	33.12
97.6	4.00	35.83
108.9	3.50	39.95
122.0	3.00	44.78
137.4	2.50	50.44
157.4	2.00	57.75
188.8	1.50	69.29
231.5	1.00	84.97
321.1	0.50	117.85
1708.4	0.00	626.95

Attachment 3

This page is blank to facilitate double sided printing.

Data for Nitrate Load Duration Curves

Flow (cfs)	% of Time Exceeded	Nitrate load (kg/d)
0.0	100	0.00
0.0	100	0.00
0.0	99	0.00
0.0	98	0.00
0.0	98	0.00
0.0	97	0.00
0.0	97	0.00
0.0	96	0.00
0.0	96	0.00
0.0	95	0.00
0.0	95	0.00
0.0	94	0.00
0.0	94	0.00
0.0	93	0.00
0.0	93	0.00
0.0	92	0.00
0.0	92	0.00
0.0	91	0.00
0.0	91	0.08
0.0	90	0.16
0.0	90	0.39
0.0	89	0.71
0.0	89	0.79
0.0	88	0.94
0.1	88	1.41
0.1	87	1.57
0.1	87	1.89
0.1	86	2.36
0.1	86	2.59
0.1	85	3.14
0.1	85	3.46
0.2	84	3.93
0.2	84	4.48
0.2	83	4.71
0.2	83	5.50
0.3	82	6.21
0.3	82	6.52
0.3	81	7.15
0.3	81	7.86
0.4	80	8.64
0.4	80	9.43
0.4	79	10.21
0.4	79	11.00
0.5	78	11.78
0.5	78	12.57
0.5	77	13.36
0.6	77	14.14
0.6	76	15.71
0.7	76	16.50
0.7	75	18.07

Observed Data

Date	Flow (cfs)	Nitrate (mg/l)	Percentile	Nitrate load (kg/d)
4/15/1992	13.81	9.3	33.5	314.18
6/3/1992	7.39	1.3	47.8	23.49
7/2/1992	4.50	0.08	56.4	0.88
8/25/1992	0.00	0.01	91.3	0.00
4/11/2002	35.65	13	14.3	1133.69
6/7/2002	17.66	12	27.9	518.53
7/10/2002	8.67	6.68	44.5	141.70
8/15/2002	3.53	0.13	59.6	1.12

Data for Nitrate Load Duration Curves

Flow (cfs)	% of Time Exceeded	Nitrate load (kg/d)
0.8	75	19.64
0.9	74	21.21
0.9	74	22.78
1.0	73	24.36
1.1	73	25.93
1.1	72	27.50
1.2	72	29.07
1.3	71	30.64
1.3	71	33.00
1.4	70	34.57
1.5	70	36.14
1.6	69	39.28
1.7	69	40.85
1.7	68	42.43
1.8	68	44.78
1.9	67	47.14
2.0	67	48.71
2.1	66	51.07
2.2	66	53.42
2.3	65	55.78
2.4	65	58.14
2.5	64	61.28
2.6	64	62.85
2.7	63	66.78
2.9	63	69.92
3.0	62	73.07
3.1	62	76.21
3.2	61	78.56
3.2	61	78.56
3.5	60	86.42
3.5	60	86.42
3.9	59	94.28
3.9	59	94.28
4.2	58	102.13
4.2	58	102.13
4.5	57	109.99
4.5	57	109.99
4.5	56	109.99
4.8	56	117.85
4.8	55	117.85
5.1	55	125.70
5.1	54	125.70
5.5	54	133.56
5.8	53	141.42
5.8	53	141.42
6.1	52	149.27
6.1	52	149.27
6.4	51	157.13
6.4	51	157.13
6.7	50	164.99
6.7	50	164.99
7.1	49	172.84

Data for Nitrate Load Duration Curves

Flow (cfs)	% of Time Exceeded	Nitrate load (kg/d)
7.1	49	172.84
7.4	48	180.70
7.4	48	180.70
7.7	47	188.56
7.7	47	188.56
8.0	46	196.41
8.3	46	204.27
8.3	45	204.27
8.7	45	212.13
9.0	44	219.98
9.0	44	219.98
9.3	43	227.84
9.3	43	227.84
9.6	42	235.69
10.0	42	243.55
10.0	41	243.55
10.3	41	251.41
10.6	40	259.26
10.6	40	259.26
10.9	39	267.12
11.2	39	274.98
11.6	38	282.83
11.6	38	282.83
11.9	37	290.69
12.2	37	298.55
12.5	36	306.40
12.5	36	306.40
12.8	35	314.26
13.2	35	322.12
13.5	34	329.97
13.5	34	329.97
13.8	33	337.83
14.1	33	345.69
14.5	32	353.54
14.8	32	361.40
15.1	31	369.25
15.4	31	377.11
15.7	30	384.97
16.1	30	392.82
16.7	29	408.54
17.0	29	416.39
17.3	28	424.25
17.7	28	432.11
18.0	27	439.96
18.6	27	455.68
18.9	26	463.53
19.3	26	471.39
19.6	25	479.25
19.9	25	487.10
20.6	24	502.82
21.2	24	518.53
21.5	23	526.38

Data for Nitrate Load Duration Curves

Flow (cfs)	% of Time Exceeded	Nitrate load (kg/d)
22.2	23	542.10
22.5	22	549.95
23.1	22	565.67
23.8	21	581.38
24.4	21	597.09
25.0	20	612.81
25.7	20	628.52
26.3	19	644.23
27.3	19	667.80
27.9	18	683.51
28.6	18	699.23
29.2	17	714.94
30.5	17	746.37
31.5	16	769.94
32.4	16	793.51
33.4	15	817.07
34.4	15	840.64
35.3	14	864.21
36.6	14	895.64
37.9	13	927.07
39.2	13	958.49
40.5	12	989.92
41.7	12	1021.34
43.4	11	1060.63
45.0	11	1099.91
46.9	10	1147.05
48.8	10	1194.19
50.7	9	1241.33
53.3	9	1304.18
55.6	9	1359.17
58.1	8	1422.02
61.0	8	1492.73
64.2	7	1571.30
68.4	7	1673.43
72.6	6	1775.57
77.7	6	1901.27
83.5	5	2042.69
90.2	5	2207.67
97.6	4	2388.37
108.9	4	2663.35
122.0	3	2985.47
137.4	3	3362.58
157.4	2	3849.68
188.8	2	4619.61
231.5	1	5664.53
321.1	1	7856.49
1708.4	0	41796.51

Attachment 4

This page is blank to facilitate double sided printing.

Data for Fecal Coliform Load Duration Curves

Flow (cfs)	% of Time Exceeded	Load (cfu/day)
0.0	100.00	0.00E+00
0.0	99.99	0.00E+00
0.0	99.45	0.00E+00
0.0	98.95	0.00E+00
0.0	98.45	0.00E+00
0.0	97.95	0.00E+00
0.0	97.45	0.00E+00
0.0	96.95	0.00E+00
0.0	96.45	0.00E+00
0.0	95.95	0.00E+00
0.0	95.45	0.00E+00
0.0	94.95	0.00E+00
0.0	94.45	0.00E+00
0.0	93.95	0.00E+00
0.0	93.45	0.00E+00
0.0	92.95	0.00E+00
0.0	92.45	0.00E+00
0.0	91.95	0.00E+00
0.0	91.45	0.00E+00
0.0	90.95	6.36E+07
0.0	90.46	1.27E+08
0.1	89.96	3.18E+08
0.1	89.46	5.73E+08
0.1	88.96	6.36E+08
0.2	88.46	7.63E+08
0.2	87.96	1.15E+09
0.3	87.46	1.27E+09
0.3	86.96	1.53E+09
0.4	86.46	1.91E+09
0.4	85.96	2.10E+09
0.5	85.46	2.54E+09
0.6	84.96	2.80E+09
0.7	84.46	3.18E+09
0.7	83.96	3.63E+09
0.8	83.46	3.82E+09
0.9	82.96	4.45E+09
1.0	82.46	5.03E+09
1.1	81.96	5.28E+09
1.2	81.46	5.79E+09
1.3	80.96	6.36E+09
1.4	80.46	7.00E+09
1.6	79.96	7.63E+09
1.7	79.46	8.27E+09
1.8	78.96	8.91E+09
2.0	78.46	9.54E+09
2.1	77.96	1.02E+10
2.2	77.46	1.08E+10
2.3	76.96	1.15E+10
2.6	76.46	1.27E+10
2.7	75.96	1.34E+10
3.0	75.46	1.46E+10
3.3	74.96	1.59E+10
3.5	74.46	1.72E+10
3.8	73.96	1.84E+10
4.0	73.46	1.97E+10

Observed Data

Date	Flow (cfs)	Fecal coliform (cfu/100 ml)	Percentile	Load (cfu/day)
5/31/1990	20.80	500	54.5	2.54E+11
7/12/1990	167.70	11000	12.1	4.51E+13
8/23/1990	37.70	6200	43.0	5.72E+12
10/10/1990	24.70	20000	51.6	1.21E+13
5/2/1991	16.90	2400	57.5	9.92E+11
5/30/1991	0.14	110000	88.5	3.85E+11
7/8/1991	6.63	600	69.0	9.73E+10
8/27/1991	54.60	1400	33.9	1.87E+12
10/2/1991	4.29	650	72.8	6.82E+10
6/2/1992	241.80	410	7.7	2.43E+12
7/20/1992	7.02	2040	68.4	3.50E+11
8/18/1992	11.57	700	62.9	1.98E+11
9/17/1992	24.70	760	51.6	4.59E+11
10/28/1992	0.17	140	88.3	5.79E+08
5/6/1993	3.12	360	75.0	2.75E+10
6/3/1993	67.60	430	29.1	7.11E+11
8/9/1993	28.60	420	48.6	2.94E+11
9/16/1993	35.10	2800	44.5	2.40E+12
5/11/1994	3.12	440	75.0	3.36E+10
6/23/1994	18.20	540	56.4	2.40E+11
7/27/1994	10.92	280	63.5	7.48E+10
9/14/1994	42.90	3500	39.9	3.67E+12
10/20/1994	2.60	1200	76.2	7.63E+10
5/4/1995	0.00	400	91.3	0.00E+00
6/21/1995	6.24	12000	69.6	1.83E+12
9/7/1995	36.40	3500	43.7	3.12E+12
9/25/1995	45.50	920	38.5	1.02E+12
5/15/1996	8.45	900	66.4	1.86E+11
7/1/1996	65.00	1400	29.9	2.23E+12
8/12/1996	23.40	440	52.5	2.52E+11
9/4/1996	422.50	280	3.6	2.89E+12
5/12/1997	5.59	820	70.6	1.12E+11
6/23/1997	0.00	1000	91.3	0.00E+00
8/12/1997	236.60	1750	7.9	1.01E+13
9/22/1997	65.00	1300	29.9	2.07E+12
7/6/1998	53.30	660	34.6	8.61E+11
9/30/1998	66.30	1600	29.5	2.60E+12
10/25/2001	28.60	400	48.6	2.80E+11
5/14/2002	92.30	2200	22.2	4.97E+12
7/8/2002	24.70	360	51.6	2.18E+11
8/1/2002	45.50	320	38.5	3.56E+11
9/16/2002	390.00	15700	4.1	1.50E+14
10/24/2002	132.60	140	15.7	4.54E+11
7/2/2003	13.00	780	60.7	2.48E+11
8/7/2003	107.90	640	19.3	1.69E+12
9/17/2003	884.00	485	1.1	1.05E+13
5/4/2004	1.05	330	82.1	8.50E+09
6/1/2004	23.40	1600	52.5	9.16E+11
6/30/2004	45.50	700	38.5	7.79E+11

Data for Fecal Coliform Load Duration Curves

Flow (cfs)	% of Time Exceeded	Load (cfu/day)
4.3	72.96	2.10E+10
4.6	72.47	2.23E+10
4.8	71.97	2.35E+10
5.1	71.47	2.48E+10
5.5	70.97	2.67E+10
5.7	70.47	2.80E+10
6.0	69.97	2.93E+10
6.5	69.47	3.18E+10
6.8	68.97	3.31E+10
7.0	68.47	3.44E+10
7.4	67.97	3.63E+10
7.8	67.47	3.82E+10
8.1	66.97	3.94E+10
8.5	66.47	4.14E+10
8.8	65.97	4.33E+10
9.2	65.47	4.52E+10
9.6	64.97	4.71E+10
10.1	64.47	4.96E+10
10.4	63.97	5.09E+10
11.1	63.47	5.41E+10
11.6	62.97	5.66E+10
12.1	62.47	5.92E+10
12.6	61.97	6.17E+10
13.0	61.47	6.36E+10
13.0	60.97	6.36E+10
14.3	60.47	7.00E+10
14.3	59.97	7.00E+10
15.6	59.47	7.63E+10
15.6	58.97	7.63E+10
16.9	58.47	8.27E+10
16.9	57.97	8.27E+10
18.2	57.47	8.91E+10
18.2	56.97	8.91E+10
18.2	56.47	8.91E+10
19.5	55.97	9.54E+10
19.5	55.47	9.54E+10
20.8	54.97	1.02E+11
20.8	54.48	1.02E+11
22.1	53.98	1.08E+11
23.4	53.48	1.15E+11
23.4	52.98	1.15E+11
24.7	52.48	1.21E+11
24.7	51.98	1.21E+11
26.0	51.48	1.27E+11
26.0	50.98	1.27E+11
27.3	50.48	1.34E+11
27.3	49.98	1.34E+11
28.6	49.48	1.40E+11
28.6	48.98	1.40E+11
29.9	48.48	1.46E+11
29.9	47.98	1.46E+11
31.2	47.48	1.53E+11
31.2	46.98	1.53E+11
32.5	46.48	1.59E+11
33.8	45.98	1.65E+11
33.8	45.48	1.65E+11
35.1	44.98	1.72E+11

Data for Fecal Coliform Load Duration Curves

Flow (cfs)	% of Time Exceeded	Load (cfu/day)
36.4	44.48	1.78E+11
36.4	43.98	1.78E+11
37.7	43.48	1.84E+11
37.7	42.98	1.84E+11
39.0	42.48	1.91E+11
40.3	41.98	1.97E+11
40.3	41.48	1.97E+11
41.6	40.98	2.04E+11
42.9	40.48	2.10E+11
42.9	39.98	2.10E+11
44.2	39.48	2.16E+11
45.5	38.98	2.23E+11
46.8	38.48	2.29E+11
46.8	37.98	2.29E+11
48.1	37.48	2.35E+11
49.4	36.98	2.42E+11
50.7	36.48	2.48E+11
50.7	35.99	2.48E+11
52.0	35.49	2.54E+11
53.3	34.99	2.61E+11
54.6	34.49	2.67E+11
54.6	33.99	2.67E+11
55.9	33.49	2.74E+11
57.2	32.99	2.80E+11
58.5	32.49	2.86E+11
59.8	31.99	2.93E+11
61.1	31.49	2.99E+11
62.4	30.99	3.05E+11
63.7	30.49	3.12E+11
65.0	29.99	3.18E+11
67.6	29.49	3.31E+11
68.9	28.99	3.37E+11
70.2	28.49	3.44E+11
71.5	27.99	3.50E+11
72.8	27.49	3.56E+11
75.4	26.99	3.69E+11
76.7	26.49	3.75E+11
78.0	25.99	3.82E+11
79.3	25.49	3.88E+11
80.6	24.99	3.94E+11
83.2	24.49	4.07E+11
85.8	23.99	4.20E+11
87.1	23.49	4.26E+11
89.7	22.99	4.39E+11
91.0	22.49	4.45E+11
93.6	21.99	4.58E+11
96.2	21.49	4.71E+11
98.8	20.99	4.83E+11
101.4	20.49	4.96E+11
104.0	19.99	5.09E+11
106.6	19.49	5.22E+11
110.5	18.99	5.41E+11
113.1	18.49	5.53E+11
115.7	18.00	5.66E+11
118.3	17.50	5.79E+11
123.5	17.00	6.04E+11
127.4	16.50	6.23E+11

Data for Fecal Coliform Load Duration Curves

Flow (cfs)	% of Time Exceeded	Load (cfu/day)
131.3	16.00	6.43E+11
135.2	15.50	6.62E+11
139.1	15.00	6.81E+11
143.0	14.50	7.00E+11
148.2	14.00	7.25E+11
153.4	13.50	7.51E+11
158.6	13.00	7.76E+11
163.8	12.50	8.02E+11
169.0	12.00	8.27E+11
175.5	11.50	8.59E+11
182.0	11.00	8.91E+11
189.8	10.50	9.29E+11
197.6	10.00	9.67E+11
205.4	9.50	1.01E+12
215.8	9.00	1.06E+12
224.9	8.50	1.10E+12
235.3	8.00	1.15E+12
247.0	7.50	1.21E+12
260.0	7.00	1.27E+12
276.9	6.50	1.36E+12
293.8	6.00	1.44E+12
314.6	5.50	1.54E+12
338.0	5.00	1.65E+12
365.3	4.50	1.79E+12
395.2	4.00	1.93E+12
440.7	3.50	2.16E+12
494.0	3.00	2.42E+12
556.4	2.50	2.72E+12
637.0	2.00	3.12E+12
764.4	1.50	3.74E+12
937.3	1.00	4.59E+12
1300.0	0.50	6.36E+12
6916.0	0.00	3.38E+13

Attachment 5

This page is blank to facilitate double sided printing.

Mauvaise Terre Responsiveness Summary

1. During the presentation, it was stated that the computer model BATHTUB used for Mauvaise Terre Lake indicated that “internal” phosphorus loading from sediment was the primary source (of phosphorus?). It was stated that the external (tributary) phosphorus loads were quantified using a scenario where internal loading was not occurring. Could you please indicate what percentage of the potential phosphorus load is external versus internal loading? I assume that the release of phosphorus from the lake sediment would occur only when the oxygen is depleted in the lake. How often or how severe is the oxygen depleted within the lake? Are there any trends?

Response: Internal phosphorus loading from the bottom sediments is the primary source of phosphorus to the water column. Model results indicate 18% of the phosphorus load is from external sources and 82 % from an internal source. Phosphorus data collected at different water depths show higher concentrations of phosphorus near the lake bottom. Mauvaise Terre Lake is shallow and dissolved oxygen does not approach zero at any of the three monitoring stations (data collected in1992, 1993 and 2005). The higher phosphorus concentrations measured deeper in the water column suggest resuspension of in-place sediments as a source. The range of phosphorus concentrations measured over 12 years is constant; no trends were observed.

2. During the presentation, a question from the public was received regarding the number of sample points (and locations) related to fecal coliform. Please confirm that there was only one sampling station 1.5 miles Northeast of Merritt used for fecal coliform with approximately 45 samples collected during the summer months between 1990 through 2004. It is my understanding that the load duration curve for Mauvaise Terre Creek was established using flows from Spring Creek (near Springfield) since there are no flow data available for Mauvaise Terre Creek at the single sampling point. It did not seem like there was much difference between low flow and high flow conditions. Is there a quantitative correlation between the City’s CSO discharges (presumably occurring during high flow conditions) and the sampling of data points for fecal coliform? There seems to be several potential sources of fecal coliform contamination upstream of the sampling point near Merritt.

Response: Data collected at the sampling station 1.5 miles Northeast of Merritt was used to develop the load duration curve. 49 samples collected at this location between May and October were used for the load duration curve. The dataset covered the period May 1990 to June 2004. You are correct that flows were not available for Mauvaise Terre Creek and that flows measured on Spring Creek were used to synthesize a flow record for Mauvaise Terre Creek. As part of the Stage 1 report, potential sources of fecal coliform were identified and included CSOs, livestock operations, municipal sewage disposal, private sewage disposal systems and runoff from manure-fertilized cropland. We do not have instream fecal coliform measurements collected on the same date of the known occurrence of CSOs. While we do have monthly DMR data that summarizes whether a CSO occurred in a given month, we do not have information on which day(s) of the month the overflow occurred. Such data could be obtained and analyzed to see if there was a trend towards higher instream concentrations during periods of CSO discharge. This information would be useful, but not necessarily conclusive because it does not take into consideration the effect that wet weather has on other potential sources.

