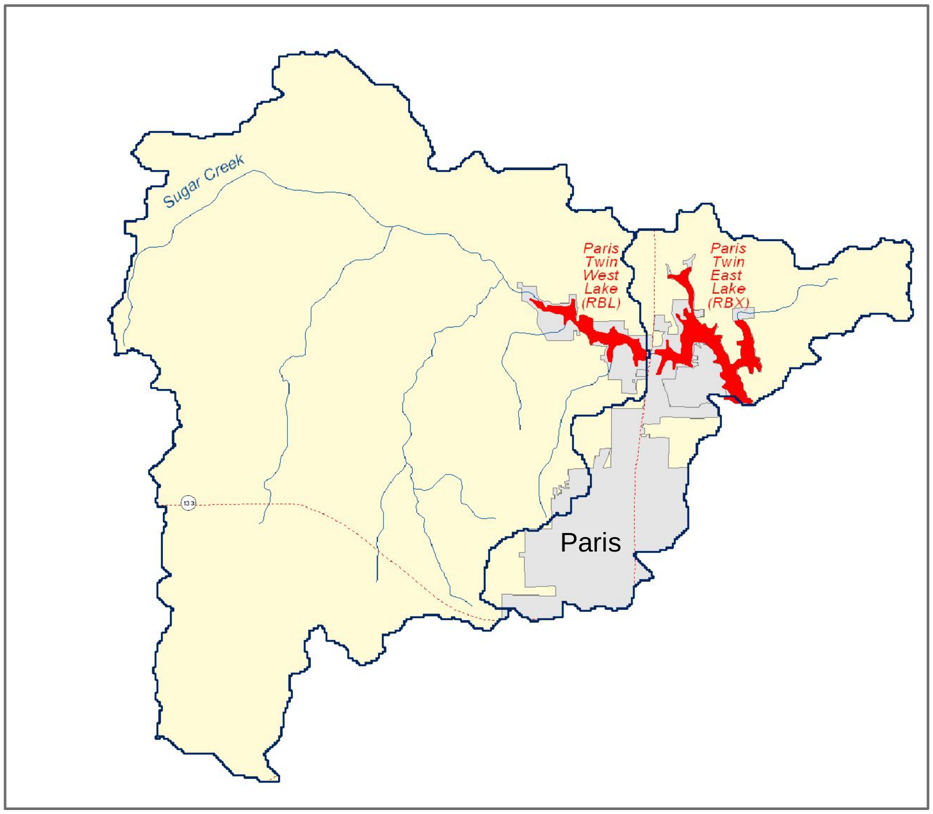
Illinois
Environmental
Protection Agency

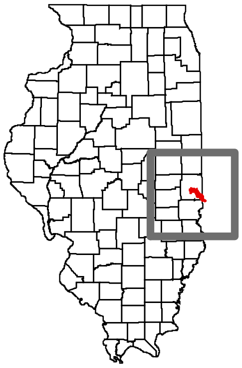
Bureau of Water
P.O. Box 19276
Springfield, IL 62794-9276

June 2008

IEPA/BOW/08-011

PARIS TWIN LAKES WATERSHED TMDL REPORT





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TMDL Development for Paris Twin Lakes, Illinois

This file contains the following documents:

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

2) Stage One Report: Watershed Characterization and Water Quality Data Analysis for Paris Twin Lake and Sugar Creek Watershed

3) Stage Three Report: TMDL Development for Paris Twin Lakes

4) Implementation Plan Report

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

SEP 28 2005

REPLY TO THE ATTENTION OF:

WW-16J

RECEIVED
OCT 17 2005
Watershed Management Section
BUREAU OF WATER

Marcia T. Willhite, Chief
Bureau of Water
Illinois Environmental Protection Agency
1021 North Grand Avenue East
P.O. Box 19276
Springfield, Illinois 62794-9276

Dear Ms. Willhite:

The United States Environmental Protection Agency (U.S. EPA) has conducted a complete review of the final Total Maximum Daily Load (TMDL) including supporting documentation and information for phosphorus, in Paris Twin Lakes, Sugar Creek Watershed, which is located in Edgar and Clark Counties County, Illinois. Based on this review, U.S. EPA has determined that Illinois' TMDLs for phosphorus, which will address total suspended solids, excess algal growth, and phosphorus impairments meets the requirements of Section 303(d) of the Clean Water Act (CWA) and U.S. EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, U.S. EPA hereby approves Illinois' two TMDLs for phosphorus and six impairments in segments ILBM02-RBX and ILBM02-RBXL of the Sugar 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 appreciate your hard work in this area and the submittal of the TMDL as required. If you have any questions, please contact Mr. Kevin Pierard, Chief of the Watersheds and Wetlands Branch at 312-886-4448.