3. During the presentation in July, it was stated that one sampling point for fecal coliform was used in Mauvaise Terre Creek near Exeter. I wonder if additional monitoring points would be advisable; perhaps both upstream and downstream of the Jacksonville Wastewater Treatment Plants, and during high and low water conditions.

Response: A Plan of Study for CSO Assessment has been submitted to the Agency by the City of Jacksonville. In this plan, the city proposes monitoring for fecal coliform and E. coli during dry and wet weather both upstream and downstream of CSO discharges. The Agency is currently reviewing this plan with the goal of having an approved monitoring plan so that monitoring can be done during the spring of 2007.

4. Mauvaise Terre Lake is a secondary public water supply source for the city. Does the standard still apply when we do not use this source often?

Response: Yes, the standard still applies. If there is the potential for the city to use this water for drinking water purposes, the public water supply standard applies.

5. The City is working with the Army Corps of Engineers for a dredging project on Mauvaise Terre Lake. We are attempting to develop a plan to dredge, or otherwise remove, some of the approximately 2.1 million cubic yards of silt, which has accumulated in the lake. I wonder how the City's plans to remove silt from the Lake Mauvaise Terre would affect the TMDL study for that body of water. Should we be working with Illinois EPA on this project and keep you informed? We have been setting aside money for dredging for the last fifteen years. The Army Corps has done a preliminary study, but they have not informed us if they are going to continue on. We really want to get this project done and would like to know if the state can contribute some funds toward this.

Response: In the TMDL Report, we state that "the lake phosphorus concentrations would still exceed the water quality standard regardless of reducing the tributary load due to elevated internal phosphorus loads from lake sediment. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, reverting back to more typical conditions." This can be a long process and while dredging takes care of the internal phosphorus load, it does not decrease the external load which caused the internal load to begin with. If the external load is not reduced, the internal source would build up once again. Illinois EPA does have 319 Nonpont Source funds to use for projects in watersheds. Because of the high costs of dredging, 319 funds are rarely used for this kind of work. 319 funds can be used on projects in the watershed to reduce runoff (external loads). More information on 319 funds and other implementation activities will be available in the Implementation Plan. Another meeting will be held in the watershed to discuss this. If you would like any information on the 319 program before this meeting, please call the Illinois EPA 319 Coordinator, Amy Walkenbach, at 217/782-3362.

6. One of the sources of fecal coliform could be septic system failures. How are you going to deal with septic problems?

Response: Household septic systems are currently regulated by the Illinois Department of Public Health and local health departments. In the TMDL Implementation Plan, we will work with these entities to provide information on septic system evaluation, testing and maintenance. If you are aware of any failures or have any questions on failing septic systems, please contact your local county health department for information. Call the Illinois Department of Public Health at (217) 782-4977 or go the website at http://www.idph.state.il.us/local/alpha.htm for county health department websites and phone numbers.

7. Is there any concern for a rural landowner who is trying to build in this watershed and add to the septic load? Does the health department check these septic systems?

Response: Individual septic systems are regulated by the Illinois Department of Public Health through local health departments. Landowners are required to comply with the regulations and ordinances of these entities. Permitting and inspections of these systems are performed by the local health department. Sewage treatment facilities with a surface discharge are required by federal law to obtain an NPDES issued by Illinois Environmental Protection Agency. Properly designed, maintained and operated septic systems should not increase the fecal coliform load to nearby streams.

This page is blank to facilitate double sided printing.

Mauvaise Terre Creek Watershed
TMDL Implementation Plan

Prepared for Illinois Environmental Protection Agency

December 2006

Mauvaise Terre Creek (IL_DD-04): Fecal Coliform

Mauvaise Terre Lake (IL_SDL): Total Phosphorus, Manganese, Nitrate

This page left blank for double sided printing

Table of Contents

List of Figures

List of Tables

This page left blank for double sided printing

SUMMARY

Total Maximum Daily Loads (TMDLs) were developed and approved by the U.S. EPA for Mauvaise Terre Lake (Morgan County, Illinois) to address water quality impairments due to total phosphorus, nitrate, and manganese, and for Mauvaise Terre Creek (Morgan and Scott Counties), to address water quality impairment due to fecal coliform bacteria. These TMDLs determined that significant reductions in existing pollutant loadings were needed to meet water quality objectives. The next step in the TMDL process is to develop a voluntary implementation plan that includes both accountability and the potential for adaptive management. This document identifies a number of alternative actions to be considered by local stakeholders for TMDL implementation; these summarized, and recommendations are presented for implementation actions and additional monitoring.

INTRODUCTION

Section 303(d) of the 1972 Clean Water Act requires States to define waters that are not meeting designated uses under technology-based controls and identify them on a list of impaired waters, which is referred to as the 303(d) list. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) requires states to develop Total Maximum Daily Loads (TMDLs) for these impaired water bodies. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and conditions in the water body. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (U.S. EPA, 1991).

Mauvaise Terre Creek (IL_DD-04) and Mauvaise Terre Lake (IL_SDL) are listed on the 2006 Illinois Section 303(d) List of Impaired Waters (IEPA, 2006) as waterbodies that are not meeting their designated uses. As such, they were targeted as high priority waterbodies for TMDL development. TMDLs for these waterbodies have been developed (LTI, 2006) and approved by the U.S. EPA. The next step in the TMDL process is to develop a voluntary implementation plan that includes both accountability and the potential for adaptive management. Adaptive management recognizes that proceeding with some initial improvement efforts is better than waiting to find a “perfect” solution. In an adaptive management approach, the TMDL and the watershed to which it applies are revisited over time to assess progress and make adjustments that continue to move toward achieving the TMDL’s goals. Adaptive management may be conducted through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented, as well as progress towards attaining water quality standards.

This document presents the implementation plan for the Mauvaise Terre Creek and Mauvaise Terre Lake TMDLs. It is divided into sections describing the watershed, summarizing the TMDLs, describing existing controls within the watershed for the pollutants of interest, outlining the implementation approach, presenting a variety of implementation alternatives, recommending particular control alternatives, describing areas for targeting controls, presenting reasonable assurances that the measures will be implemented, and outlining future monitoring and adaptive management.

WATERSHED DESCRIPTION

The impaired waterbodies addressed in this report are in the Mauvaise Terre Creek watershed, located in Morgan and Scott counties in west-central Illinois. The two waterbodies of concern are Mauvaise Terre Lake (IL_SDL) and Mauvaise Terre Creek downstream of Town Brook (IL_DD-04). Mauvaise Terre Lake lies in Morgan County, while Mauvaise Terre Creek flows through both Morgan and Scott Counties. Mauvaise Terre Lake was constructed by damming the upper part of Mauvaise Terre Creek (above the North Fork). The lake has a surface area of 172 acres and serves as a source of drinking water for Jacksonville and several surrounding communities. Most of the water supply, however, comes from wells located 26 miles from the Jacksonville (City of Jacksonville, 2004). Mauvaise Terre Lake is approximately "L" shaped, with an arm extending west from the inlet, and a second arm extending north to the dam. Mauvaise Terre Lake is connected near the corner of the "L" to a smaller lake called Morgan Lake. The Stage 1 Report (LTI, 2005) provides detailed characterizations of the impaired waterways and their watersheds.

Figure 1 shows a map of the watershed, and includes some key features such as waterways, impaired waterbodies, public water intakes and other key features. In addition to Mauvaise Terre Lake and Mauvaise Terre Creek, the map shows North Fork Mauvaise Terre Creek, which will be addressed in a separate TMDL. The map also shows the locations of point source discharges that have a permit to discharge under the National Pollutant Discharge Elimination System (NPDES).

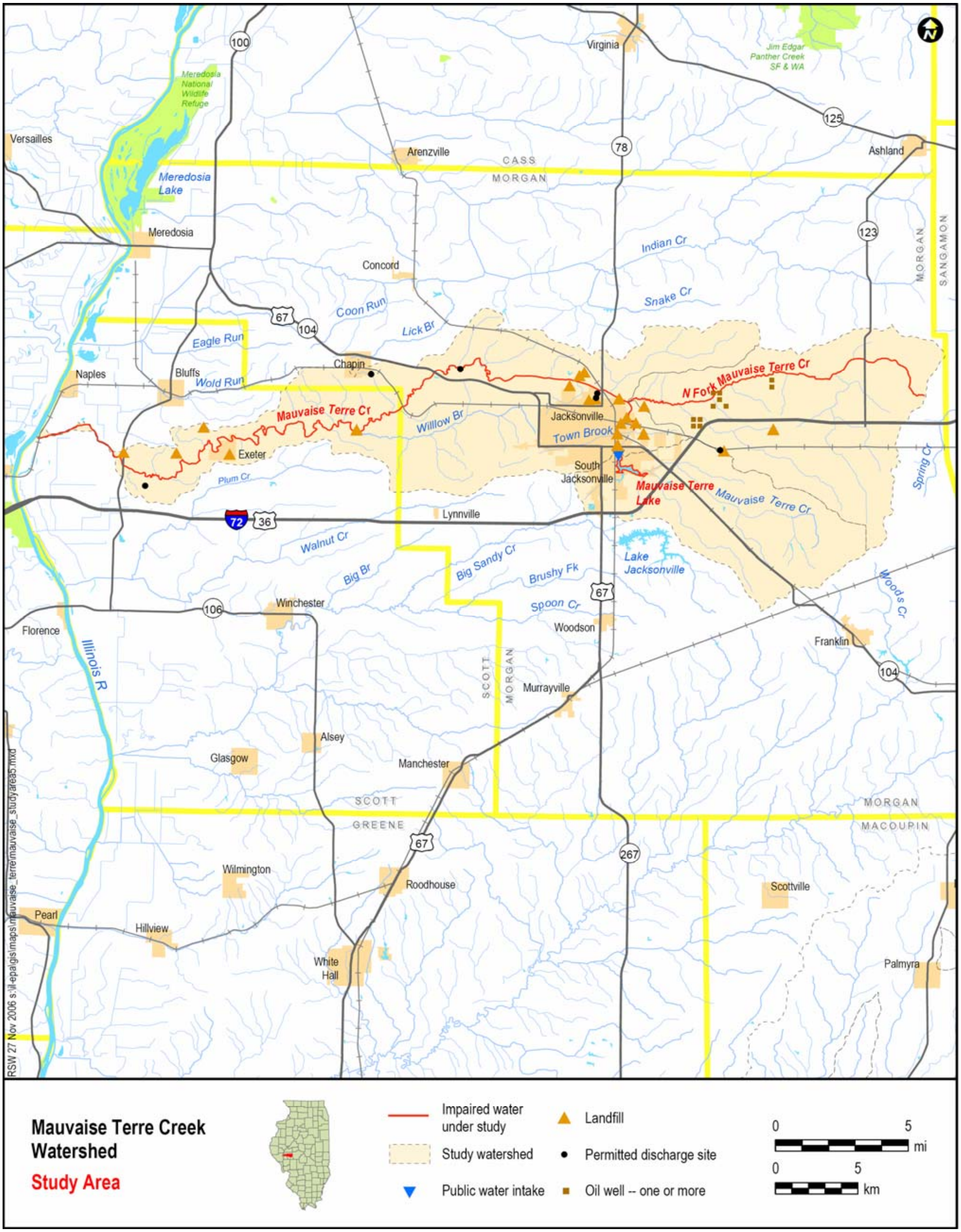


Figure 1. Mauvaise Terre Creek Watershed

TMDL SUMMARY

The impairments in waters of the Mauvaise Terre Creek Watershed addressed in this report are summarized in Table 1, with the parameters (causes) that they are listed for, and the impairment status of each designated use, as identified in the 303(d) list (IEPA, 2006). TMDL Implementation Plans for Mauvaise Terre Creek and Mauvaise Terre Lake are included in this report. TMDLs for North Fork Mauvaise Terre Creek (IL_DDC) for dissolved oxygen and manganese required additional data collection, and will be conducted separately. While TMDLs have only been developed for pollutants that have numerical water quality standards (indicated below with bold font), many controls that are implemented to address TMDLs for these pollutants will reduce other pollutants as well. For example, any controls to reduce phosphorus loads from watershed sources (stream bank erosion, runoff, etc.) would serve to reduce not only phosphorus, but also sediment loads to Mauvaise Terre Lake, as phosphorus Best Management Practices (BMPs) are often the same or similar to sediment BMPs. Furthermore, any reduction of phosphorus loads, either through implementation of watershed controls or dredging of lake sediments, is expected to work towards reducing algae concentrations, as phosphorus is the nutrient most responsible for limiting algal growth.

Table 1. Summary of Impairments

Mauvaise Terre Creek	
Assessment Unit ID	IL_DD-04
Size (length)	36.71
Listed For	**Fecal Coliform**
Use Support[1]	Aquatic life (F), Fish consumption (F), Primary contact (N), Secondary contact (X), Aesthetic quality (X)

[1] F = fully supporting, N=not supporting, X = not assessed

Mauvaise Terre Lake	
Assessment Unit ID	IL_SDL
Size (Acres)	172
Listed For	**Manganese, Phosphorus, Nitrate,** total suspended solids, aquatic algae
Use Support[1]	Aquatic life (N), Fish consumption (F), Public and food processing water supplies (N), Primary contact (X), Secondary contact (X), Aesthetic quality (N),

[1] F = fully supporting, N=not supporting, X = not assessed

Mauvaise Terre Creek is listed on the 303(d) list as impaired, with fecal coliform bacteria as a cause, while Mauvaise Terre Lake is listed as impaired with manganese, phosphorus, and nitrate as causes. Potential sources contributing to the listing of these waterbodies on the 303(d) list are summarized in Table 2. For Mauvaise Terre Creek, fecal coliform sources include runoff from pastureland and animal feeding operations, private sewage disposal systems, municipal point sources, and combined sewer overflows. For Mauvaise Terre Lake, phosphorus sources include agricultural sources, resuspension of existing lake bottom sediments, recreation activities (golf course and camp sites), and failing private sewage disposal systems. Sources of manganese are primarily background sources due to naturally high concentrations in area soils and groundwater; release from existing sediments may also contribute. For nitrate, potential sources include agricultural runoff and recreational activities (i.e., golf courses).

Table 2. Waterbody Impairment Causes and Sources

Waterbody	Cause of impairments	Potential Sources
Mauvaise Terre Creek (IL_DD-04)		
	FECAL COLIFORM	Runoff from pastureland and animal feeding operations, failing private sewage disposal systems (septic and surface discharge systems), municipal point sources, combined sewer overflows.
Mauvaise Terre Lake (IL_SDL)		
	MANGANESE	Natural background sources including groundwater, surface runoff and soil erosion
	TOTAL PHOSPHORUS	Runoff from lawns and agricultural lands (fertilized cropland and agricultural land with livestock), release from sediments when dissolved oxygen is absent, recreational activities (golf courses). Failing private sewage disposal systems (septic and surface discharge systems) are also a potential source.
	NITRATE	Runoff from lawns and agricultural lands (fertilized cropland and agricultural land with livestock), recreational activities (golf courses).

EXISTING CONTROLS

The local Natural Resource Conservation Service (NRCS), Farm Service Agency (FSA), and Soil and Water Conservation District (SWCD) offices have information on existing best management practices within the watershed, and can be contacted to understand what efforts have been made or are planned to control nonpoint sources. Discussions with local NRCS and SWCD staff during the early stages of TMDL development indicated that the Environmental Quality Incentives Program (EQIP) is being used to fund controls for livestock operations, such as grazing management. There appears to be a high level of interest in this program, with applications exceeding available funding (Morgan County NRCS, 2004).

During a 2004 site visit, a streambank stabilization project was observed in Scott County (identified as the Edwin Lakamp Project); this project was funded by Conservation 2000. Local agency staff can provide additional information on this and other existing or planned projects.

IMPLEMENTATION APPROACH

The approach to be taken for TMDL development and implementation is based upon discussions with Illinois EPA and its Scientific Advisory Committee. The approach consists of the following steps, with the first three steps corresponding to TMDL development and the latter two steps corresponding to implementation:

1. Use existing data to define overall existing pollutant loads, as opposed to developing a watershed model that might define individual loading sources.
2. Apply relatively simple models (e.g. BATHTUB) to define the load-response relationship and define the maximum allowable pollutant load that the lakes can assimilate and still attain water quality standards.
3. Compare the maximum allowable load to the existing load to define the extent to which existing loads must be reduced in order to meet water quality standards.
4. Develop a voluntary implementation plan that includes both accountability and the potential for adaptive management.
5. Carry out adaptive management through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented, as well as progress towards attaining water quality standards.

This approach is designed to accelerate the pace at which TMDLs are being developed for sites dominated by nonpoint sources, which will allow implementation activities (and water quality improvement) to begin sooner. The approach also places decisions on the types of nonpoint source controls to be implemented at the local level, which will allow those with the best local knowledge to prioritize sources and identify restoration alternatives. The Association of Illinois Soil and Water Conservation Districts (SWCDs), using Section 319 grant funding, have made available a Watershed Liaison to provide educational, informational, and technical assistance to local agencies and communities. The liaison can assist in establishing local watershed planning groups, as well as acting as an overall facilitator for coordination between local, state, and Federal agencies.

The adaptive management approach to be followed recognizes that models used for decision-making are approximations, and that there is never enough data to completely remove uncertainty. The adaptive process allows decision-makers to proceed with initial decisions based on modeling, and then to update these decisions as experience and knowledge improve.

Steps One through Three described above have been completed, as described in the TMDL report (LTI, 2006). This plan represents Step Four of the process. Step Five is briefly described in the last section of this document, and will be conducted as implementation proceeds.

IMPLEMENTATION ALTERNATIVES

Based on the objectives for the TMDL, information obtained at the public meetings, and experience in other watersheds, a number of alternatives have been identified for the implementation phase of these TMDLs. These alternatives are focused on those sources suspected of contributing phosphorus and nitrate loads to the lake (agricultural sources, release from existing lake bottom sediments, recreation activities such as golf courses, and failing private sewage disposal systems) and fecal coliform loads to the creek (runoff from livestock operations, municipal point sources, combined sewer overflows, and failing private sewage disposal systems). For manganese, the primary source appears to be naturally high levels in groundwater, which cannot be addressed by the BMPs described herein. However, BMPs designed to reduce erosion are expected to provide secondary benefits in reducing manganese, given that manganese concentrations in local soils are often elevated (LTI, 2005). The alternatives identified for this watershed include:

- Nutrient Management Plans
- Conservation Tillage
- Conservation Buffers
- Sediment Control Structures
- Streambank and Shoreline Enhancement and Protection
- Grassed Waterways
- Private Sewage Disposal System Inspection and Maintenance Program
- Aeration
- Dredging
- Phosphorus Inactivation
- Combined Sewer Overflow Controls
- Point Source Controls
- Restrict Livestock Access to Creek and Tributaries

Each of these alternatives is described briefly in this section, including information about their costs and effectiveness in reducing loadings of the constituents of concern. Costs have been updated from their original sources, based on literature citations, to 2006 costs using the Engineering News Record Construction Cost Index, as provided by the Natural Resource Conservation Service (NRCS) (http://www.economics.nrcs.usda.gov/cost/priceindexes/index.html). Some of the measures described below are most applicable to a single pollutant, while others will have broader applicability. Table 3 summarizes the implementation alternatives and the pollutants which each is expected to reduce.

It should be noted that there is usually a wide range in the effectiveness of the various practices; this is largely due to variations in climate, soils, crops, topography, design, construction, and maintenance of the practices (NRCS, 2006). Establishing the effectiveness of alternatives for phosphorus reduction is complicated by the different forms in which phosphorus can be transported. Some practices are effective at reducing particulate phosphorus, but may exacerbate the transport of dissolved phosphorus, the more bioavailable form (NRCS, 2006).

Table 3. Applicability of Implementation Alternatives

Alternative	Manganese	Phosphorus	Nitrate	Fecal Coliform
Nutrient Management Plans		◆	◆	
Conservation Tillage	*	◆	◆	
Conservation Buffers	*	◆	◆	◆
Sediment Control Structures	*	◆		
Streambank and Shoreline Enhancement and Protection	*	◆		
Grassed Waterways	*	◆		
Aeration		◆		
Dredging	◆	◆		
Phosphorus Inactivation				
Private Sewage Disposal System Inspection and Maintenance Program		◆		◆
Combined Sewer Overflow Controls				◆
Point Source Controls				◆
Restrict Livestock Access to Creek and Tributaries		◆	◆	◆

* While not directly tied to primary sources of manganese, BMPs designed to reduce erosion are expected to provide secondary benefits in reducing manganese

Nutrient Management

Nutrient management plans are designed to minimize nutrient losses from agricultural lands, and therefore minimize the amount of phosphorus and nitrogen transported to Mauvaise Terre Lake. Because agriculture is the most common land use in the watershed, controls focused on reducing phosphorus and nitrogen loads from these areas are expected to help reduce phosphorus and nitrate loads delivered to the lake. The focus of a nutrient management plan is to increase the efficiency with which applied nutrients are used by crops, thereby reducing the amount available to be transported to both surface and ground waters (EPA, 2003). The majority of phosphorus lost from agricultural land is transported via surface runoff, mostly in particulate form attached to eroded soil particles, while nitrogen generally leaches through the soil. A nutrient management plan identifies the amount, source, time of application, and placement of each nutrient needed to produce each crop grown on each field each year, to optimize efficient use of all sources of nutrients (including soil reserves, commercial fertilizer, legume crops, and organic sources) and minimize the potential for losses that lead to degradation of soil and water quality (UIUC, 2005).

Steps in developing a nutrient management plan include (UIUC, 2005):

- Assess the natural nutrient sources (soil reserves and legume contributions).
- Identify fields or areas within fields that require special nutrient management precautions.
- Assess nutrient needs for each field by crop.

- Determine quantity of nutrients that will be available from organic sources, such as manure or industrial or municipal wastes.
- Allocate nutrients available from organic sources.
- Calculate the amount of commercial fertilizer needed for each field.
- Determine the ideal time and method of application.
- Select nutrient sources that will be most effective and convenient for the operation.

A Pennsylvania State University study on the relative effectiveness of nutrient management in controlling nitrogen and phosphorus indicated that total phosphorus loads can be reduced by 35% with nutrient management, while total nitrogen loads can achieve a 15% reduction (EPA, 2003). Nutrient management is generally effective, but for phosphorus, most fertilizer is applied to the surface of the soil and is subject to transport (NRCS, 2006). In an extensively cropped watershed, the loss of even a small fraction of the fertilizer-applied phosphorus can have a significant impact on water quality.

Costs of developing nutrient management plans have been estimated at $6 to $20/acre (EPA, 2003). These costs are often offset by the savings associated with using less fertilizer. For example, a study in Iowa showed that improved nutrient management on cornfields led to a savings of about $3.60/acre (EPA, 2003).

Conservation Tillage

The objective of conservation tillage is to provide profitable crop production while minimizing soil erosion (UIUC, 2005). This reduction in erosion also reduces the amount of nutrients, particularly phosphorus, lost from the land and delivered to the lake. The Natural Resources Conservation Service (NRCS) has replaced the term conservation tillage with the term crop residue management, or the year-round management of residue to maintain the level of cover needed for adequate control of erosion. This often requires more than 30% residue cover after planting (UIUC, 2005). Conservation tillage/crop residue management systems are recognized as cost-effective means of significantly reducing soil erosion and maintaining productivity. The most recent Illinois Soil Transect Survey (IDOA, 2004) suggests that 92% of land under soybean production and all of the land in small grain production in Morgan County is farmed using reduced till, mulch till, or no-till, while 68% of corn fields are farmed with conventional methods. Additional conservation tillage measures might want to be considered as part of this implementation plan, particularly for cornfields.

Conservation tillage practices have been reported to reduce total phosphorus loads by 45%, and total nitrogen (including organic nitrogen, ammonia, and nitrate) loads by 55% (EPA, 2003). In general, conservation tillage and no-till practices are moderate to highly effective at reducing particulate phosphorus, but exhibit low or even negative effectiveness in reducing dissolved phosphorus (NRCS, 2006). A wide range of costs has been reported for conservation tillage practices, ranging from $12/acre to $83/acre in capital costs (EPA, 2003). For no-till, costs per acre provided in the Illinois Agronomy Handbook for machinery and labor range from $36 to $66 per acre, depending on the farm size and planting methods used (UIUC, 2005). In general, the total cost per acre for machinery and labor decreases as the amount of tillage decreases and farm size increases (UIUC, 2005).

Conservation Buffers

Conservation buffers are areas or strips of land maintained in permanent vegetation to help control pollutants (NRCS, 1999), generally by slowing the rate of runoff, while filtering sediment and nutrients. Additional benefits may include the creation of wildlife habitat, improved aesthetics, and potential economic benefits from marketing specialty forest crops (Trees Forever, 2005). This category of controls includes buffer strips, field borders, filter strips, vegetative barriers, riparian buffers, etc. (NRCS, 1999).

Filter strips and similar vegetative control methods can be very effective in reducing nutrient transport. The relative gross effectiveness of filter strips in reducing total phosphorus has been reported as 75% (EPA, 2003). Reduction of particulate phosphorus is moderate to high, while effectiveness for dissolved phosphorus is low to negative (NRCS, 2006). Vegetated filter strips and riparian buffers can also be used to reduce bacteria; riparian buffer zones have bacteria removal efficiencies of 43-57% (Commonwealth of Virginia, 2003).

Costs of conservation buffers vary from about $200/acre for filter strips of introduced grasses or direct seeding of riparian buffers, to approximately $360/acre for filter strips of native grasses or planting bare root riparian buffers, to more than $1,030/acre for riparian buffers using bare root stock shrubs (NRCS, 2005).

The Conservation Practices Cost-Share Program (CPP), part of the Illinois Conservation 2000 Program, provides cost sharing for conservation practices including field borders and filter strips (http://www.agr.state.il.us/Environment/conserv/index.html). The Department of Agriculture distributes funding for the cost-share program to Illinois' soil and water conservation districts (SWCDs), which prioritize and select projects. The Illinois Buffer Partnership offers cost sharing for installation of streamside buffer plantings at selected sites. An additional program that may be of interest is the Visual Investments to Enhance Watersheds (VIEW), which involves a landscape design consultant in the assessment and design of targeted BMPs within a watershed. Sponsored by Trees Forever (www.treesforever.org), VIEW guides a committee of local stakeholders through a watershed landscape planning process (Trees Forever, 2005). Additional funding for conservation buffers may be available through other sources such as the Conservation Reserve Program.

Sediment Control Basins

Sediment control basins trap sediments (and nutrients bound to that sediment) before they reach surface waters (EPA, 2003). Basins could be installed throughout the watershed, in areas selected to minimize disruption to existing croplands. In addition to controlling sediment, these basins would reduce phosphorus loads to the lakes. Costs for these basins can vary widely depending on location and size; estimates prepared for another Illinois watershed range from $1,200 to more than $200,000 per basin (Zahniser Institute, undated). This same study estimated a trapping efficiency for sediment of 75%.

Storm water detention wetlands might also warrant consideration. These wetlands would trap sediments and nutrients; a study prepared for another Illinois watershed provides an estimated phosphorus removal rate of 45% (Zahniser Institute, undated). Wetlands generally have low to moderate effectiveness at reducing particulate phosphorus, and low to negative effectiveness at reducing dissolved phosphorus (NRCS, 2006).

Streambank and Shoreline Enhancement and Protection

Sediment derived from streambank shoreline erosion not only increases solids in the lake and decreases lake volume, but also can increase nutrient loads to the lake, and loads of other pollutants to the Creek. Shoreline enhancement efforts, such as planting deep-rooted vegetation or installing rip-rap in unprotected shoreline areas, can provide protection against erosion and the associated increased pollutant loads. Streambank protection and stabilization can reduce both nutrient and bacteria loads by 40% (Commonwealth of Virginia, 2003). Estimates for rip-rapping are approximately $67-$73/ton (NRCS, 2005), while estimates for plantings at another Illinois lake suggest a cost of approximately $5/linear foot (CMT, 2004).

A recent aerial assessment report identified streambank incision and erosion within the Mauvaise Terre Creek watershed (Kinney, 2005). This study was conducted downstream of Mauvaise Terre Lake; however, given that a number of erosion sites were identified along North Fork Mauvaise Terre Creek, other sites for streambank stabilization likely exist elsewhere within the watershed. The study recommended rock riffle grade control and stone toe protection to stabilize the banks of North Fork Mauvaise Terre Creek, with estimated costs of $4,375 per riffle (with riffles spaced 240 feet apart) and $2,500 per site for stone toe protection, based on a cost of $25 per ton of stone. Because of the potential cost of stabilizing streambanks throughout the watershed, additional study is recommended to prioritize sites for streambank stabilization. Such study should include direct observation of bank conditions, as well as an assessment of stream hydraulics and geomorphology to support identification and design of effective stabilization measures.

Grassed Waterways

Grassed waterways are another alternative to consider for this watershed. A grassed waterway is a natural or constructed channel that is planted with suitable vegetation to reduce erosion (NRCS, 2000). Grassed waterways are used to convey runoff without causing erosion or flooding, to reduce gully erosion, and to improve water quality. They may be used in combination with filter strips, and are effective at reducing soil loss, with typical reductions between 60 and 80 percent (Lin et al, 1999). Grassed waterways cost approximately $1,800/acre, not including costs for tile or seeding (MCSWCD, 2006).

Aeration

The available data indicate the Mauvaise Terre Lake does not have a significant problem with low dissolved oxygen. However, aeration in either the lake or its tributaries may reduce manganese concentrations. In the tributaries, instream energy dissipation via rock weirs or rock riffles could be used. An aerator could also be installed in the lake. In either case, manganese in the water column would be oxidized and precipitate from the water column. However, given that the manganese impairment is for the public water supply use, it would likely be more cost efficient to consider treatment of the public water supply, rather than the entire lake. It is important to note that the water quality standard is designed to prevent offensive tastes and appearances in drinking water, as well as staining laundry and fixtures. Manganese in water does not present a human health hazard.

Dredging

As noted in the TMDL report (LTI, 2006), in-place sediments are a significant source of phosphorus. Mauvaise Terre Lake is shallow lake (sampling data suggest depths of only 8 feet at routine monitoring locations). The available data suggest that resuspension of in-place sediments (perhaps by wind-driven resuspension or bioturbation) causes release of phosphorus (and perhaps manganese) from the sediments. Control of this internal load requires removal of phosphorus (and manganese) from the lake bottom, such as through dredging. Dredging of the existing sediments is one alternative to address this source. It is, however, an expensive alternative, and would be only a temporary solution; if phosphorus and manganese loads are not reduced in the watershed, it is likely that the flux of these elements from the sediments will continue to be a problem in the future.

Phosphorus Inactivation

Phosphorus inactivation involves application of aluminum salts or calcium compounds to the lake to reduce phosphorus in the water column and slow its release from sediments (McComas, 1993). This can be an effective means of mitigating excess phosphorus in lakes and reservoirs (NALMS, 2004). Addition of aluminum sulfate (alum) is most common, but compounds such as calcium carbonate and calcium hydroxide (lime) can also be used (McComas, 1993). When alum is added to lake water, a series of chemical hydrolysis steps leads to the formation of a solid precipitate that has a high capacity to absorb phosphates. This flocculent material settles to the lake bottom, removing the phosphorus from the water column and providing a barrier that retards release of phosphorus from the sediments (NALMS, 2004). Aluminum concentrations in lake water are usually at acceptable levels for drinking water shortly after alum application (NALMS, 2004).

This alternative is best used in combination with a reduction in phosphorus inputs from watershed sources. If the external phosphorus load is being addressed, and most of the phosphorus comes from in-place sediments, a single dose treatment will likely be sufficient (Sweetwater, 2006). If watershed sources are not controlled, repeated treatments will be needed. Often, it is possible to do repeat dosing over several years, giving a partial dose every three to five years (Sweetwater, 2006). Phosphorus inactivation has been used in shallow, unstratified lakes like Mauvaise Terre Lake, with an average reduction in total phosphorus of approximately 50% that lasted for five to eleven years (Cooke et al, 2005). Costs for phosphorus inactivation are approximately $1,000 to $1,300 per acre (Sweetwater, 2006). This translates to a cost of $172,000 to $223,600 for Mauvaise Terre Lake. This alternative is recommended only in concert with watershed load reductions.

Private Sewage Disposal System Inspection and Maintenance Program

Most of the watershed, with the exception of the City of Jacksonville, and the area known as Marnico Village, is unsewered (MCHD, 2004). The Morgan County Health Department has a permitting program for private sewage disposal systems, and conducts inspections primarily when complaints are received (MCHD, 2004). A more proactive program to maintain functioning systems and address nonfunctioning systems could be developed to minimize the potential for releases from private sewage disposal systems. The U.S. EPA has developed guidance for managing private sewage disposal systems (EPA, 2005). This guidance includes procedures for assessing existing conditions, assessing public health and environmental risks, selecting a management approach, and implementing a management program (including funding information).

This alternative would require the commitment of staff time for County Health Department personnel; cost depends on whether the additional inspection activities could be accomplished by existing staff or would require additional personnel.

Combined Sewer Overflow Controls

Jacksonville's CSOs are a source of fecal coliform to Mauvaise Terre Creek. The City is required under its NPDES permit to conduct a CSO Assessment, and to develop a Long-Term Control Plan (LTCP) by November 2008, if the CSO Assessment indicates that the CSO outfalls cause or contribute to violations of water quality standards. IEPA has requested that the City monitor the CSO discharges and calculate the aggregate loading from the outfalls, for comparison to the wasteload allocation specified by the TMDL. In the event that bacterial load limits cannot be achieved without additional treatment, the LTCP will be required to address these loadings (IEPA, 2006). IEPA will address CSO controls through the NPDES permitting program; the permit will need to be modified to ensure consistency with the wasteload allocation.

Point Source Controls

There are three NPDES permitted point source dischargers of fecal coliform in the Mauvaise Terre Creek watershed: Jacksonville STP, Marnico Village STP, and Chapin STP. Marnico Village and Chapin currently have disinfection exemptions, and are not required to remove fecal coliform from their discharges. IEPA will examine disinfection exemptions as part of TMDL implementation. IEPA intends to remove disinfection exemptions for point sources discharging directly to impaired waterbodies, and will require point sources discharging upstream of impaired segments to demonstrate that their discharge has no reasonable potential to exceed water quality standards in applicable stream reaches. The Jacksonville STP currently has a daily maximum limit for fecal coliform of 400 per 100 ml. IEPA will evaluate the need for additional point source controls through the NPDES permitting program; permits might need to be modified to ensure consistency with the WLA.

Restrict Livestock Access to Lake and Tributaries

Livestock are a source of bacteria, and are present within the Mauvaise Terre Creek and Mauvaise Terre Lake watersheds (Morgan County NRCS, 2004). It is unclear to what extent livestock have access to the creek and its tributaries; discussions with local NRCS staff during the early stages of the TMDL suggested that some animals likely have access (Morgan County NRCS, 2004). One recommended component of TMDL implementation would be to restrict livestock access to the creek. This could be accomplished by fencing and installation of alternative systems for livestock watering. Livestock exclusion and other grazing management measures have been shown to reduce phosphorus loads on the order of 49%, and fecal coliform counts by 29-46% (EPA, 2003). The principal direct costs of providing grazing practices vary from relatively low variable costs of dispersed salt blocks to higher capital and maintenance costs of supplementary water supply improvements. Improving the distribution of grazing pressure by developing a planned grazing system or strategically locating water troughs, salt, or feeding areas to draw cattle away from riparian zones can result in improved utilization of existing forage, better water quality, and improved riparian habitat. Fencing costs are estimated as $3,500 to $4,000 per mile (USEPA, 2003). Capital costs for pipeline watering range from $0.32 to $2.60 per foot, while watering tanks and troughs range from $291 to $1,625 each (EPA, 2003).

IDENTIFYING PRIORITY AREAS FOR CONTROLS

Priority areas for locating controls were identified through a review of available information. Information reviewed included: tributary water quality data; an aerial assessment report; and GIS-based information. Based on this review, it is recommended that streambank stabilization be initiated in the Mauvaise Terre Lake Watershed to reduce bank erosion, and that this work occur concurrently with watershed controls in priority areas. Additional data collection is also recommended, to help focus control efforts.

Tributary Monitoring

Available water quality data obtained as part of the Stage 1 Watershed Characterization work were reviewed and no recent tributary monitoring data were identified. Additional data collection is therefore recommended to help understand where loads are being generated in the watershed and focus control efforts. Specific data collection recommendations are provided in the Monitoring and Adaptive Management section later in this Implementation Plan.

Aerial Assessment Report

A recent aerial assessment report identified streambank incision and erosion within the Mauvaise Terre Creek watershed (Kinney, 2005). This study was conducted downstream of Mauvaise Terre Lake; however, given that a number of erosion sites were identified along North Fork Mauvaise Terre Creek, other sites for streambank stabilization likely exist elsewhere within the watershed. The study recommended rock riffle grade control and stone toe protection to stabilize the banks of North Fork Mauvaise Terre Creek; such controls would likely benefit Mauvaise Terre Lake if they were installed at appropriate upstream locations.

GIS Analysis

GIS soils, land use and topography data were analyzed to identify areas that are expected to generate the highest sediment and associated phosphorus loads. Within the GIS, maps were generated to show areas with steep slopes (Figure 2), highly erodible soils (Figure 3), and finally, priority areas for best management practices (BMPs). Priority areas are defined as agricultural areas that have both steep slopes and highly erodible soils (Figure 4). These maps serve as a good starting point for selecting areas to target for implementing control projects, to maximize the benefit of the controls. Note that these maps show the entire watershed, including the segment impaired only for fecal coliform. This analysis focuses only on sediment and phosphorus loads, and thus priority areas are those shown in Figure 4 upstream of Mauvaise Terre Lake.