Sincerely yours,

JoLynn Traub

Jo Lynn Traub,
Director, Water Division

Enclosure

cc: Bruce Yurdin, IEPA
Trevor Sample, IEPA

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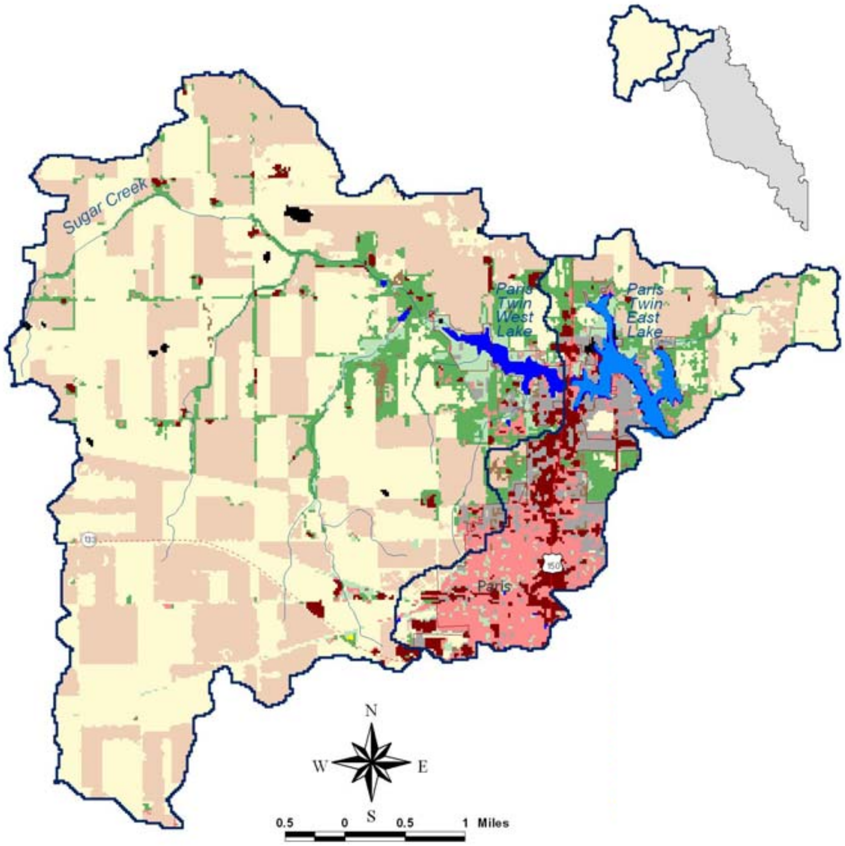
TMDL Development for Paris Twin Lakes

September 8, 2005

Final Report



TMDL Development for Paris Twin Lakes

FINAL REPORT

September 8, 2005

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

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

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Stage One Report: Watershed Characterization and Data Analysis for Sugar Creek and Paris Twin Lakes Watershed

Key Findings

As part of the Section 303(d) listing process, the Illinois Environmental Protection Agency identified four waterbodies in the Sugar Creek watershed as impaired:

- Paris Twin West Lake (segment RBX)
- Paris Twin East Lake (segment RBL)
- Sugar Creek (segment BMC2)
- Sugar Creek (segment BM02)

A comprehensive review of the available water quality data confirmed the Paris Twin West and East Lake total phosphorus (TP) impairments. Stage Two and Stage Three TMDL developmetn for Sugar Creek segments BMC2 and BM02 are availabel in a separate report. The purpose of this report is therefore to present the TMDL analysis for Paris Twin West Lake and East Lake.

Illinois water quality standards require that total phosphorus concentrations within lakes not exceed 0.05 mg/L. Historic sampling within both Paris Twin West Lake and East Lake indicate that this standard is routinely exceeded with TP concentrations averaging 0.12 mg/L in West Lake and 0.10 mg/L East Lake.

Continuous flow and TP data are not available for Sugar Creek upstream of the Paris Twin Lakes. Loads to the lakes were therefore estimated based on data from a comparable watershed and these loads were input to the BATHTUB model to determine the load reductions necessary to meet the 0.05 mg/L water quality standard. The BATHTUB analysis indicated that a 75 percent reduction in loads is necessary to meet the 0.05 mg/L standard during each of the modeled years. The sources of TP were not a focus of the current analysis. An Implementation Plan will be prepared that fully addresses all potential sources and discusses alternatives for achieving the desired load reductions.

1 Introduction

The Sugar Creek watershed (ILBM02) is located in east-central Illinois and trends in a southeasterly direction. The watershed drains approximately 65 square miles within the State of Illinois and an additional 27 square miles lie within the State of Indiana. Within Illinois, most of the watershed is in southeastern Edgar County, and a smaller portion of the basin is located in northeastern Clark County.

The Paris Twin West Lake and Paris Twin East Lake are located within the Sugar Creek watershed. The Twin Lakes were created in 1894 by damming and flooding a portion of Sugar Creek. The lakes have a combined surface area of 222 acres and drain approximately 14,284 acres of primarily agricultural land. Paris West Twin Lake serves as a sedimentation basin to protect East Lake (Bogner, 1992). The Twin Lakes serve as the community drinking water supply for Paris, Illinois. Water is obtained from one surface water intake in the lakes with average pumpage of 1.5 million gallons per day to approximately 4,115 service connections and an estimated population of 8,990 people.