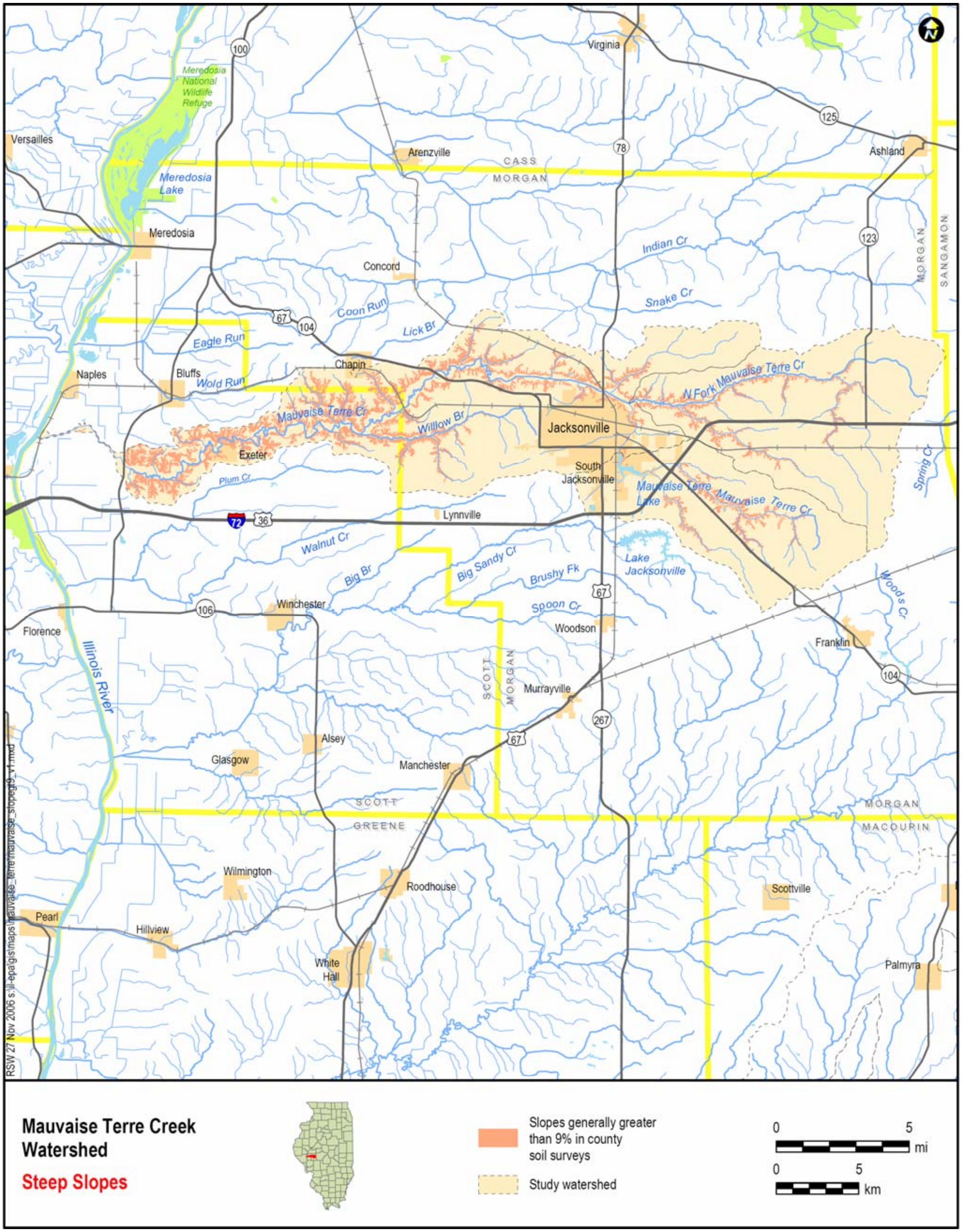


Figure 2. Areas with Steep Slopes

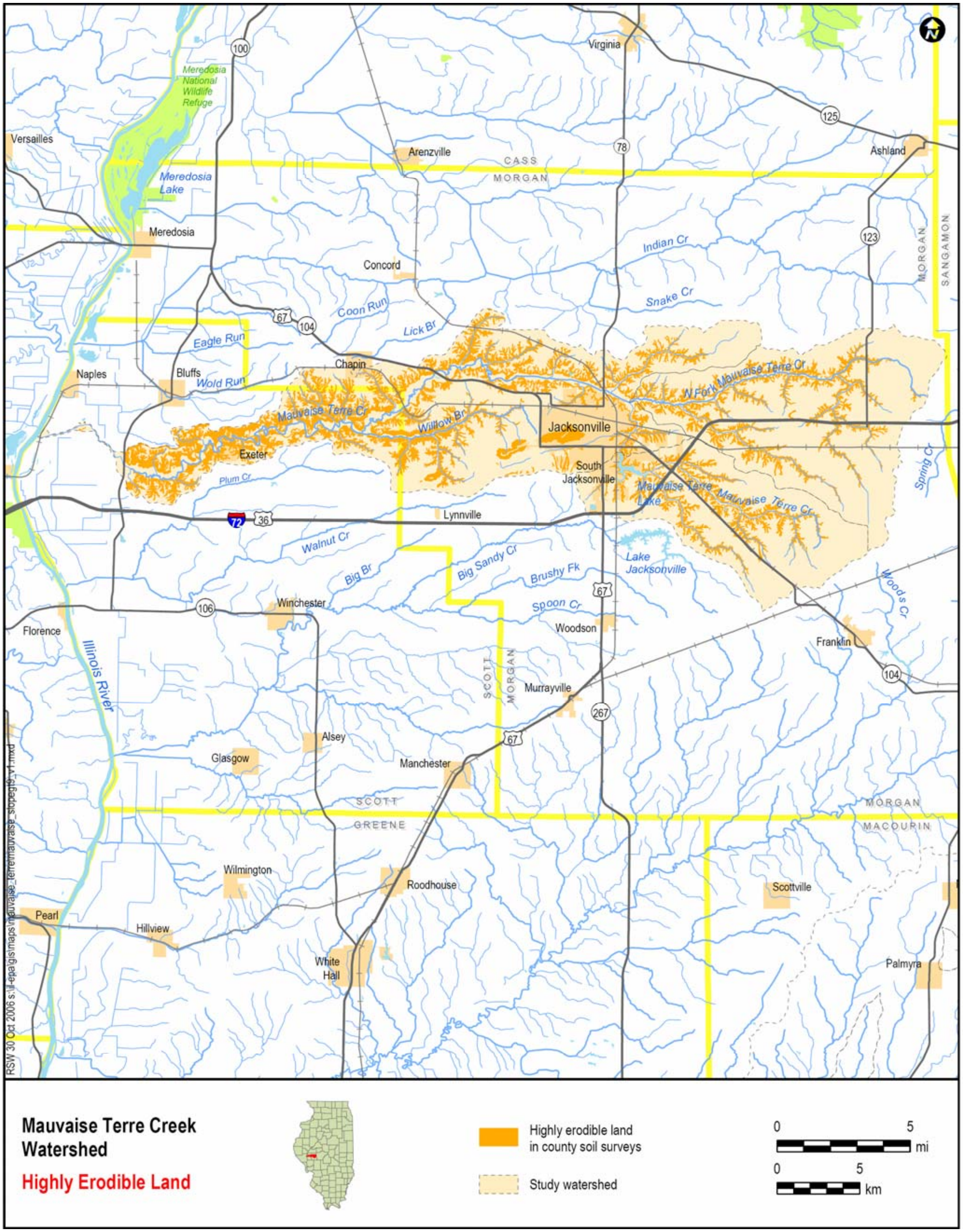


Figure 3. Areas of Highly Erodible Land

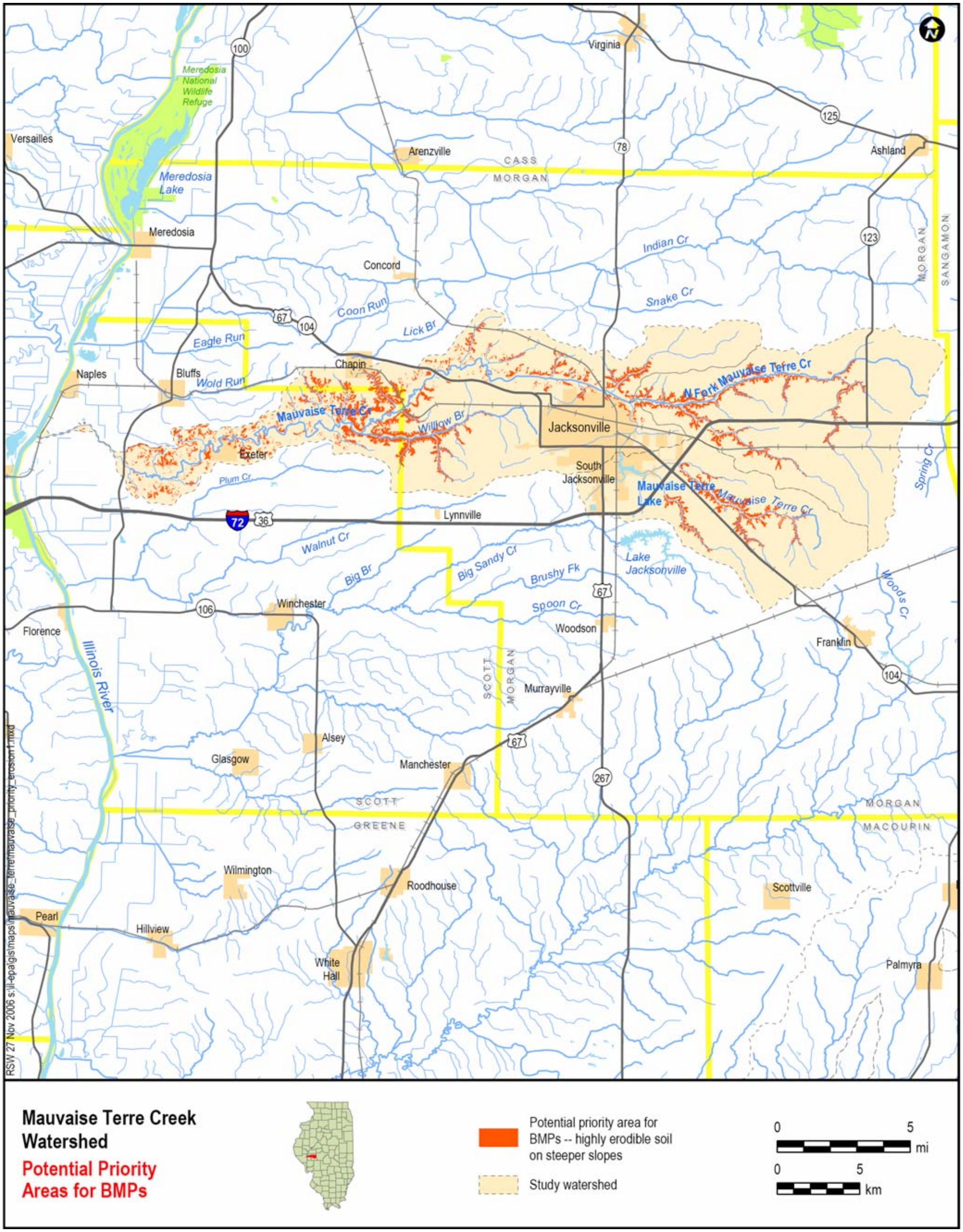


Figure 4. Potential Priority Areas for BMPs

REASONABLE ASSURANCE

The U.S. EPA requires states to provide reasonable assurance that the load reductions identified in the TMDL will be met. Reasonable assurance for point sources means that NPDES permits will be consistent with any applicable wasteload allocation contained in the TMDL. In terms of reasonable assurance for point sources, Illinois EPA administers the NPDES permitting program for treatment plants, stormwater permitting and CAFO permitting. The permits for the point source dischargers in the watershed (Jacksonville, Marnico Village, and Chapin STPs) will be modified if necessary to ensure they are consistent with the applicable wasteload allocations presented in the TMDL. The current permits for these facilities expire October 31, 2009; February 20, 2008; and December 31, 2007; respectively.

For nonpoint sources, reasonable assurance means that nonpoint source controls are specific to the pollutant of concern, implemented according to an expeditious schedule and supported by reliable delivery mechanisms and adequate funding (U.S. EPA, 1999).

One of the most important aspects of implementing nonpoint source controls is obtaining adequate funding to implement voluntary or incentive-based programs. Funding is available from a variety of sources, including the following:

- *Illinois Nutrient Management Planning Program*, cosponsored by the Illinois Department of Agriculture (IDOA) and IEPA (http://www.agr.state.il.us/Environment/LandWater/tmdl.html). This program targets funding to Soil and Water Conservation Districts (SWCDs) for use in impaired waters. The nutrient management plan practice cost share is only available to landowners/operators with land in TMDL watersheds. The dollar amount allocated to each eligible SWCD is based on their portion of the total number of cropland acres in eligible watersheds.
- *Clean Water Act Section 319 grants* to address nonpoint source pollution (http://www.epa.state.il.us/water/financial-assistance/non-point.html). Section 319 of the Clean Water Act provides Federal funding for states for the implementation of approved nonpoint source (NPS) management programs. Funding under these grants has been used in Illinois to finance projects that demonstrate cost-effective solutions to NPS problems. Projects must address water quality issues relating directly to NPS pollution. Funds can be used for the implementation of watershed management plans, including the development of information/education programs, and for the installation of best management practices.
- *Conservation 2000* (http://www.epa.state.il.us/water/conservation-2000/), which funds nine programs across three state natural resource agencies (IEPA, IDOA, and the Department of Natural Resources). Conservation 2000 is a six-year, $100 million initiative designed to take a broad-based, long-term ecosystem approach to conserving, restoring, and managing Illinois' natural lands, soils, and water resources while providing additional high-quality opportunities for outdoor recreation. This program includes the Priority Lake and Watershed Implementation Program and the Clean Lakes Program.
- *Conservation Practices Cost-Share Program*. Another component of Conservation 2000, the Conservation Practices Program (CPP) focuses on conservation practices,

such as terraces, filter strips and grass waterways, that are aimed at reducing soil loss on Illinois cropland to tolerable levels. IDOA distributes funding for the cost-share program to Illinois' SWCDs, which prioritize and select projects. Construction costs are divided between the state and landowners.

- *Conservation Reserve Program* administered by the Farm Service Agency (http://www.nrcs.usda.gov/programs/crp/). The Conservation Reserve Program (CRP) provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. CRP is administered by the Farm Service Agency, with NRCS providing technical land eligibility determinations, conservation planning and practice implementation.
- *Wetlands Reserve Program* (http://www.nrcs.usda.gov/programs/wrp/). NRCS's Wetlands Reserve Program (WRP) is a voluntary program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. The NRCS provides technical and financial support to help landowners with their wetland restoration efforts. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection
- *Environmental Quality Incentive Program* sponsored by NRCS (general information at http://www.nrcs.usda.gov/PROGRAMS/EQIP/; Illinois information and materials at http://www.il.nrcs.usda.gov/programs/eqip/). The Environmental Quality Incentives Program (EQIP) provides a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical assistance to eligible participants to install or implement structural and management practices on eligible agricultural land. EQIP may cost-share up to 75 percent of the costs of certain conservation practices. Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive.
- *Wildlife Habitat Incentives Program* (WHIP) (http://www.il.nrcs.usda.gov/programs/whip/index.html). WHIP is a NRCS program for developing and improving wildlife habitat, primarily on private lands. It provides both technical assistance and cost-share payments to help establish and improve fish and wildlife habitat.
- *Funding for Private Sewage Systems.* EPA guidance (2005) indicates that funding might be available through programs such as the USDA Rural Utilities Service. (http://www.epa.gov/owm/septic/pubs/onsite_handbook.pdf)

In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

- Convene local experts familiar with nonpoint sources of pollution in the watershed
- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability
- Use the results of future monitoring to conduct adaptive management.

MONITORING AND ADAPTIVE MANAGEMENT

Future monitoring is needed to assess the effectiveness of the various restoration alternatives and conduct adaptive management. The Illinois EPA conducts a variety of lake and stream monitoring programs (IEPA, 2002). Ongoing stream monitoring programs include: a statewide 213-station Ambient Water Quality Monitoring Network (AWQMN); an Intensive Basin Survey Program that covers all major watersheds on a five-year rotation basis; and a Facility-Related Stream Survey Program that conducts approximately 20-30 stream surveys each year. Mauvaise Terre Creek is monitored at one location (near Merritt) as part of the AWQMN. The ongoing Illinois EPA Lake Monitoring Program includes: an Ambient Lake Monitoring Program that samples approximately 50 lakes annually; an Illinois Clean Lakes Program that typically monitors three to five projects each year; and a Volunteer Lake Monitoring Program that encompasses over 170 lakes each year. Mauvaise Terre Lake is considered a “core” lake and is monitored approximately every three years. Beyond this IEPA monitoring, local agencies and watershed organizations are encouraged to conduct additional monitoring to assess sources of pollutants and evaluate changes in water quality in the lake.

In particular, the following monitoring is recommended:

- Monitoring for phosphorus, nitrate, and suspended solids in major tributaries upstream of Mauvaise Terre Lake, to better understand where loads are being generated in the watershed. Preliminary recommended locations include Mauvaise Terre Creek at Woods Lane, Ginder Road, and Davis Road; Dick Woods Brook at Earl Road; and the creek that enters the easternmost part of Mauvaise Terre Lake (just south of Mauvaise Terre Creek), at Woods Lane and at Hembrough Road. This monitoring should be conducted during both wet and dry weather.
- Wet and dry weather monitoring for phosphorus, nitrate, and suspended solids in both Mauvaise Terre and Morgan Lakes. It is recommended that Mauvaise Terre Lake sampling include a site near the Jacksonville Country Club.
- Dry weather monitoring for manganese in major tributaries, including Mauvaise Terre Creek at Woods Lane and the creek having its mouth at the easternmost part of Mauvaise Terre Lake at Woods Lane, as well as Morgan and Mauvaise Terre Lakes. Limited water quality data suggest that groundwater may be the primary source of manganese to the lake. Manganese concentrations measured in community water supply wells within Morgan County indicate elevated levels of manganese. Sampling Mauvaise Terre Creek upstream of the lake, under low flow conditions, will allow confirmation of groundwater as the source of the manganese.
- Monitoring for fecal coliform in Mauvaise Terre Creek upstream and downstream of the Jacksonville, Marnico Village, and Chapin STP outfalls, and of the Jacksonville CSOs, to assess the contributions of these sources to the fecal coliform impairment. This monitoring should be conducted during both wet and dry weather, to assess the contributions of these outfalls.
- Fecal coliform monitoring in Mauvaise Terre Creek and Willow Branch. This monitoring should be conducted during both wet and dry weather. Sites to consider include the outlet of Mauvaise Terre Lake, Mauvaise Terre Creek at Myrtle Street, Mauvaise Terre Creek at Highway 67, Mauvaise Terre Creek at McGlasson Road, Mauvaise Terre Creek at Exeter

Road, Mauvaise Terre Creek at Route 100, and Willow Branch at Headen Road. Sites should be selected to include locations downstream of potential fecal coliform loads, such as livestock operations.

These activities will provide additional information to identify or confirm potential sources of the pollutants of concern, and assist in targeting implementation efforts.

Continued monitoring efforts will provide the basis for assessment of the effectiveness of the TMDLs, as well as future adaptive management decisions. As various alternatives are implemented, the monitoring will determine their effectiveness and identify which alternatives should be expanded, and which require adjustments to meet the TMDL goals.

REFERENCES

Commonwealth of Virginia, 2003. *Guidance Manual for Total Maximum Daily Load Implementation Plans*. Department of Conservation and Recreation, Department of Environmental Quality. http://www.deq.state.va.us/tmdl/implans/ipguide.pdf

Crawford, Murphy, and Tilly, Inc. (CMT), 2004. *Phase I Diagnostic / Feasibility Study; Clean Lakes Program; Lake Paradise, Coles County, Illinois*.

Cooke, GD; EB Welch; SA Peterson; and SA Nichols, 2005. *Restoration and Management of Lakes and Reservoirs, Third Edition*. Taylor & Francis, Boca Raton, FL.

Illinois Department of Agriculture (IDOA), 2004. *2004 Illinois Soil Conservation Transect Survey Summary*. http://www.agr.state.il.us/pdf/soiltransectsurvey.pdf

Illinois Environmental Protection Agency (IEPA), 2006. *Plan of Study for CSO Assessment – Review Letter, City of Jacksonville*. Letter from Michael S. Garretson, Manager, Compliance Assurance Section, Bureau of Water to John Calise, Benton and Associates, Inc.

Illinois Environmental Protection Agency (IEPA), 2002. *Water Monitoring Strategy 2002-2006*. Bureau of Water, Springfield, IL. IEPA/BOW/02-005. (Available at http://www.epa.state.il.us/water/water-quality/monitoring-strategy/2002-2006/monitoring-strategy-2002-2006.pdf)

Limno-Tech, Inc. (LTI), 2006. *Mauvaise Terre Creek Watershed Final Approved TMDL. Mauvaise Terre Creek (IL_DD-04): Fecal Coliform; Mauvaise Terre Lake (IL_SDL): Total Phosphorus, Manganese, Nitrate*. Prepared for Illinois Environmental Protection Agency, September 2006.

Limno-Tech, Inc. (LTI), 2005. *Final Stage 1 Progress Report. Mauvaise Terre Creek Watershed: Mauvaise Terre Creek (IL_DD-04), Mauvaise Terre Lake (IL_SDL), North Fork Mauvaise Terre Creek (IL_DDC).* Prepared for Illinois Environmental Protection Agency, April, 2005.

McComas, S., 1993. *LakeSmarts: The First Lake Maintenance Handbook.* Produced by the Terrene Institute, Washington, DC, in cooperation with U.S. Environmental Protection Agency

Office of Water, Office of Wetlands, Oceans and Watershed, Assessment and Watershed Protection Division, Washington, DC.

Morgan County Health Department (MCHD), 2004. Personal Communication with Quentin Lucassen, Environmental Health Inspector, June 2004.

Morgan County Natural Resource Conservation Service, 2004. Personal Communication with Matt Bunger, District Conservationist, February 2004.

Natural Resources Conservation Service (NRCS), 2006. Personal communication with Don Pitts, State Water Quality Specialist. March 28, 2006.

Natural Resources Conservation Service (NRCS), 2005. Personal communication with Montgomery County District Conservationist. November 3, 2005.

Natural Resources Conservation Service (NRCS), 2000. *Natural Resources Conservation Service Conservation Practice Standard, Grassed Waterway, Code 412*. Available at http://www.age.uiuc.edu/clmt/Workbook/WK_FILES/NRC_WATR.DOC

Natural Resources Conservation Service (NRCS), 1999. *CORE4 Conservation Practices Training Guide. The Common Sense Approach to Natural Resource Conservation*. U.S. Department of Agriculture. Available at http://www.nrcs.usda.gov/technical/ECS/agronomy/core4.pdf

North American Lake Management Society (NALMS), 2004. The Use of Alum for Lake Management. Position Statement 2, adopted by the NALMS Board of Directors on February 26, 2004. Available at http://www.nalms.org/news/positions/position_statment_2_alum.pdf.

U.S. Environmental Protection Agency (EPA), 2005. *Handbook for Managing Onsite and Clustered (Decentralized) Wastewater Treatment Systems*. EPA 832-B-05-001. Office of Water, Washington, DC. Available at http://www.epa.gov/owm/septic/pubs/onsite_handbook.pdf

U.S. Environmental Protection Agency (EPA), 2003. *National Management Measures to Control Nonpoint Source Pollution from Agriculture*. EPA 841-B-03-004. Office of Water, Washington, DC. Available at http://www.epa.gov/owow/nps/agmm/index.html

University of Illinois at Urbana-Champaign (UIUC), 2005. *Illinois Agronomy Handbook*. Online version, accessed October 2005. http://www.aces.uiuc.edu/iah/index.php?ch=smap.content.html

Zahniser Institute for Environmental Studies (undated; believed 2004). *Clean Lakes Program Phase 1 Diagnostic Feasibility Study, Glenn Shoals Lake, City of Hillsboro, Montgomery County, Illinois*. Prepared for the City of Hillsboro in cooperation with the Illinois Environmental Protection Agency.

North Fork Mauvaise Terre Creek Watershed
Final Approved TMDL

Prepared for: **Illinois Environmental Protection Agency**

August 2007

North Fork Mauvaise Terre Creek (IL_DDC): Manganese

LimnoTech
Water | Environment | Scientists | Engineers

Ann Arbor, Michigan
www.limno.com

This page is blank to facilitate double sided printing.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

INTRODUCTION

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the 2006 303(d) list, which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (USEPA, 1991).

North Fork Mauvaise Terre Creek (IL_DDC) is listed on the 2006 Illinois Section 303(d) List of Impaired Waters (IEPA, 2006) as a waterbody that is not meeting its designated use for support of aquatic life. This document presents a TMDL designed to allow this waterbody to fully support its designated uses. The report covers each step of the TMDL process and is organized as follows:

- Problem Identification
- Required TMDL Elements
- Watershed Characterization
- Description of Applicable Standards and Numeric Targets
- Development of Water Quality Model
- TMDL Development
- Public Participation and Involvement
- Adaptive Implementation Process

This page is blank to facilitate double sided printing.

1 PROBLEM IDENTIFICATION

North Fork Mauvaise Terre Creek has been identified in the 303 (d) list (ILEPA, 2006) as not supporting the aquatic life use due to manganese, dissolved oxygen deficits, total nitrogen and total suspended solids (IEPA, 2006). This report presents the manganese TMDL for this creek. Manganese is also being used as a surrogate for total suspended solids. Dissolved oxygen will be delisted as an impairment based on monitoring that was conducted in 2006.

While TMDLs are currently only being developed for pollutants that have numerical water quality standards, many controls that are implemented to address TMDLs for these pollutants will reduce other pollutants as well. For example, any controls to reduce manganese loads from watershed sources such as stream bank erosion would also serve to reduce total suspended solids loads to the river.

North Fork Mauvaise Terre Creek	
Assessment Unit ID	IL_DDC
Size (length)	14.03
Listed For	**Manganese,** Dissolved Oxygen[2]**,** Total Nitrogen, Total Suspended Solids
Use Support[1]	Aquatic life (N), Fish consumption (X), Primary contact (X), Secondary contact (X), Aesthetic quality (X)

[1] F = fully supporting, N=not supporting, X = not assessed

[2] Dissolved oxygen will be delisted.

This page is blank to facilitate double sided printing.

2 REQUIRED TMDL ELEMENTS

USEPA Region 5 guidance for TMDL development requires TMDLs to contain eleven specific components. Each of those components is summarized below.

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** North Fork Mauvaise Terre Creek, HUC 0713001104. The pollutant of concern addressed in this TMDL is manganese. Additional pollutants causing impairments include total nitrogen and total suspended solids; however, these pollutants will not be addressed at this time, as they do not have numerical water quality criteria. Soils naturally enriched in manganese are a potential source contributing to the listing of North Fork Mauvaise Terre Creek. North Fork Mauvaise Terre Creek is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006). This waterbody has a medium priority ranking.

2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The IEPA guidelines (IEPA, 2006) for identifying manganese as a cause of impairment in streams state that manganese is a potential cause of impairment of the aquatic life use if there is a single exceedance of the applicable numeric criteria for manganese. Public and food processing water supply is not listed as a designated use for the North Fork Mauvaise Terre Creek, thus the target is based on the water quality criterion for aquatic life. The TMDL target is a total manganese concentration of 1,000 ug/l.

3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** A load capacity calculation was completed to determine the maximum manganese loads that will maintain compliance with the total manganese standard under a range of flow conditions:

North Fork Mauvaise Terre Creek (IL_DDC) Flow (cfs)	Manganese load capacity (lbs/day)
1	5.4
3	16.2
5	27.0
10	53.9
25	134.8
75	404.5
200	1078.7
500	2696.8

4. **Load Allocations (LA):** Load allocations designed to achieve compliance with the above TMDL are calculated by the following equation:

$$\text{Load allocation} = \text{Load capacity} - \text{MOS} - \Sigma\text{WLAs}$$

North Fork Mauvaise Terre Creek Flow (cfs)	Manganese load allocation (lbs/day)
1	4.85
3	14.56
5	24.27
10	48.54
25	121.36
75	364.07
200	970.86
500	2427.14

5. **Wasteload Allocations (WLA):** There are no permitted point source dischargers in the North Fork Mauvaise Terre Creek watershed, therefore the wasteload allocation does not need to be calculated.

6. **Margin of Safety:** The manganese TMDL contains an implicit and explicit Margin of Safety. An implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no loss of manganese that enters the creek, and therefore represents an upper bound of expected concentrations for a given pollutant load. The TMDL also contains an explicit Margin of Safety of 10%. This 10% MOS was included in addition to the implicit MOS to address potential uncertainty in the effectiveness of load reduction alternatives.

North Fork Mauvaise Terre Creek Flow (cfs)	Manganese Margin of Safety (lbs/day)
1	0.54
3	1.62
5	2.70
10	5.39
25	13.48
75	40.45
200	107.87
500	269.68

7. **Seasonal Variation:** The TMDL was conducted with an explicit consideration of seasonal variation. The manganese standard will be met regardless of flow conditions in any season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in the creek.

8. **Reasonable Assurances:** There are no permitted point sources in the North Fork Mauvaise Terre Creek watershed, so reasonable assurances for point sources are not discussed.

   In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

   - Convene local experts familiar with nonpoint sources of pollution in the watershed
   - Ensure that they define priority sources and identify restoration alternatives
   - Develop a voluntary implementation plan that includes accountability.

   Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in Attachment 1 (see First Quarterly Progress Report, Watershed Characterization).

9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan is included as part of the implementation plan (Attachment 3).

10. **Transmittal Letter:** A transmittal letter is included with the TMDL.

11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (listed in Attachment 1; see First Quarterly Progress Report, Appendix A). As quarterly progress reports were produced, the Agency posted them to their website. In March 2005, a public meeting was conducted in Jacksonville, Illinois to present the results of the Stage 1 characterization work. In May 2007, a public meeting was conducted in Jacksonville, Illinois to present the results of the Stage 3 TMDL and Implementation Plan.

This page is blank to facilitate double sided printing.

3 WATERSHED CHARACTERIZATION

The Stage 1 Report (Attachment 1) presents and discusses information describing the North Fork Mauvaise Terre Creek watershed (as well as the Mauvaise Terre Creek watershed and Mauvaise Terre Lake) and supports the identification of sources contributing to the manganese impairment. Watershed characterization activities were focused on gaining an understanding of key features of the watershed, including geology and soils, climate, land cover, hydrology, urbanization and population growth, point source discharges and watershed activities.

North Fork Mauvaise Terre Creek lies within Morgan County and drains a 46.9-square mile area (Figure 1). The city of Jacksonville is located nearby, but downstream and outside of the study area watershed. The predominant land use in the watershed is agriculture, with croplands comprising 90.8% of the watershed. Only 2% of the watershed is forested, and 1.5% developed. IEPA does not have information on CAFOs available at this time. There are no MS4 communities in the study area.

Although population within Morgan County is forecast to increase, annual estimates of the population of metropolitan and micropolitan statistical areas, show that the community of Jacksonville has had a declining population between April 1, 2000 and July 1, 2004 (http://www.census.gov/population/www/estimates/metropop/table01.xls). As such, growth in this predominantly agricultural watershed is not expected to have an impact on the nonpoint loads to the creek.

Many of the soils in the Mauvaise Terre watershed contain manganese concretions or accumulations and are also somewhat acidic. This could result in manganese moving into solution and being transported in base flow and/or runoff, and contribute to the manganese impairment.

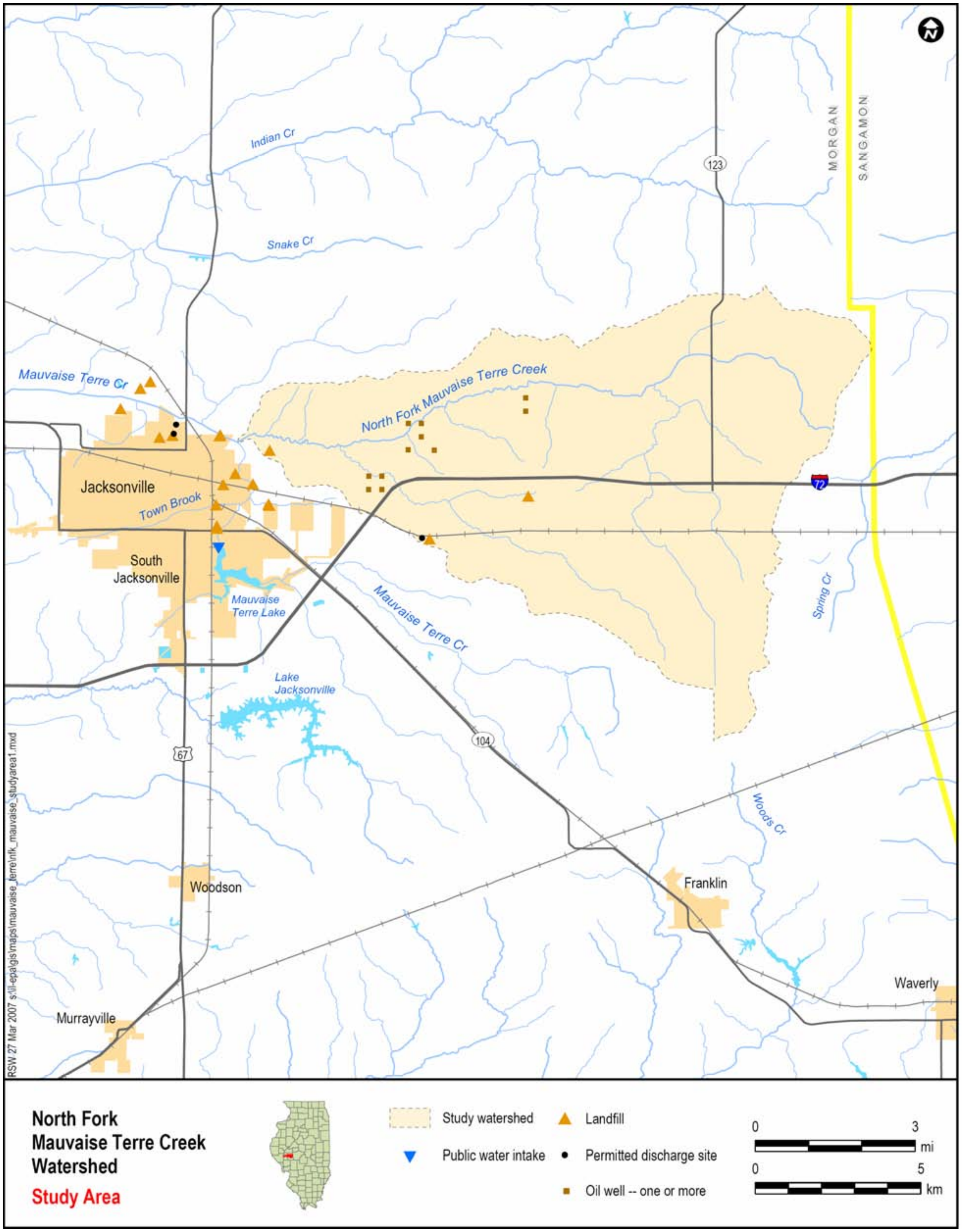


Figure 1. North Fork Mauvaise Terre Creek Watershed

4 DESCRIPTION OF APPLICABLE STANDARDS AND NUMERIC TARGETS

A water quality standard includes the designated uses of the waterbody, water quality criteria to protect designated uses, and an antidegradation policy to maintain and protect existing uses and high quality waters. Water quality criteria are sometimes in a form that are not directly amenable for use in TMDL development and may need to be translated into a target value for TMDLs. This section discusses the applicable designated uses, use support, criteria and TMDL targets for North Fork Mauvaise Terre Creek.

4.1 DESIGNATED USES AND USE SUPPORT

Water quality assessments in Illinois are based on a combination of chemical (water, sediment and fish tissue), physical (habitat and flow discharge), and biological (macroinvertebrate and fish) data. Illinois EPA conducts its assessment of water bodies using a set of seven designated uses: aquatic life, aesthetic quality, indigenous aquatic life (for specific Chicago-area waterbodies), primary contact (swimming), secondary contact, public and food processing water supply, and fish consumption (IEPA, 2006). For each water body, and for each designated use applicable to the water body, Illinois EPA's assessment concludes one of two possible "use-support" levels:

- Fully Supporting (the water body attains the designated use); or
- Not Supporting (the water body does not attain the designated use).

Water bodies assessed as "Not Supporting" for any designated use are identified as impaired. Waters identified as impaired based on biological (macroinvertebrate, macrophyte, algal and fish), chemical (water, sediment and fish tissue), and/or physical (habitat and flow discharge) monitoring data are placed on the 303(d) list. Potential causes and sources of impairment are also identified for impaired waters (IEPA, 2006).

Following the U.S. EPA regulations at 40 CFR Part 130.7(b)(4), the Illinois Section 303(d) list was prioritized on a watershed basis. Illinois EPA watershed boundaries are based on the USGS ten-digit hydrologic units to provide the state with the ability to address watershed issues at a manageable level and document improvements to a watershed's health (IEPA, 2006).

4.2 WATER QUALITY CRITERIA

Illinois has established water quality criteria and guidelines for allowable concentrations of manganese under its CWA Section 305(b) program, as summarized below.

4.2.1 Manganese

The IEPA guidelines (IEPA, 2006) for identifying manganese as a cause of impairment in streams state that one exceedance of an applicable Illinois water quality standard (related to the protection of aquatic life) results in identifying the parameter as a potential cause of impairment. In this case, manganese is identified as a potential cause of impairment of the aquatic life use if there is a single exceedance of the applicable total manganese criterion (1000 ug/l).

4.3 DEVELOPMENT OF TMDL TARGETS

The TMDL target is a numeric endpoint specified to represent the level of acceptable water quality that is to be achieved by implementing the TMDL. Where possible, the water quality criterion for the pollutant of concern is used as the numeric endpoint. When appropriate numeric standards do not exist, surrogate parameters must be selected to represent the designated use.

4.3.1 Manganese

For the North Fork Mauvaise Terre Creek manganese TMDL, the target is set at the water quality criterion for manganese of 1000 ug/l.

5 DEVELOPMENT OF WATER QUALITY MODELS

Water quality models are used to define the relationship between pollutant loading and resulting water quality. . The TMDL for manganese utilizes a Load Duration Curve method in addition to a Load Capacity Calculation. The development of the Load Duration Curve Approach is described in this section.

5.1 LOAD DURATION CURVE APPROACH

A load duration curve approach was used in the manganese analysis for North Fork Mauvaise Terre Creek. A load duration curve is a graphical representation of observed pollutant load compared to maximum allowable load over a range of flow conditions. The load duration curve provides information to:

- Help identify the issues surrounding the problem and differentiate between point and nonpoint source problems, as discussed immediately below;
- Address frequency of deviations (how many samples lie above the curve vs. those that plot below); and
- Aid in establishing the level of implementation needed, by showing the magnitude by which existing loads exceed standards for different flow conditions.

5.1.1 Model Selection

The load duration curve approach was selected for manganese because it is consistent with the selected level of TMDL implementation for this TMDL and it can be applied with the existing data. The load duration curve approach identifies broad categories of sources over the entire range of flows, and the extent of control required from these source categories to attain water quality standards.

5.1.2 Approach

The load duration curve approach uses stream flows for the period of record to gain insight into the flow conditions under which exceedances of the water quality standard occur. A load-duration curve is developed by: 1) ranking the daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results; 2) translating the flow duration curve (produced in step 1) into a load duration curve by multiplying the flows by the TMDL target; and 3) plotting observed pollutant loads (measured concentrations times stream flow) on the same graph. Observed loads that fall above the load duration curve exceed the maximum allowable load, while those that fall on or below the line, do not exceed the maximum allowable load. An analysis of the observed loads relative to the load duration curve provides information on whether the pollutant source is point or nonpoint in nature. A more complete description of the load duration curve approach is provided in Attachment 1.

5.1.3 Data Inputs

The load duration curve approach requires a long-term flow record and concentration measurements that are paired to flows.