As part of the Section 303(d) listing process, the Illinois Environmental Protection Agency (IEPA) has identified four waterbodies in the ILBM02 watershed as impaired (Table 1-1):

- Paris Twin West Lake (RBX)
- Paris Twin East Lake (RBL)
- Sugar Creek (BMC2)
- Sugar Creek (BM02)

The ILBM02 watershed was ranked high priority for TMDL development. The potential causes of impairment for segments RBX and RBL are phosphorus, total suspended solids (TSS), excessive algal growth/chlorophyll *a*. Dissolved oxygen, sedimentation/siltation, unspecified nutrients, and other flow alterations are the impairments for segment BMC2. Segment BM02 is impaired for pathogens (Illinois EPA, 2002). These impairments result in partial support of primary contact (swimming), secondary contact (recreation), and aquatic life designated uses.

The Clean Water Act and USEPA regulations require that states develop TMDLs for waters on the Section 303(d) lists. Illinois EPA is currently developing TMDLs for pollutants that have numeric water quality standards. Of the pollutants impairing Paris Twin West Lake and Paris Twin East Lake, phosphorus is the only parameter with a water quality standard for lakes. Illinois EPA believes that addressing the phosphorus impairment should lead to an overall improvement in water quality due to the interrelated nature of the other listed pollutants. For example, phosphorus is often attached to the sediment washing into the lake and to reduce phosphorus loads, sediment loads will also have to be reduced. Finally, there is a direct relationship between phosphorus concentrations and excessive algal growth (see Figure 4-12) and reducing loads of phosphorus should result in lower chlorophyll *a* concentrations.

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

- Assess the water quality of the impaired waterbodies and identify key issues associated with the impairments and potential pollutant sources.

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

Table 1-1. 2002 303(d) List Information for the Sugar Creek Watershed (ILBM02)

Segment (Area)	Name	Designated Uses and Support Status	Causes of Impairment	Potential Sources of Impairment
RBX (56.7 acres)	Paris Twin West Lake	Overall Use (Not Assessed), Aquatic Life Support (Partial), Primary Contact /swimming (Partial), Secondary Contact/ recreation (Partial), Fish Consumption (Full), Drinking Water Supply (Full)	Total Phosphorus, Excessive Algal Growth, TSS	Agriculture (crop related sources, non–irrigated crop production), Habitat modification (Streambank Modification/destabilization, Highway Maintenance and Runoff), Waterfowl, Forest/grassland/parkland
RBL (162.8 acres)	Paris Twin East Lake	Overall Use (Full), Aquatic Life Support (Full), Primary Contact /swimming (Partial), Secondary Contact/recreation (Partial), Fish Consumption (Full), Drinking Water Supply (Full)	Total Phosphorus, Excessive Algal Growth, TSS	Agriculture (crop related sources, non–irrigated crop production), Habitat modification (Streambank Modification/destabilization, Highway Maintenance and Runoff), Waterfowl, Forest/grassland/parkland
BMC2 (2.9 miles)	Sugar Creek	Aquatic Life Support (Partial)	Dissolved Oxygen, Sedimentation/ Siltation, Unspecified Nutrients, Other Flow Alterations	Municipal Point Source, Hydrologic/Habitat Modification (flow regulation/modification)
BM02 (12.9 miles)	Sugar Creek	Aquatic Life Support (Full) Primary Contact/Swimming (Partial)	Pathogens	Source Unknown

Source: Illinois EPA, 2002.

The project is being initiated in three stages. Stage One was completed in the Spring of 2005 and involved the characterization of the watershed, an assessment of the available water quality data, and identification of potential technical approaches (see Sections 2 through 4). Stage Two (in progress for the identified segments of Sugar Creek) involves additional data collection. Stage Three involves model development and calibration, TMDL scenarios, and implementation planning. This report documents the Stage 1 and Stage 3 tasks for Paris Twin Lakes. An Implementation Plan will be prepared following EPA approval of this report.

2 Watershed Characteristics

The physical characteristics of the Sugar Creek watershed are described in the following sections. For the purposes of this characterization, the watershed was subdivided into four subwatersheds according to their respective Illinois water body segment identification. These subwatersheds correspond to the upstream contributing areas of Paris Twin West Lake (RBX), Paris Twin East Lake (RBL), Sugar Creek (BMC2), and Sugar Creek (BM02). The subwatersheds were defined using digital elevation data, and the delineation process is discussed in section 3.2.3. This type of watershed subdivision allows for a more pertinent discussion of land use and soils information for each of the water body segments.

2.1 Location

The Sugar Creek watershed (Figure 2-1) is located in east-central Illinois, trends in a southeasterly direction, and drains approximately 42,041 acres within the State of Illinois. An additional 17,196 acres lie within the State of Indiana. Approximately 41,443 acres lie in southeastern Edgar County. A smaller portion of the watershed, approximately 598 acres, is located in northeastern Clark County.

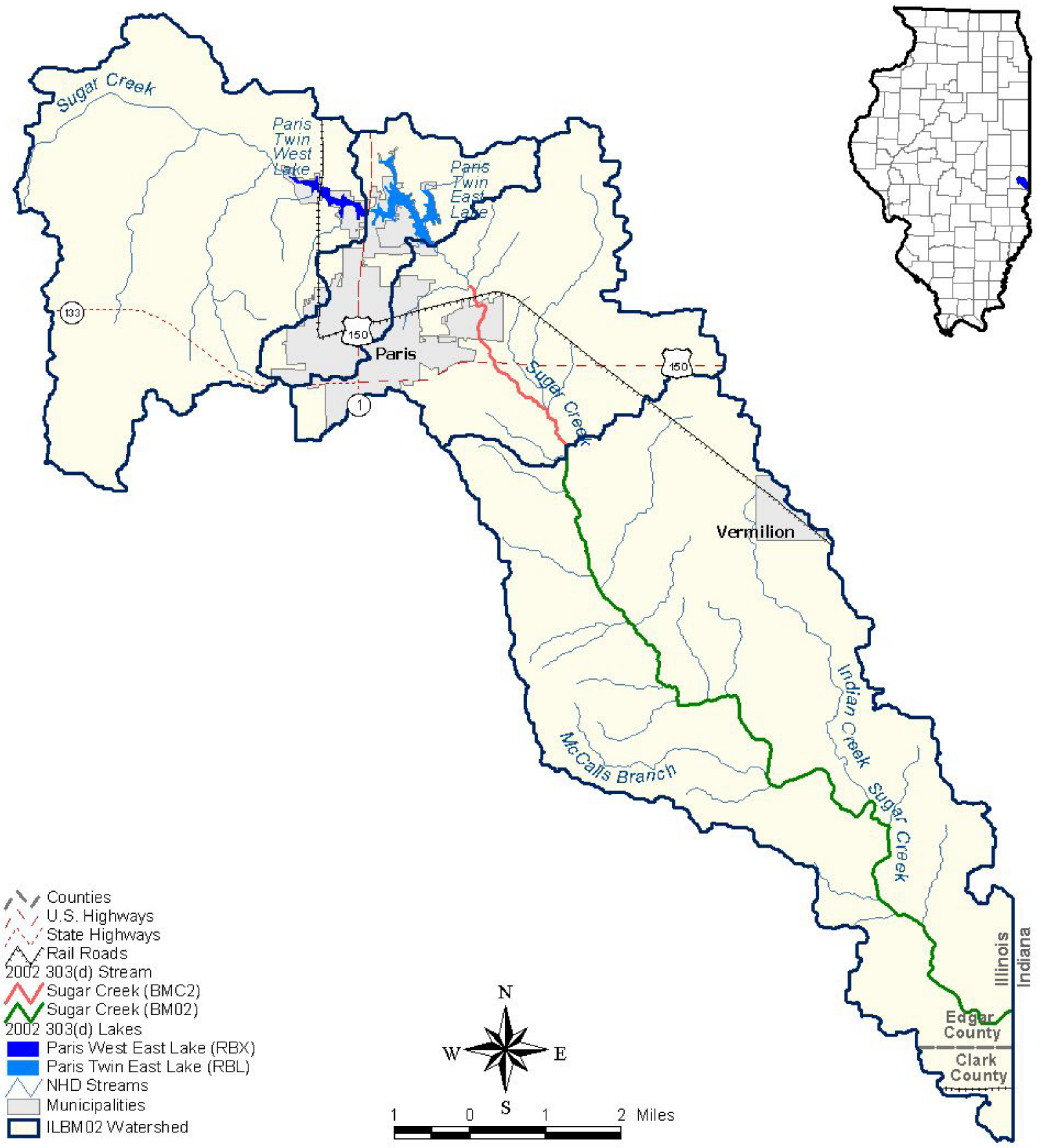

Figure 2-1. Location of the Sugar Creek watershed.

2.2 Topography

Topography is an important factor in watershed management because stream types, precipitation, and soil types can vary dramatically by elevation. Digital elevation models (DEM) containing 30-meter grid resolution elevation data are available from the USGS for each 1:24,000-topographic quadrangle in the

United States. Elevation in the Sugar Creek watershed ranges from 755 feet above sea level in the headwaters to 511 feet at the most downstream point of the segment (Figure 2-2). The absolute elevation change is 186 feet over the 25.2-mile stream length of Sugar Creek, which yields a stream gradient of 7.5 feet per mile.