Manganese data collected during June- October 2001 by the Illinois EPA Ambient Water Quality Monitoring Program, as well as Stage 2 manganese data collected in June 2006 by LimnoTech were used in this analysis.

The load duration curve approach requires a matching of flows to water quality data for the recent period. Daily flows were not available for North Fork Mauvaise Terre Creek for recent years. Instead, daily average flows measured at the USGS gage on nearby Spring Creek at Springfield, Illinois (05577500) were used in the analysis. Flows are available for the period 1949-2006. The flows measured on Spring Creek were adjusted for the size of the drainage area (46.9 square miles versus 107 square miles).

5.1.4 Analysis

A load duration curve was developed for manganese to characterize pollutant problems over the entire flow regime and gain an understanding of manganese impairments in North Fork Mauvaise Terre Creek.

A flow duration curve was generated by ranking daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results. A load duration curve for manganese was generated by multiplying the flows in the duration curve by the water quality standard of 1,000 ug/l. This is shown with a solid line in Figure 2. Observed pollutant loads (measured concentrations multiplied by corresponding stream flow), were plotted at triangles on the same graph. The worksheet for this analysis is provided in Attachment 2.

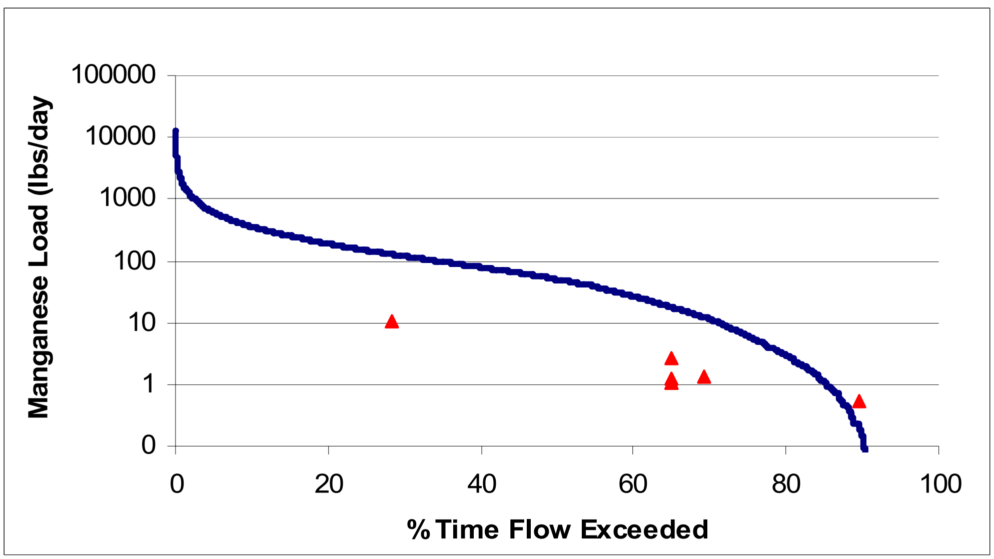


Figure 2. Manganese Load Duration Curve for North Fork Mauvaise Terre Creek with Observed Loads (triangles)

As shown in Figure 2, the single exceedance of the manganese target is observed at low flow. Potential sources include groundwater or manganese release from the bottom sediments during anoxic conditions. Instream dissolved oxygen measured 2.05 mg/l on the day of the manganese exceedance. Although this DO concentration is not low enough to cause manganese release from the bottom sediments, it is possible that DO concentrations were lower at other times of the day. If DO dropped to zero, then sediment release of manganese may have occurred.

This page is blank to facilitate double sided printing.

6 TMDL DEVELOPMENT

This section presents the development of the Total Maximum Daily Load for the North Fork Mauvaise Terre Creek watershed. It begins with a description of how the total loading capacity was calculated, and then describes how the loading capacity is allocated among point sources, non-point sources, and the margin of safety. A discussion of critical conditions and seasonality considerations is also provided.

6.1 MANGANESE

A load capacity calculation approach was applied to support development of a manganese TMDL for North Fork Mauvaise Terre Creek.

6.1.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards. The loading capacity was defined over a range of specified flows based on expected flows for North Fork Mauvaise Terre Creek. The allowable loading capacity was computed by multiplying flow by the water quality standard (1000 ug/l for manganese). The manganese loading capacity is presented in Table 1.

Table 1. Manganese Loading Capacity

North Fork Mauvaise Terre Creek (IL_DDC) Flow (cfs)	Manganese load capacity (lbs/day)
1	5.4
3	16.2
5	27.0
10	53.9
25	134.8
75	404.5
200	1078.7
500	2696.8

The maximum concentrations of manganese for the expected flow ranges were examined to estimate the percent reduction in existing loads required to meet the 1000 ug/l target. As noted in Figure 1, the sole exceedance of the manganese water quality criterion occurred at low flow. Up to a 57% reduction in manganese is needed during very low flows, while no reductions are needed at higher flows.

6.1.2 Allocation

A TMDL consists of waste load allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and a margin of safety (MOS).

There are no permitted dischargers in the North Fork Mauvaise Terre watershed and the WLA does not need to be calculated. The remainder of the loading capacity is given to the load allocation for nonpoint sources and the margin of safety (Table 2). The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall manganese load.

Table 2. Manganese TMDL Allocation[1]

North Fork Mauvaise Terre Creek Flow (cfs)	Manganese Loading Capacity (lbs/day)	Manganese LA (lbs/day)	Manganese MOS (lbs/day)
1	5.4	4.85	0.54
3	16.2	14.56	1.62
5	27.0	24.27	2.70
10	53.9	48.54	5.39
25	134.8	121.36	13.48
75	404.5	364.07	40.45
200	1078.7	970.86	107.87
500	2696.8	2427.14	269.68

[1] Due to rounding, numbers may not add up exactly.

6.1.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Figure 2 provides a graphical depiction of the data compared to the load capacity, showing that exceedances of the TMDL target occur at low flow conditions. TMDL development utilizing the load-duration approach applies to the full range of flow conditions; therefore critical conditions were addressed during TMDL development.

6.1.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The manganese standard will be met regardless of flow conditions in any season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in the river.

6.1.5 Margin of Safety

TMDLs are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be either implicit (e.g., incorporated into the TMDL analysis through conservative assumptions), or explicit (e.g., expressed in the TMDL as a portion of the loading), or expressed as a combination of both. The manganese TMDL contains a combination of both types. An implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no loss of manganese that enters the river, and therefore represents an upper bound of expected concentrations for a given pollutant load. The TMDL also contains an explicit margin of safety of 10%. This 10% margin of safety was included in addition to the implicit margin of safety to address potential uncertainty in the effectiveness of load reduction alternatives. This margin of safety can be reviewed in the future as new data are developed.

This page is blank to facilitate double sided printing.

7 PUBLIC PARTICIPATION AND INVOLVEMENT

The TMDL process included numerous opportunities for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in Summer 2004 to notify stakeholders about the upcoming TMDLs for the Mauvaise Terre Creek watershed, including the North Fork Mauvaise Terre Creek. A number of phone calls were made to identify and acquire data and information (see Appendix A to the First Quarterly Progress Report, presented in Attachment 1). As quarterly progress reports were produced during the first stage of the TMDL process, the Agency posted them to their website for public review.

In January 2005 a public meeting was announced for presentation of the Stage 1 findings. This announcement was mailed to everyone on the previous TMDL mailing list and published in local newspapers. The public meeting was held at 6:30 pm on Tuesday, March 1, 2005 at the Jacksonville Municipal Building in Jacksonville, Illinois. In addition to the meeting's sponsors, nine (9) individuals attended the meeting. Attendees registered and listened to an introduction to the TMDL Program from Illinois EPA and a presentation on the Stage 1 findings by LimnoTech. This was followed by a general question and answer session.

The results of the TMDL and implementation plan were presented to the public at a May 9, 2007 meeting in Jacksonville, Illinois.

This page is blank to facilitate double sided printing.

8 ADAPTIVE IMPLEMENTATION PROCESS

The approach to be taken for TMDL implementation is based upon discussions with Illinois EPA and its Scientific Advisory Committee. The approach consists of the following steps:

1. Use existing data to define overall existing pollutant loads, as opposed to developing a watershed model that might define individual loading sources.
2. Apply relatively simple models (e.g. load capacity calculations) to define the load-response relationship and define the maximum allowable pollutant load that the lake can assimilate and still attain water quality standards
3. Compare the maximum allowable loading capacity to the existing load to define the extent to which existing loads must be reduced in order to meet water quality standards
4. Develop a voluntary implementation plan that includes both accountability and the potential for adaptive management.
5. Carry out adaptive management through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented, as well as progress towards attaining water quality standards.

This approach is designed to accelerate the pace at which TMDLs are being developed for sites dominated by nonpoint sources, which will allow implementation activities (and water quality improvement) to begin sooner. The approach also places decisions on the types of nonpoint source controls to be implemented at the local level, which will allow those with the best local knowledge to prioritize sources and identify restoration alternatives. Finally, the adaptive management approach to be followed recognizes that models used for decision-making are approximations, and that there is never enough data to completely remove uncertainty. The adaptive process allows decision-makers to proceed with initial decisions based on modeling, and then to update these decisions as experience and knowledge improve.

Steps 1-3 correspond to TMDL development and have been completed, as described in Section 5 of this document. Steps 4 and 5 correspond to implementation.

This page is blank to facilitate double sided printing.

REFERENCES

Illinois Environmental Protection Agency (IEPA), 2006. Illinois Integrated Water Quality Report and Section 303(d) list-2006. Illinois EPA Bureau of Water. April 2006. IEPA/BOW/04-005 http://www.epa.state.il.us/water/watershed/reports/303d-report/2006/303d-report.pdf

U.S. Environmental Protection Agency (EPA), 1991. *Guidance for Water Quality-based Decisions: The TMDL Process.* EPA 440/4-91-001. Office of Water, Washington, DC.

This page is blank to facilitate double sided printing.

Attachment 1

This page is blank to facilitate double sided printing.

Data for Manganese Load Duration Curve

North Fork Mauvaise Terre Creek Flow at DDC-12 (cfs)	% of Time Exceeded	Mn load (lbs/day)
0.00	100.00	0
0.0	99.47	0
0.0	98.50	0
0.0	98.01	0
0.0	97.05	0
0.0	96.56	0
0.0	95.59	0
0.0	95.11	0
0.0	94.14	0
0.0	93.66	0
0.0	92.69	0
0.0	91.72	0
0.0	90.75	0
0.0	89.78	0
0.0	88.81	0
0.1	87.84	0
0.1	86.88	1
0.2	85.91	1
0.2	84.94	1
0.3	83.97	1
0.3	83.00	2
0.4	82.03	2
0.4	81.06	2
0.5	80.10	3
0.6	79.61	3
0.7	78.64	4
0.7	77.67	4
0.9	76.71	5
1.0	75.74	5
1.2	74.77	6
1.4	73.80	7
1.5	72.83	8
1.7	71.86	9
1.9	70.89	10
2.1	69.93	11
2.3	68.96	12
2.5	67.99	14
3.0	66.05	16
3.2	65.08	17
3.5	64.11	19
3.9	63.15	21
4.2	62.18	23
4.4	61.21	24
4.8	60.24	26
5.3	59.27	28
5.3	58.79	28
5.7	57.82	31
6.1	56.85	33
6.6	55.88	35
7.0	54.91	38
7.5	53.94	40
7.9	52.98	43
8.3	52.01	45
8.8	51.04	47
9.2	50.07	50
10.1	48.62	54

Observed Data

Date	North Fork Mauvaise Terre Creek Flow at DDC-12 (cfs)	Concentration (ug/l)	Percentile	Mn load (lbs/day)
6/22/2001	24	78	28.24	10
7/25/2001	2	110	69.21	1
10/1/2001	0	2300	89.59	1
6/29/2006	3	60	64.96	1
6/29/2006	3	60	64.96	1
6/29/2006	3	70	64.96	1
6/29/2006	3	150	64.96	3

Data for Manganese Load Duration Curve

North Fork Mauvaise Terre Creek Flow at DDC-12 (cfs)	% of Time Exceeded	Mn load (lbs/day)
10.5	47.65	57
11.0	46.68	59
11.4	45.71	61
11.8	44.74	64
12.3	43.77	66
13.1	42.81	71
13.6	41.84	73
14.0	40.87	76
14.5	39.90	78
15.3	38.93	83
15.8	37.96	85
16.7	36.99	90
18.0	35.06	97
18.4	34.09	99
19.3	33.12	104
20.2	32.15	109
21.0	31.18	113
21.9	30.21	118
22.8	29.25	123
23.7	28.28	128
25.0	27.31	135
25.9	26.34	139
26.7	25.37	144
28.1	24.40	151
29.4	23.43	158
30.7	22.47	165
32.4	21.50	175
33.8	20.53	182
35.5	19.56	191
37.7	18.59	203
39.4	17.62	213
42.1	16.65	227
44.7	15.69	241
47.3	14.72	255
50.8	13.75	274
53.9	12.78	291
57.4	11.81	310
61.4	10.84	331
67.1	9.87	362
73.2	8.91	395
79.8	7.94	430
87.7	6.97	473
98.6	6.00	532
112.6	5.03	608
131.1	4.06	707
160.0	3.09	863
209.5	2.05	1130
213.5	1.99	1151
301.1	1.09	1624
319.5	0.98	1723
341.9	0.85	1844
389.2	0.69	2099
420.8	0.55	2270
482.1	0.42	2601
552.3	0.33	2979
613.6	0.25	3310
1038.8	0.12	5603
2301.2	0.01	12412
2331.9	0.00	12577

Attachment 2

This page is blank to facilitate double sided printing.

North Fork Mauvaise Terre Creek Watershed
TMDL Implementation Plan

Prepared for Illinois Environmental Protection Agency

August 2007

North Fork Mauvaise Terre Creek (IL_DDC): Manganese

This page left blank for double sided printing

Table of Contents

List of Figures

List of Tables

This page left blank for double sided printing

SUMMARY

A Total Maximum Daily Load (TMDL) has been developed for the North Fork Mauvaise Terre Creek (Morgan County, Illinois) to address manganese impairment. This TMDL determined that significant reductions in existing pollutant loadings were needed to meet water quality objectives. The next step in the TMDL process is to develop a voluntary implementation plan that includes both accountability and the potential for adaptive management. This document identifies a number of alternative actions to be considered by local stakeholders for TMDL implementation; these alternative actions are summarized, and recommendations are presented for implementation actions and additional monitoring.

INTRODUCTION

Section 303(d) of the 1972 Clean Water Act requires States to define waters that are not meeting designated uses under technology-based controls and identify them on a list of impaired waters, which is referred to as the 303(d) list. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) requires states to develop Total Maximum Daily Loads (TMDLs) for these impaired water bodies. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and conditions in the water body. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (U.S. EPA, 1991).

North Fork Mauvaise Terre Creek (IL_DDC) is listed on the 2006 Illinois Section 303(d) List of Impaired Waters (IEPA, 2006) as a waterbody that is not meeting its designated use for support of aquatic life. As such, it was targeted as a high priority waterbody for TMDL development, and a TMDL for this waterbody was developed in 2007 (LTI, 2007). The next step in the TMDL process is to develop a voluntary implementation plan that includes both accountability and the potential for adaptive management. Adaptive management recognizes that proceeding with some initial improvement efforts is better than waiting to find a “perfect” solution. In an adaptive management approach, the TMDL and the watershed to which it applies are revisited over time to assess progress and make adjustments that continue to move toward achieving the TMDL’s goals. Adaptive management may be conducted through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented, as well as progress towards attaining water quality standards.

This document presents the implementation plan for the North Fork Mauvaise Terre Creek TMDL. It is divided into sections describing the watershed, summarizing the TMDL, describing existing controls within the watershed for the pollutants of interest, outlining the implementation approach, presenting a variety of implementation alternatives, recommending particular control alternatives, describing areas for targeting controls, presenting reasonable assurances that the measures will be implemented, and outlining future monitoring and adaptive management.

WATERSHED DESCRIPTION

North Fork Mauvaise Terre Creek lies within Morgan County and drains a 46.9-square mile area. The predominant land use in the watershed is agriculture, with croplands comprising almost 91% of the watershed. Only 2% of the watershed is forested, and less than 2% is developed. Many of the soils in the North Fork Mauvaise Terre Creek watershed contain manganese concretions or accumulations and are also somewhat acidic. This could result in manganese moving into solution and being transported in base flow and/or runoff, and contribute to the manganese impairment. Figure 1 shows a map of the watershed.

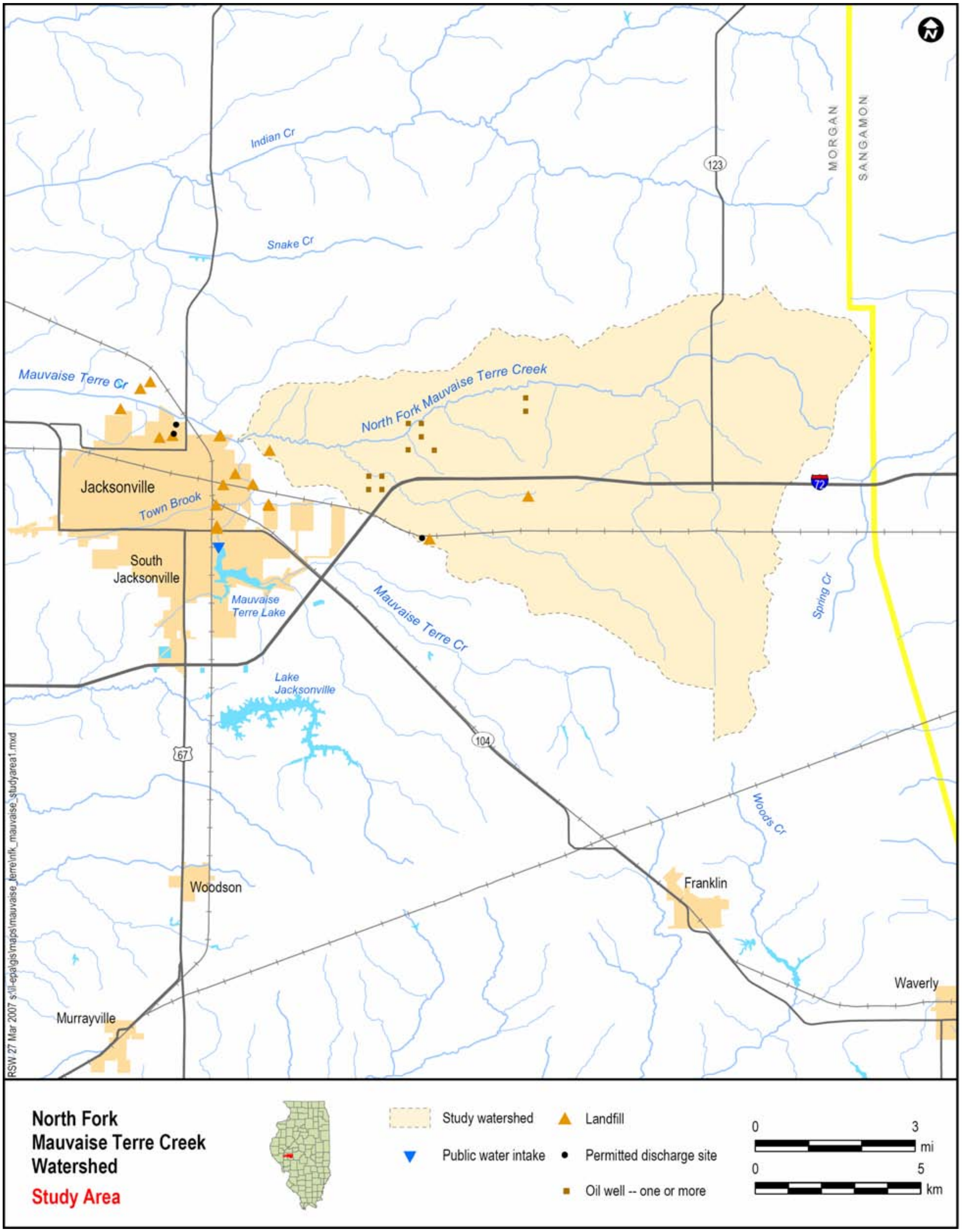


Figure 1. North Fork Mauvaise Terre Creek Watershed

TMDL SUMMARY

The impairments in waters of the North Fork Mauvaise Terre Creek watershed addressed in this report are summarized in Table 1, with the parameters (causes) that they are listed for, and the impairment status of each designated use, as identified in the 303(d) list (IEPA, 2006). While a TMDL has only been developed for pollutants that have numerical water quality standards (in this case, manganese, which is indicated below with bold font), controls that are implemented to address manganese will reduce other pollutants as well. For example, any controls to reduce manganese loads from watershed sources (stream bank erosion, runoff, etc.) would serve to reduce not only manganese, but also sediment loads to the creek, as manganese Best Management Practices (BMPs) are often the same or similar to sediment BMPs.