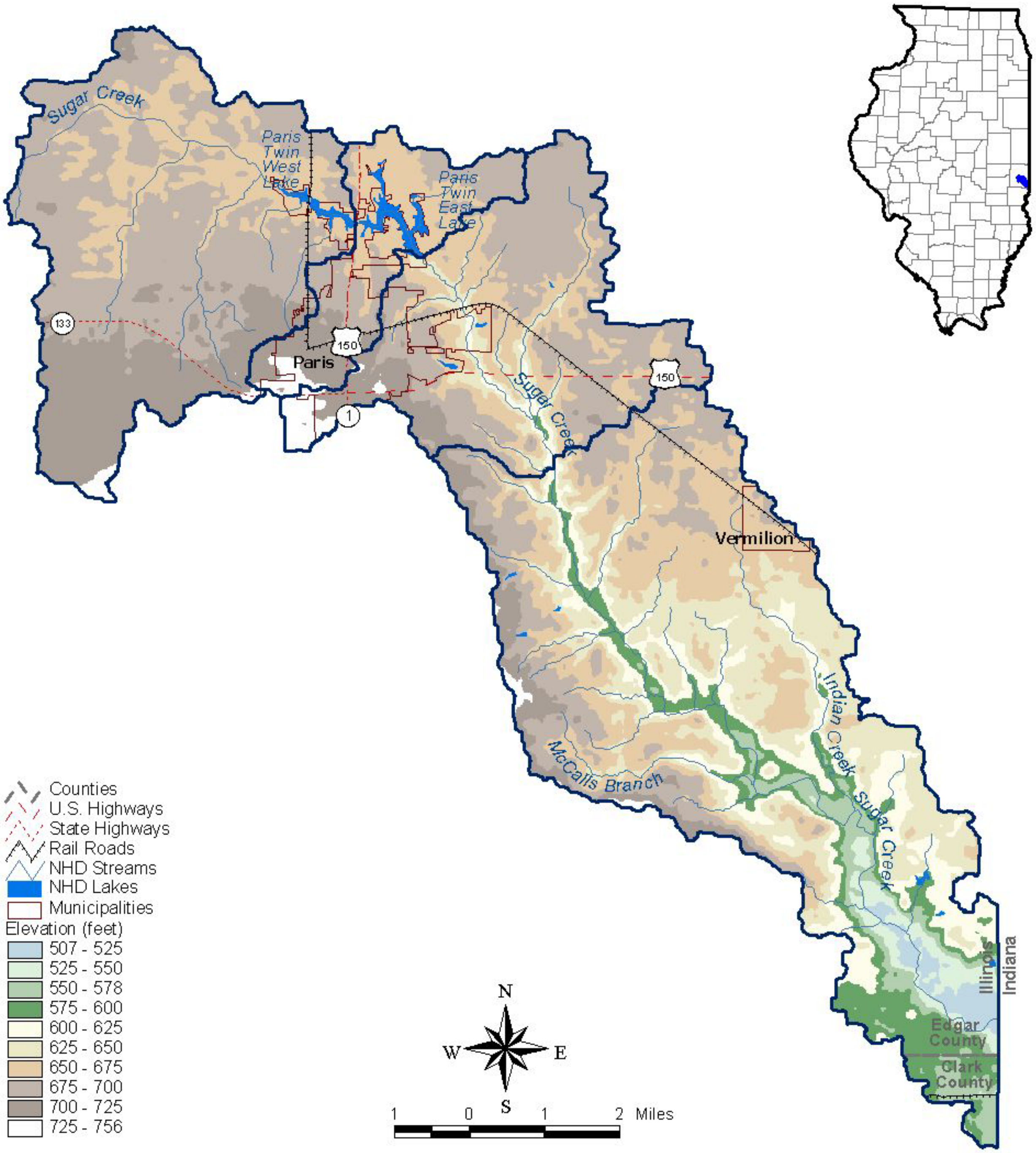

Figure 2-2. Elevation in the Sugar Creek watershed.

2.3 Land Use and Land Cover

General land cover data for the Sugar Creek watershed were extracted from the Illinois Natural History Survey's GAP Analysis Land cover database (INHS, 2003). This database was derived from satellite imagery taken during 1999 and 2000 and is the most current detailed land cover data known to be available. Each 98-foot by 98-foot pixel contained within the satellite image is classified according to its reflective characteristics. Figure 2-3 displays land use and land cover in the Sugar Creek watershed. A complete listing of the Illinois GAP land cover categories is given in Table A-1 in Appendix A.

The land cover data reveal that approximately 29,276 acres, representing nearly 70 percent of the total watershed area, are devoted to agricultural activities. Approximately 21 percent of the watershed is forested, and nearly seven percent is devoted to urban land uses. Tillage system practices are not available specifically for the Sugar Creek watershed, however, county-wide tillage system surveys have been undertaken by the Illinois Department of Agriculture (2000; 2002). It is assumed that the general tillage practice trends evidenced throughout the county are applicable to the Sugar Creek watershed. The results of these surveys for Edgar County are presented in Table 2-1. The table shows that the percentage of surveyed cornfields employing conventional tillage in Edgar County decreased from 2000 to 2002, and that no-till practices dramatically increased during the same time frame. For soybean production within the county, conventional tillage practices increased while conservation tillage practices remained roughly the same from 2000 to 2002. In 2002, all small grain production involved reduced-till practices through the county.

Table 2-1. Percentage of Agricultural Fields Surveyed with Indicated Tillage System in Edgar County, Illinois, in 2000 and 2002.

2000 Transect Survey				
	Tillage Practice			
Crop Field Type	**Conventional**	**Reduced-till**	**Mulch-till**	**No-till**
Corn	70	12	6	12
Soybean	13	21	19	48
Small Grain	0	0	0	0
2002 Transect Survey				
	Tillage Practice			
Crop Field Type	**Conventional**	**Reduced-till**	**Mulch-till**	**No-till**
Corn	59	9	2	30
Soybean	21	24	10	45
Small Grain	0	100	0	0

Source: Illinois Dept. of Agriculture, 2000; 2002.

In the following sections, land use and land cover are described and summarized for each of the listed water bodies, and their respective subwatershed areas.

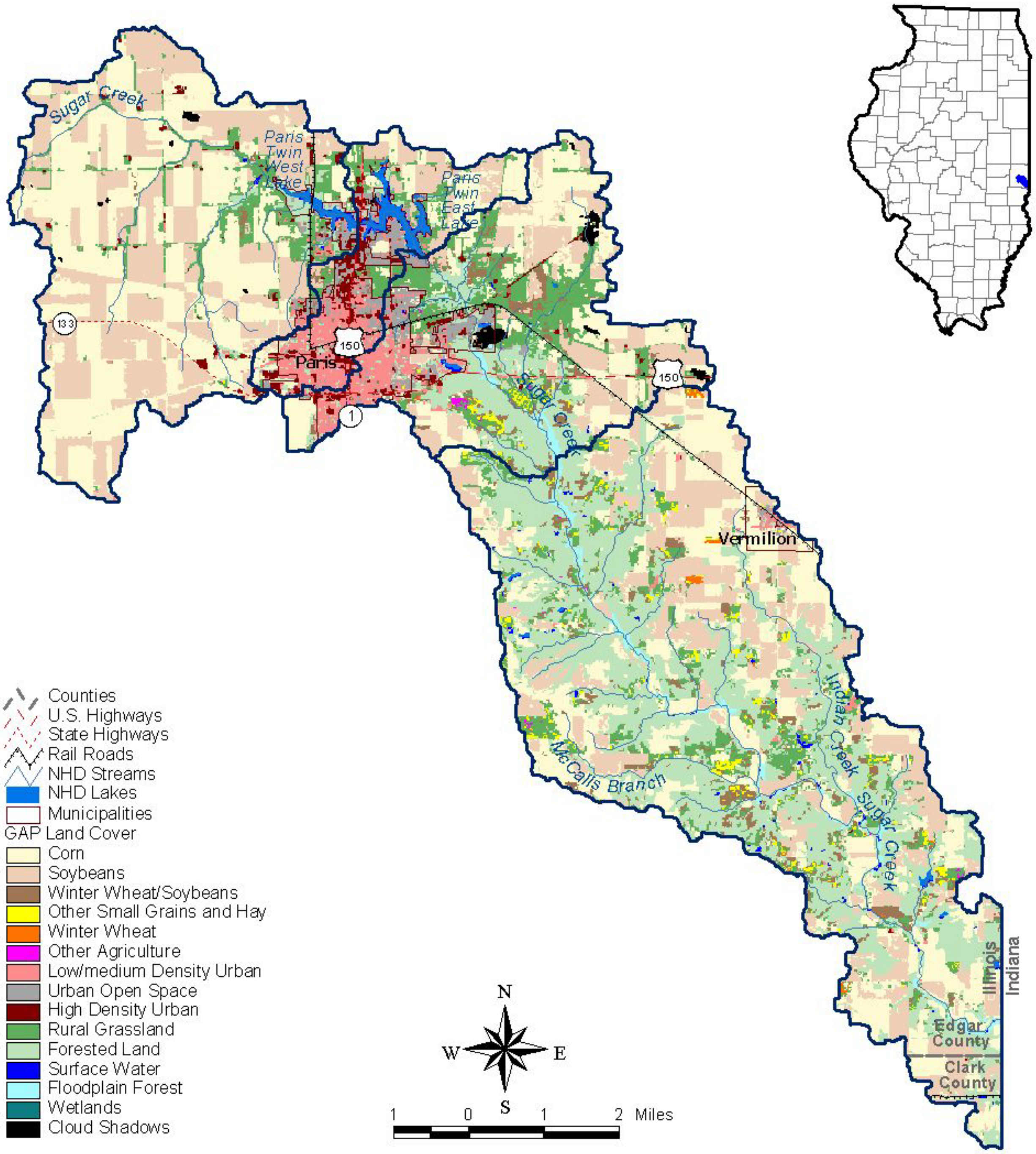

Figure 2-3. GAP land use/land cover in the Sugar Creek watershed.

2.3.1 Paris Twin West Lake (Illinois Water Body Segment RBX)

Land use and land cover in the Paris Twin West Lake subwatershed is summarized in Table 2-2. The table shows that agricultural land uses account for 10,585 acres, representing nearly 94 percent of the subwatershed area. Corn and soybeans dominate land cover, accounting for 47 and 39 percent of subwatershed area, respectively. Rural grassland, urban land uses, and forested lands represent seven, three, and two percent of the subwatershed area, respectively. All other cover types represent less that one percent of the subwatershed area.

Table 2-2. Land Use and Land Cover in the Paris Twin West Lake Subwatershed

Land Use / Land Cover Description	Area		Percent of Watershed Area
	Acres	Square Miles	
Corn	5,310.8	8.3	47.1
Soybeans	4,398.5	6.9	39.0
Rural Grassland	828.6	1.3	7.3
Urban	347.2	0.5	3.1
Forested	231.5	0.4	2.1
Water	83.6	0.1	0.7
Winter Wheat/Soybeans	46.0	0.1	0.4
Other	34.0	0.1	0.3
Other Small Grains And Hay	1.1	<0.1	0.0
Wetland	0.4	<0.1	0.0
Total	**11,281.7**	**17.7**	**100.0**

2.3.2 Paris Twin East Lake (Illinois Water Body Segment RBL)

Agricultural land use is the dominant land use type in the Paris Twin East Lake subwatershed and accounts for 84 percent (12,044 acres) of the total subwatershed area. As shown in Table 2-3, corn and soybeans are the dominant crops, representing 41 percent and 34 percent, respectively, of all subwatershed land use and land cover types. Approximately 1,592 acres are devoted to urban land uses, representing slightly over 11 percent of the subwatershed area. Rural grassland, forested lands and surface water represent approximately 8 percent, 2.5 percent and 1.8 percent, respectively, of the subwatershed area. Other land cover types represent less than one percent of the subwatershed area.