Table 1. Summary of Impairments

North Fork Mauvaise Terre Creek	
Assessment Unit ID	IL_DDC
Size (length)	14.03
Listed For	**Manganese,** Dissolved Oxygen[2]**,** Total Nitrogen, Total Suspended Solids
Use Support[1]	Aquatic life (N), Fish consumption (X), Primary contact (X), Secondary contact (X), Aesthetic quality (X)

[1] F = fully supporting, N=not supporting, X = not assessed

[2] Dissolved oxygen will be delisted.

Potential sources contributing to the manganese listing of this waterbody are summarized in Table 2.

Table 2. Potential Manganese Sources

Cause of Impairment	Potential Sources
Manganese	Natural background sources including groundwater, surface runoff and soil erosion

EXISTING CONTROLS

The local Natural Resource Conservation Service (NRCS), Farm Service Agency (FSA), and Soil and Water Conservation District (SWCD) offices have information on existing best management practices within the watershed, and can be contacted to understand what efforts have been made or are planned to control nonpoint sources. Recent discussions with local NRCS staff indicated that no large-scale BMPs have been implemented in the watershed within the last several years, and no streambank stabilization or restoration projects have been undertaken. The NRCS has been working with individual landowners to implement small-scale BMPs (e.g., filter strips) on individual properties. However, the NRCS indicated that it is difficult to quantify the impact of these individual property BMPs over the entire watershed (NRCS, 2007).

IMPLEMENTATION APPROACH

The approach to be taken for TMDL development and implementation is based upon discussions with Illinois EPA and its Scientific Advisory Committee. The approach consists of the following steps, with the first three steps corresponding to TMDL development and the latter two steps corresponding to implementation:

1. Use existing data to define overall existing pollutant loads, as opposed to developing a watershed model that might define individual loading sources.
2. Apply relatively simple tools (e.g., load duration curve) to define the load-response relationship and define the maximum allowable pollutant load that the creek can assimilate and still attain water quality standards.
3. Compare the maximum allowable load to the existing load to define the extent to which existing loads must be reduced in order to meet water quality standards.
4. Develop a voluntary implementation plan that includes both accountability and the potential for adaptive management.
5. Carry out adaptive management through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented, as well as progress towards attaining water quality standards.

This approach is designed to accelerate the pace at which TMDLs are being developed for sites dominated by nonpoint sources, which will allow implementation activities (and water quality improvement) to begin sooner. The approach also places decisions on the types of nonpoint source controls to be implemented at the local level, which will allow those with the best local knowledge to prioritize sources and identify restoration alternatives. The Association of Illinois Soil and Water Conservation Districts (SWCDs), using Section 319 grant funding, have made available a Watershed Liaison to provide educational, informational, and technical assistance to local agencies and communities. The liaison can assist in establishing local watershed planning groups, as well as acting as an overall facilitator for coordination between local, state, and Federal agencies.

The adaptive management approach to be followed recognizes that models used for decision-making are approximations, and that there is never enough data to completely remove uncertainty. The adaptive process allows decision-makers to proceed with initial decisions based on modeling, and then to update these decisions as experience and knowledge improve.

Steps One through Three described above have been completed, as described in the TMDL report (LTI, 2007). This plan represents Step Four of the process. Step Five is briefly described in the last section of this document, and will be conducted as implementation proceeds.

IMPLEMENTATION ALTERNATIVES

For manganese, the primary sources are natural sources, including soils and groundwater. Manganese reductions are needed during low flow conditions. Soils naturally enriched in manganese can settle in the river and contribute to manganese exceedances during low flow, anoxic conditions, as the metals are released into the water column. The extent to which this mechanism contributes to the low flow exceedances of manganese is not known; however, controls targeted at reducing wet weather loads of sediment and manganese may also reduce sedimentation and subsequent release of the manganese during low flow periods. Because it is difficult to control groundwater sources, implementation alternatives were focused on measures to reduce erosion, including:

- Conservation Tillage
- Conservation Buffers
- Sediment Control Structures
- Streambank Enhancement and Protection
- Grassed Waterways
- Dredging

Each of these alternatives is described briefly in this section, including information about their costs and effectiveness in reducing manganese loadings   Costs have been updated from their original sources, based on literature citations, to 2007 costs using the Engineering News Record Construction Cost Index, as provided by the Natural Resource Conservation Service (NRCS) (http://www.economics.nrcs.usda.gov/cost/priceindexes/index.html). Table 3 summarizes the implementation alternatives.

It should be noted that there is usually a wide range in the effectiveness of the various practices; this is largely due to variations in climate, soils, topography, design, construction, and maintenance of the practices (NRCS, 2006).

Table 3. Implementation Alternatives for Manganese

Alternative	**Applicability for Addressing Manganese**
Conservation Tillage	*
Conservation Buffers	*
Sediment Control Structures	*
Streambank Enhancement and Protection	*
Grassed Waterways	*
Dredging	◆

* While not directly tied to primary sources of manganese, BMPs designed to reduce erosion are expected to provide secondary benefits in reducing manganese

Conservation Tillage

The objective of conservation tillage is to provide profitable crop production while minimizing soil erosion (UIUC, 2005). The NRCS has replaced the term conservation tillage with the term crop residue management, or the year-round management of residue to maintain the level of cover needed for adequate control of erosion. This often requires more than 30% residue cover after planting (UIUC, 2005). Conservation tillage/crop residue management systems are recognized as cost-effective means of significantly reducing soil erosion and maintaining productivity. The most recent Illinois Soil Transect Survey (IDOA, 2006) suggests that 73% of the land under soybean production in Morgan County is farmed using reduced till, mulch till, or no till, 100% of the land in small grain production is farmed using no-till and 60% of the corn fields are farmed with conventional methods. Additional conservation tillage measures should be considered as part of this implementation plan, particularly for cornfields.

Conservation tillage practices have been reported to reduce sediment loads by 75%. A wide range of costs has been reported for conservation tillage practices, ranging from $12/acre to $83/acre in capital costs (U.S. EPA, 2003). For no-till, costs per acre provided in the Illinois Agronomy Handbook for machinery and labor range from $36 to $66 per acre, depending on the farm size and planting methods used (UIUC, 2005). In general, the total cost per acre for machinery and labor decreases as the amount of tillage decreases and farm size increases (UIUC, 2005).

Conservation Buffers

Conservation buffers are areas or strips of land maintained in permanent vegetation to help control pollutants (NRCS, 1999), generally by slowing the rate of runoff, while filtering sediment, bacteria, and nutrients. Additional benefits may include the creation of wildlife habitat, improved aesthetics, and potential economic benefits from marketing specialty forest crops (Trees Forever, 2005). This category of controls includes buffer strips, field borders, filter strips, vegetative barriers, riparian buffers, etc. (NRCS, 1999).

Filter strips and similar vegetative control methods can be very effective in reducing nutrient transport. The relative gross effectiveness of filter strips in reducing total phosphorus has been reported as 75% (U.S. EPA, 2003). Reduction of particulate phosphorus is moderate to high, while effectiveness for dissolved phosphorus is low to negative (NRCS, 2006). Vegetated filter strips and riparian buffers can also be used to reduce bacteria; riparian buffer zones have bacteria removal efficiencies of 43-57% (Commonwealth of Virginia, 2003).

Conservation buffers can help stabilize a stream and reduce its water temperature (NRCS, undated). Riparian buffers can work to improve instream dissolved oxygen concentrations by promoting increased infiltration and baseflow and lowering stream temperature.

Costs of conservation buffers vary from about $200/acre for filter strips of introduced grasses or direct seeding of riparian buffers, to approximately $360/acre for filter strips of native grasses or planting bare root riparian buffers, to more than $1,030/acre for riparian buffers using bare root stock shrubs (NRCS, 2005).

The Conservation Practices Cost-Share Program (CPP), part of the Illinois Conservation 2000 Program, provides cost sharing for conservation practices including field borders and filter strips (http://www.agr.state.il.us/Environment/conserv/index.html). The Department of Agriculture distributes funding for the cost-share program to Illinois' soil and water conservation districts (SWCDs), which prioritize and select projects. The Illinois Buffer Partnership offers cost sharing for installation of streamside buffer plantings at selected sites. An additional program that may be of interest is the Visual Investments to Enhance Watersheds (VIEW), which involves a landscape design consultant in the assessment and design of targeted BMPs within a watershed. Sponsored by Trees Forever (www.treesforever.org), VIEW guides a committee of local stakeholders through a watershed landscape planning process (Trees Forever, 2005). Additional funding for conservation buffers may be available through other sources such as the Conservation Reserve Program.

Sediment Control Basins

Sediment control basins trap sediments (and constituents bound to that sediment) before they reach surface waters (EPA, 2003). Because the manganese impairments have been attributed to natural contributions from local soils, sediment control basins could help reduce loadings of these sources. Costs for these basins can vary widely depending on location and size; estimates prepared for another Illinois watershed range from $1,200 to more than $200,000 per basin (Zahniser Institute, undated). This same study estimated a trapping efficiency for sediment of 75%. Siting considerations and costs are driven mainly by the size of the basin required, land availability, and land acquisition costs.

Streambank Enhancement and Protection

A recent aerial assessment report identified streambank incision and erosion within the Mauvaise Terre Creek watershed (Kinney, 2005). A number of erosion sites were identified along North Fork Mauvaise Terre Creek. The study recommended rock riffle grade control and stone toe protection to stabilize the banks of North Fork Mauvaise Terre Creek, with estimated costs of $4,375 per riffle (with riffles spaced 240 feet apart) and $2,500 per site for stone toe protection, based on a cost of $25 per ton of stone. Because of the potential cost of stabilizing streambanks throughout the watershed, additional study is recommended to prioritize sites for streambank stabilization. Such study should include direct observation of bank conditions, as well as an assessment of stream hydraulics and geomorphology to support identification and design of effective stabilization measures.

Grassed Waterways

Grassed waterways are another alternative to consider for this watershed. A grassed waterway is a natural or constructed channel that is planted with suitable vegetation to reduce erosion (NRCS, 2000). Grassed waterways are used to convey runoff without causing erosion or flooding, to reduce gully erosion, and to improve water quality. They may be used in combination with filter strips, and are effective at reducing soil loss, with typical reductions between 60 and 80 percent (Lin et al, 1999). Grassed waterways cost approximately $1,800/acre, not including costs for tile or seeding (MCSWCD, 2006).

Dredging

As noted in the TMDL report (LTI, 2007), manganese release from bottom sediments is a potential source of manganese. Control of this internal load would require removal of manganese from the creek bottom, such as through dredging. Dredging existing sediments is an expensive alternative and would be only a temporary solution. If manganese loads are not reduced in the watershed, it is likely that the flux of manganese from the sediments will continue to be a problem in the future.

IDENTIFYING PRIORITY AREAS FOR CONTROLS

Priority areas for locating controls were identified through a review of available information. Information reviewed included: tributary water quality data; an aerial assessment report; and GIS-based information. Based on this review, it is recommended that streambank stabilization be initiated in the North Fork Mauvaise Terre Lake Watershed to reduce bank erosion, and that this work occur concurrently with watershed controls in priority areas. Additional data collection is also recommended, to help focus control efforts.

Tributary Monitoring

Available water quality data obtained as part of the Stage 1 Watershed Characterization work were reviewed and no recent tributary monitoring data were identified. Since completion of the Stage 1 work, three additional samples of the North Fork Mauvaise Terre Creek (Lisbon Rd. [closed road south and off of Deornellas Road; approximately a 50 yard walk-in to old bridge]; Mobil Road [Hacker Road on Atlas]; and Illinois Route 123/Franklin-Alexander Road) and one unnamed tributary have been completed. Through this sampling it was observed that manganese concentrations did not exceed the water quality standard of 1 mg/L. The highest observed concentration in this sampling was the Illinois Route 123/Franklin-Alexander Road sample, which had a manganese concentration of 0.15 mg/L. Additional tributary monitoring data would help target particular areas for implementation efforts. Specific data collection recommendations are provided in the Monitoring and Adaptive Management Section later in this Implementation Plan.

Aerial Assessment Report

A recent aerial assessment report identified streambank incision and erosion within the North Fork Mauvaise Terre Creek watershed (Kinney, 2005). A number of erosion sites were identified along North Fork Mauvaise Terre Creek. The study recommended rock riffle grade control and stone toe protection to stabilize the banks of North Fork Mauvaise Terre Creek.

GIS Analysis

GIS soils, land use and topography data were analyzed to identify areas that are expected to generate the highest sediment and associated phosphorus loads. Within the GIS, maps were generated to show areas with steep slopes (Figure 2), highly erodible soils (Figure 3), and finally, priority areas for best management practices (BMPs). Priority areas are defined as agricultural areas that have both steep slopes and highly erodible soils (Figure 4). These maps serve as a good starting point for selecting areas to target for implementing control projects, to maximize the benefit of the controls.