Table 2-3. Land Use and Land Cover in the Paris Twin East Lake Subwatershed

Land Use / Land Cover Description	Watershed Area		Percent of Watershed Area
	Acres	Square Miles	
Corn	5,899.2	9.2	41.3
Soybeans	4,880.4	7.6	34.1
Urban	1,592.3	2.5	11.1
Rural Grassland	1,170.9	1.8	8.2
Forested	353.2	0.6	2.5
Water	254.2	0.4	1.8
Winter Wheat/Soybeans	92.7	0.1	0.6
Other	48.7	0.1	0.3
Other Small Grains And Hay	1.1	0.0	0.1
Wetland	0.9	0.0	0.0
Total	**14,293.6**	**22.3**	**100.0**

2.3.3 Upper Sugar Creek (Illinois Water Body Segment BMC2)

Of the 21,932 acres draining the upper Sugar Creek subwatershed, 14,565 acres, slightly greater than 66 percent of the subwatershed area, is dedicated to agricultural activities. The dominant crop types are corn and soybeans (see Table 2-4), which represent 35 percent and 29 percent of the total subwatershed acreage, respectively. Urban lands account for 12 percent of the subwatershed area, while rural grassland, forested land uses, and winter wheat/soybeans account for approximately 11 percent, 8 percent, and 2 percent of the subwatershed area, respectively.

Table 2-4. Land Use and Land Cover in the Upper Sugar Creek Subwatershed

Land Use / Land Cover Description	Watershed Area		Percent of Watershed Area
	Acres	Square Miles	
Corn	7,763.6	12.1	35.40
Soy	6,259.7	9.8	28.54
Urban	2,665.4	4.2	12.15
Rural Grassland	2,496.4	3.9	11.38
Forested	1,721.1	2.7	7.85
Winter Wheat/Soybeans	456.1	0.7	2.08
Surface Water	278.4	0.4	1.27
Other	188.1	0.3	0.86
Other Small Grains and Hay	68.5	0.1	0.31
Wetlands	17.3	0.0	0.08
Other Agriculture	15.6	0.0	0.07
Winter Wheat	1.8	0.0	0.01
Total	21,932.0	34.2	100.00

2.3.4 Lower Sugar Creek (Illinois Water Body Segment BM02)

The lower Sugar Creek subwatershed represents the entire Sugar Creek watershed within Illinois, and drains approximately 42,041 acres (Table 2-5). Of this area, approximately 29,276 acres is dedicated to agricultural land use, representing nearly 70 percent of the total watershed area. Corn and soybean are the dominant crop types, accounting for 31 percent and 25 percent, respectively, of all land use and land cover within the watershed. Forested lands account for slightly more than 21 percent of the watershed area, while rural grassland, urban land uses, and winter wheat account for approximately 10 percent, 7 percent, and 3 percent of the watershed area.

Table 2-5. Land Use and Land Cover in the Lower Sugar Creek Subwatershed within Illinois

Land Use / Land Cover Description	Watershed Area		Percent of Watershed Area
	Acres	Square Miles	
Corn	13,093.9	20.5	31.1
Soybeans	10,503.7	16.4	25.0
Forested	9,058.6	14.2	21.5
Rural Grassland	4,084.7	6.4	9.7
Urban	2,783.3	4.3	6.6
Winter Wheat/Soybeans	1,198.7	1.9	2.9
Water	366.7	0.6	0.9
Wetland	366.7	0.6	0.9
Other Small Grains And Hay	323.8	0.5	0.8
Other	190.1	0.3	0.5
Winter Wheat	44.9	0.1	0.1
Other Agriculture	25.8	0.0	0.1
Total	**42,040.9**	**65.7**	**100.0**

2.4 Soils

Soils data and GIS coverages from the Natural Resources Conservation Service (NRCS) were used to characterize soils in the Sugar Creek watershed. General soils data and map unit delineations for the country are provided as part of the State Soil Geographic (STATSGO) database. GIS coverages provide locations for the soil map units at a scale of 1:250,000 (USDA, 1995). A map unit is composed of several soil series having similar properties. It should be noted that map units can be highly variable and the following maps are meant as general representations. Figure 2-4 displays the STATSGO soil map units in the Sugar Creek watershed. Identification fields in the GIS coverage can be linked to a database that provides information on chemical and physical soil characteristics for each map unit. Of particular interest for water resource studies are the hydrologic soil group, the K-factor of the Universal Soil Loss Equation, and depth to water table. The following sections describe and summarize the specified soil characteristics for each of the listed water bodies, and their respective subbasins, in the Sugar Creek watershed.