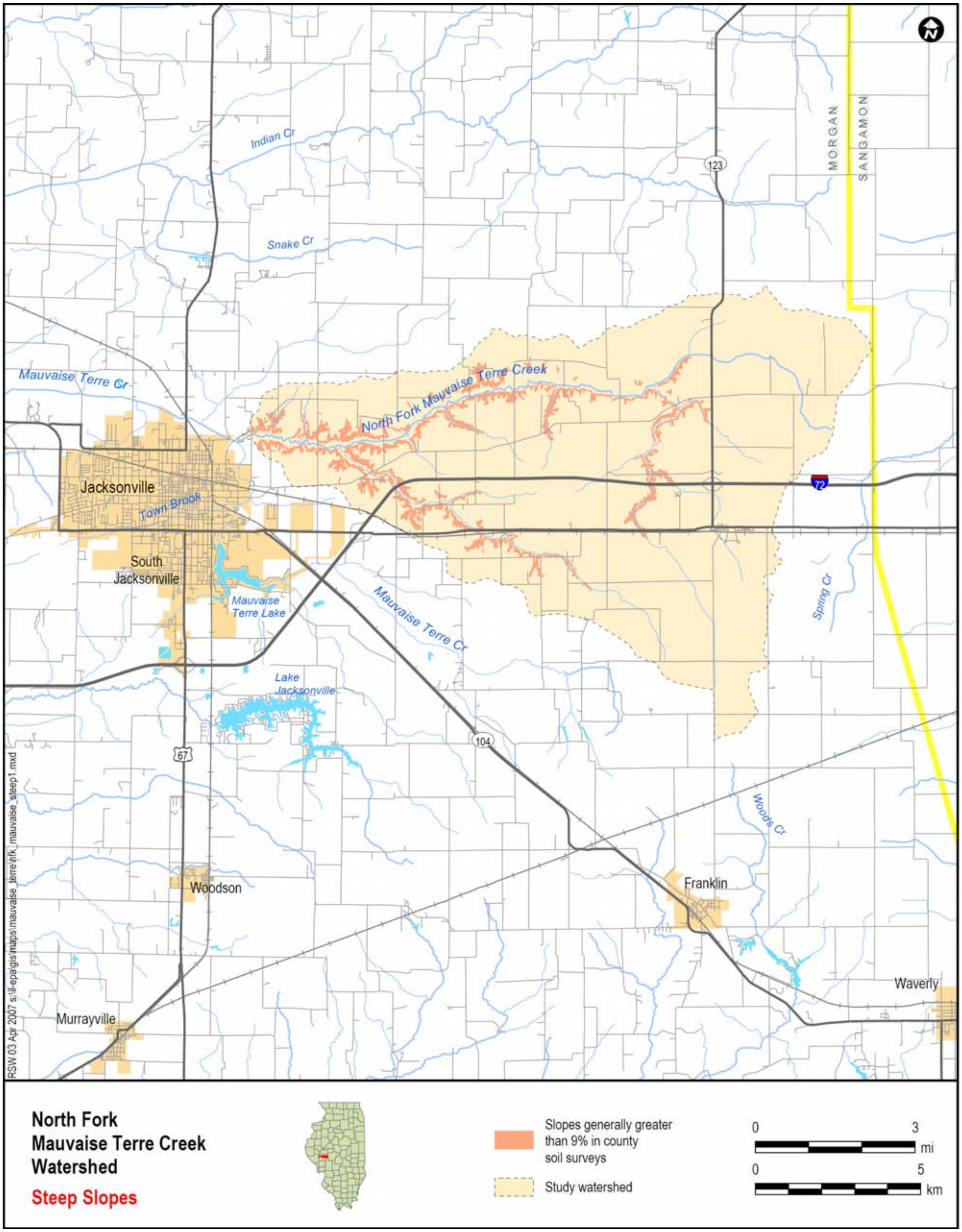


Figure 2. Areas with Steep Slopes

This page left blank for double sided printing

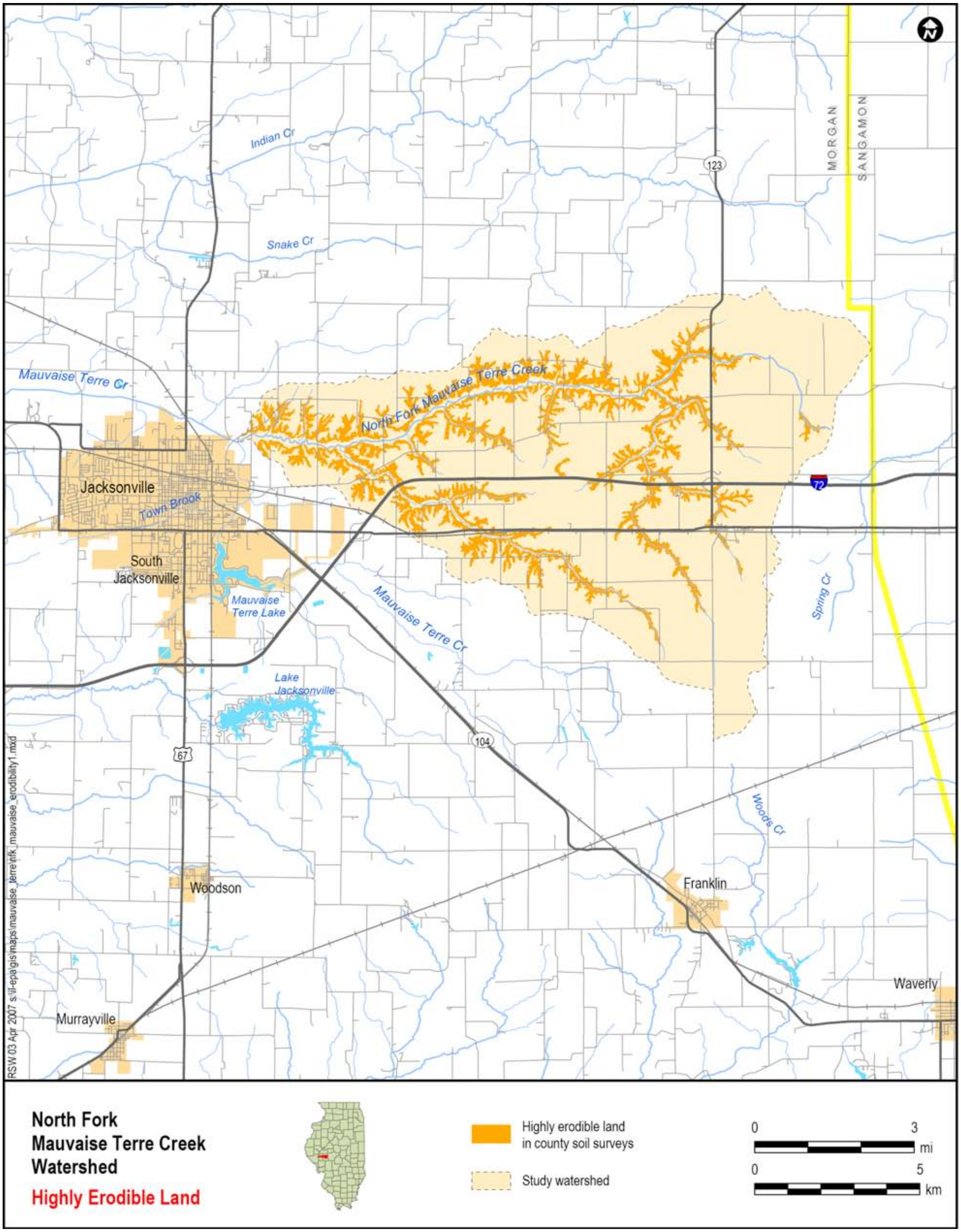


Figure 3. Areas of Highly Erodible Land

This page left blank for double sided printing

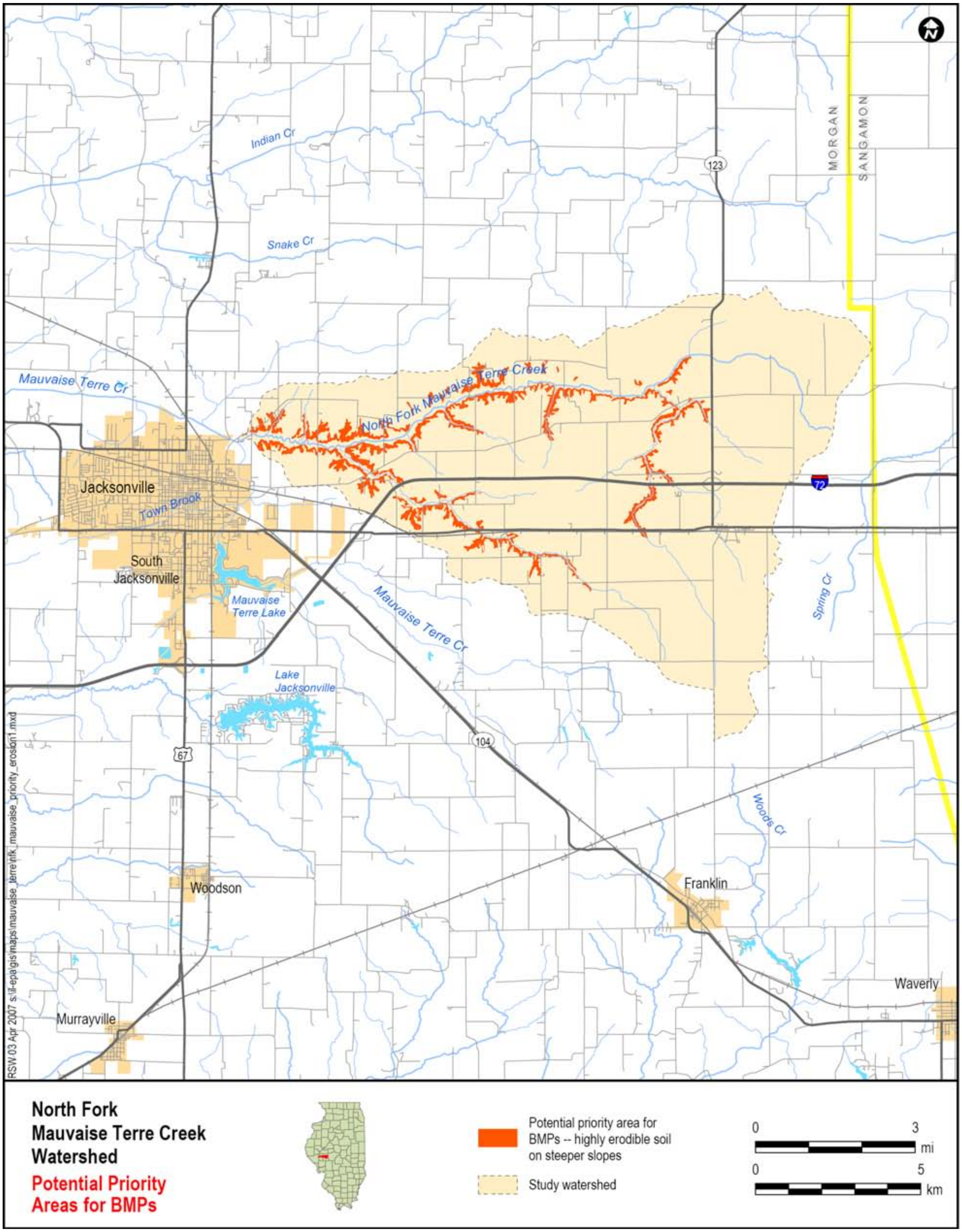


Figure 4. Potential Priority Areas for BMPs

This page left blank for double sided printing

REASONABLE ASSURANCE

The U.S. EPA requires states to provide reasonable assurance that the load reductions identified in the TMDL will be met. For nonpoint sources, which are the focus of this work, reasonable assurance means that nonpoint source controls are specific to the pollutant of concern, implemented according to an expeditious schedule and supported by reliable delivery mechanisms and adequate funding (U.S. EPA, 1999).

One of the most important aspects of implementing non-point source controls is obtaining adequate funding to implement voluntary or incentive-based programs. Funding is available from a variety of sources, including those listed below. It should be noted that the Federal programs listed are based on the 2002 Farm Bill, which expires on September 30, 2007. It is currently unknown what conservation programs will be included in a future farm bill.

- *Illinois Nutrient Management Planning Program*, cosponsored by the Illinois Department of Agriculture (IDOA) and IEPA (http://www.agr.state.il.us/Environment/LandWater/tmdl.html). This program targets funding to Soil and Water Conservation Districts (SWCDs) for use in impaired waters. The nutrient management plan practice cost share is only available to landowners/operators with land in TMDL watersheds. The dollar amount allocated to each eligible SWCD is based on their portion of the total number of cropland acres in eligible watersheds.
- *Clean Water Act Section 319 grants* to address nonpoint source pollution (http://www.epa.state.il.us/water/financial-assistance/non-point.html). Section 319 of the Clean Water Act provides Federal funding for states for the implementation of approved nonpoint source (NPS) management programs. Funding under these grants has been used in Illinois to finance projects that demonstrate cost-effective solutions to NPS problems. Projects must address water quality issues relating directly to NPS pollution. Funds can be used for the implementation of watershed management plans, including the development of information/education programs, and for the installation of best management practices.
- *Conservation 2000* (http://www.epa.state.il.us/water/conservation-2000/), which funds nine programs across three state natural resource agencies (IEPA, IDOA, and the Department of Natural Resources). Conservation 2000 is a six-year, $100 million initiative designed to take a broad-based, long-term ecosystem approach to conserving, restoring, and managing Illinois' natural lands, soils, and water resources while providing additional high-quality opportunities for outdoor recreation.
- *Conservation Practices Cost-Share Program* (http://www.agr.state.il.us/Environment/conserv/index.html). Another component of Conservation 2000, the Conservation Practices Program (CPP) focuses on conservation practices, such as terraces, filter strips and grass waterways, which are aimed at reducing soil loss on Illinois cropland. IDOA distributes funding for the cost-share program to Illinois' SWCDs, which prioritize and select projects. Construction costs are divided between the state and landowners.
- *Conservation Reserve Program* administered by the Farm Service Agency (http://www.nrcs.usda.gov/programs/crp/). The Conservation Reserve Program (CRP)

provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. CRP participants may enroll in 10 and 15-year contracts. CRP is administered by the Farm Service Agency, with NRCS providing technical land eligibility determinations, conservation planning and practice implementation.

- *Wetlands Reserve Program* (http://www.nrcs.usda.gov/programs/wrp/). NRCS's Wetlands Reserve Program (WRP) is a voluntary program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. The NRCS provides technical and financial support to help landowners with their wetland restoration efforts. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection. Figure 5 shows potential wetland restoration areas. These are areas with hydric soils that are not currently developed, covered by water or forested.
- *Environmental Quality Incentive Program* sponsored by NRCS (general information at http://www.nrcs.usda.gov/PROGRAMS/EQIP/; Illinois information and materials at http://www.il.nrcs.usda.gov/programs/eqip/). The Environmental Quality Incentives Program (EQIP) provides a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical assistance to eligible participants to install or implement structural and management practices on eligible agricultural land. EQIP may cost-share up to 75 percent of the costs of certain conservation practices (e.g., grassed waterways, nutrient management, riparian buffers, and wetland restoration). Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive.
- *Wildlife Habitat Incentives Program* (WHIP) (http://www.il.nrcs.usda.gov/programs/whip/index.html). WHIP is a NRCS program for developing and improving wildlife habitat, primarily on private lands. It provides both technical assistance and cost-share payments to help establish and improve fish and wildlife habitat.

In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

- Convene local experts familiar with nonpoint sources of pollution in the watershed
- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability
- Using the results of future monitoring to conduct adaptive management

MONITORING AND ADAPTIVE MANAGEMENT

Future monitoring is needed to assess the effectiveness of the various restoration alternatives and conduct adaptive management. The Illinois EPA conducts a variety of water quality monitoring programs (IEPA, 2002). Ongoing stream monitoring programs include: a statewide 213-station Ambient Water Quality Monitoring Network (AWQMN); an Intensive Basin Survey Program that covers all major watersheds on a five-year rotation basis; and a Facility-Related Stream

Survey Program that conducts approximately 20-30 stream surveys each year. North Fork Mauvaise Terre Creek is not monitored regularly as part of any of these programs. Local agencies and watershed organizations are therefore encouraged to conduct additional monitoring to assess sources of pollutants and evaluate changes in water quality in the creek.

In particular, the following monitoring is recommended:

- Dry weather monitoring for manganese in the North Fork Mauvaise Terre Creek. Limited water quality data suggest that groundwater may be the primary source of manganese to the creek. Manganese concentrations measured in community water supply wells within Morgan County indicate elevated levels of manganese. Sampling North Fork Mauvaise Terre Creek under low flow conditions at a location that has been previously sampled (such as the Illinois Route 123/Franklin-Alexander Road site) will allow confirmation of groundwater as the source of the manganese.

Monitoring will provide additional information to identify or confirm potential sources of manganese, and assist in targeting implementation efforts.

Continued monitoring efforts will provide the basis for assessment of the effectiveness of the TMDL, as well as future adaptive management decisions. As various alternatives are implemented, the monitoring will determine their effectiveness and identify which alternatives should be expanded, and which require adjustments to meet the TMDL goals.

This page left blank for double sided printing

REFERENCES

Commonwealth of Virginia, 2003. *Guidance Manual for Total Maximum Daily Load Implementation Plans*. Department of Conservation and Recreation, Department of Environmental Quality. http://www.deq.state.va.us/tmdl/implans/ipguide.pdf

Kinney, W. 2005. Aerial Assessment Report on Mauvaise Terre River, June 2005. Prepared for Illinois Department of Agriculture.

Illinois Department of Agriculture (IDOA), 2006. *2006 Illinois Soil Conservation Transect Survey Summary*. http://www.agr.state.il.us/darts/References/transect/transect06.pdf

Illinois Environmental Protection Agency (IEPA), 2006. Illinois Integrated Water Quality Report and Section 303(d) list-2006. Illinois EPA Bureau of Water. April 2006. IEPA/BOW/04-005 Available at http://www.epa.state.il.us/water/watershed/reports/303d-report/2006/303d-report.pdf

Illinois Environmental Protection Agency (IEPA), 2002. *Water Monitoring Strategy 2002-2006*. Bureau of Water, Springfield, IL. IEPA/BOW/02-005. (Available at http://www.epa.state.il.us/water/water-quality/monitoring-strategy/2002-2006/monitoring-strategy-2002-2006.pdf)

Limno-Tech, Inc. (LTI), 2007. North Fork *Mauvaise Terre Creek Watershed Final TMDL. North Fork Mauvaise Terre Creek (IL_DDC): Manganese*. Prepared for Illinois Environmental Protection Agency, August 2007.

Lin, SD, WC Bogner, and RK Raman, 1999. *Phase I: Diagnostic-Feasibility Study of Otter Lake, Macoupin County, Illinois*. Contract Report 652, Illinois State Water Survey, Watershed Science Section, Champaign, Illinois. October 1999.

Madison County Soil and Water Conservation District (MCSWCD), 2006. Personal communication with Rick Macho, Resource Conservationist. March 29, 2006.

Morgan County Health Department (MCHD), 2004. Personal Communication with Quentin Lucassen, Environmental Health Inspector, June 2004.

Natural Resources Conservation Service (NRCS), 2007. Personal communication with Jill Keaton, State Water Quality Specialist. March 28, 2006.

Natural Resources Conservation Service (NRCS), 2006. Personal communication with Don Pitts, State Water Quality Specialist. March 28, 2006.

Natural Resources Conservation Service (NRCS), 2005. Personal communication with Montgomery County District Conservationist. November 3, 2005.

Natural Resources Conservation Service (NRCS), 2000. *Natural Resources Conservation Service Conservation Practice Standard, Grassed Waterway, Code 412*. Available at http://www.age.uiuc.edu/clmt/Workbook/WK_FILES/NRC_WATR.DOC

Natural Resources Conservation Service (NRCS), 1999. *CORE4 Conservation Practices Training Guide. The Common Sense Approach to Natural Resource Conservation*. U.S. Department of Agriculture. Available at http://www.nrcs.usda.gov/technical/ECS/agronomy/core4.pdf

Natural Resources Conservation Service (NRCS), undated. [online] http://www.nrcs.usda.gov/FEATURE/buffers/

Trees Forever, 2005. Available at http://www.treesforever.org/content.asp?ID=2142. Accessed October 2005.

U.S. Environmental Protection Agency (EPA), 2003. *National Management Measures to Control Nonpoint Source Pollution from Agriculture*. EPA 841-B-03-004. Office of Water, Washington, DC. Available at http://www.epa.gov/owow/nps/agmm/index.html

U.S. Environmental Protection Agency (EPA), 1999. *Protocol for Developing Nutrient TMDLs*. EPA 841-B-99-007. Office of Water, Washington, DC. Available at http://www.epa.gov/owow/tmdl/nutrient/pdf/nutrient.pdf

U.S. Environmental Protection Agency (EPA), 1991. *Guidance for Water Quality-based Decisions: The TMDL Process.* EPA 440/4-91-001. Office of Water, Washington, DC.

University of Illinois at Urbana-Champaign (UIUC), 2005. *Illinois Agronomy Handbook*. Online version, accessed October 2005. http://www.aces.uiuc.edu/iah/index.php?ch=smap.content.html

Zahniser Institute for Environmental Studies (undated; believed 2004). *Clean Lakes Program Phase 1 Diagnostic Feasibility Study, Glenn Shoals Lake, City of Hillsboro, Montgomery County, Illinois*. Prepared for the City of Hillsboro in cooperation with the Illinois Environmental Protection Agency.

Attachment 3

This page is blank to facilitate double sided printing.

Attachment 3: Responsiveness Summary

This responsiveness summary responds to substantive questions and comments received during the public comment period from April 19, 2007 through June 8, 2007 postmarked, including those from the May 9, 2007 public meeting discussed below.

What is a TMDL?

A Total Maximum Daily Load (TMDL) is the sum of the allowable amount of a pollutant that a water body can receive from all contributing sources and still meet water quality standards or designated uses. This TMDL is for the North Fork Mauvaise Terre Watershed. This report details the watershed characteristics, impairment, sources, load and wasteload allocations, and reductions for each segment. The Illinois EPA implements the TMDL program in accordance with Section 303(d) of the federal Clean Water Act and regulations there under.

Background

North Fork Mauvaise Terre Creek (14 miles) lies within Morgan County and drains a 46.9 square mile area. Land use in the watershed is 91 percent agriculture, 2 percent forest and 2 percent developed. North Fork Mauvaise Terre Creek is listed on the Illinois EPA 2006 Section 303(d) List as being impaired for aquatic life use with the potential cause of manganese. The Clean Water Act and USEPA regulations require that states develop TMDLs for waters on the Section 303(d) List.

Public Meetings

Public meetings were held in Jacksonville on March 1, 2005 and May 9, 2007. The Illinois EPA provided public notices for all meetings by placing a display ad in the local newspaper in the watershed; the Jacksonville Journal Courier. This notice gave the date, time, location, and purpose of the meetings. It also provided references to obtain additional information about this specific site, the TMDL Program and other related issues. Individuals and organizations were also sent the public notice by first class mail. The draft TMDL Report was available for review at the Jacksonville Municipal Building and also on the Agency's web page at http://www.epa.state.il.us/water/tmdl .

The first public meeting on March 1, 2005 started at 6:00 p.m. and was attended by approximately 15 people. The second public meeting on May 9, 2007, started at 6:00 p.m. and was attended by eight people. The meeting record remained open until midnight, June 8, 2007.

Questions and Comments

1. What can we do if nobody wants to do any kind of implementation in the watershed? If farmers do not do anything, how can there be any effects without nonpoint source controls?

   Response
   Illinois EPA has no regulatory control over nonpoint sources of pollution. Runoff from farm fields is considered a source of nonpoint pollution. Efforts to abate this kind of pollution are incentive-based and voluntary. Local landowners and groups interested in such efforts can obtain additional information online (see response 3). We have recommended implementation actions for phosphorus/manganese reductions in the TMDL report and also included different programs that can provide funding. One of the best ways the community can start work in their watershed is to develop a watershed group with local stakeholders. This group can decide what their priorities are in the watershed and where they want to direct their efforts.

2. How can manganese be reduced if it is part of the soil?

   Response
   Manganese is naturally occurring in soils and adheres to soil particles. So, whenever there is erosion, there will be manganese. By controlling or limiting erosion, manganese will be reduced in the watershed.

3. Is there actually any money to do implementation projects in this watershed?

   Response
   Yes, however the funding available and the qualification requirements vary with each program. In the Implementation Plan that is included in the TMDL Report, there are 8 funding programs mentioned. Here is a list of those programs and their websites:

   Illinois Nutrient Management Planning Program
   www.agr.state.il.us/Environment/LandWater/tmdl.html
   Clean Water Act Section 319 Grants- www.epa.state.il.us/water/financial-assistance/non-point.html
   Conservation 2000- www.epa.state.il.us/water/conservation-2000/
   Conservation Reserve Program- www.nrcs.usda.gov/programs/crp/
   Conservation Practices Cost-Share Program- www.agr.state.il.us/Environment/conserv/index.html
   Wetlands Reserve Program- www.nrcs.usda.gov/programs/wrp
   Environmental Quality Incentive Program- www.il.nrcs.usda.gov/programs/eqip/
   Wildlife Habitat Incentives Program- www.il.nrcs.usda.gov/programs/whip/index.html