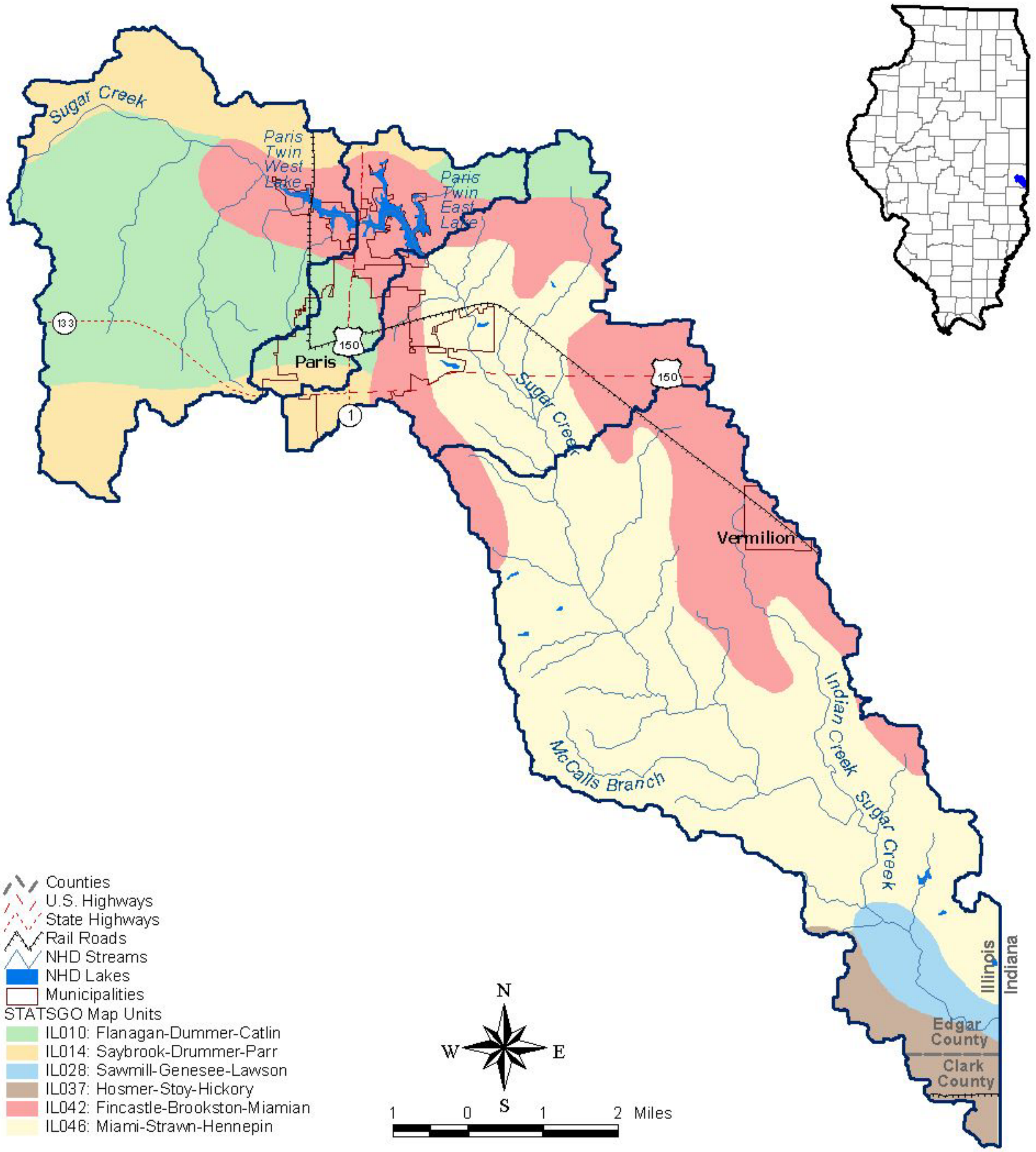

Figure 2-4. Distribution of STATSGO Map Units in the Sugar Creek watershed.

2.4.1 Hydrologic Soil Group

The hydrologic soil group classification is a means for grouping soils by similar infiltration and runoff characteristics during periods of prolonged wetting. Typically, clay soils that are poorly drained have lower infiltration rates, while well-drained sandy soils have the greatest infiltration rates. NRCS (2001) has defined four hydrologic groups for soils as listed in Table 2-6. In addition, soils with tile drainage in Illinois should be designated as Class B soils (i.e., due to the presence of tile drainage the soil takes on the attribute of a Class B soil ((McKenna, personal communications, December 15, 2004)). Figure 2-5 presents the general distribution of hydrologic soil groups in the Sugar Creek watershed. The figure shows the dominant hydrologic groups in the basin are B and C. Hydrologic soil group B composes soils in the lower and middle reaches of the basin, which includes Sugar Creek below Paris Twin East Lake. The headwaters region also contains soils classified as hydrologic soil group B. Hydrologic group C accounts for soils in the areas adjacent to Paris Twin East Lake and Paris Twin West Lake as well as areas near Vermilion village and the Clark County line.

Table 2-6. NRCS Hydrologic Soil Groups

Hydrologic Soil Group	Description
A	Soils with high infiltrations rates. Usually deep, well drained sands or gravels. Little runoff.
B	Soils with moderate infiltration rates. Usually moderately deep, moderately well drained soils.
C	Soils with slow infiltration rates. Soils with finer textures and slow water movement.
D	Soils with very slow infiltration rates. Soils with high clay content and poor drainage. High amounts of runoff.

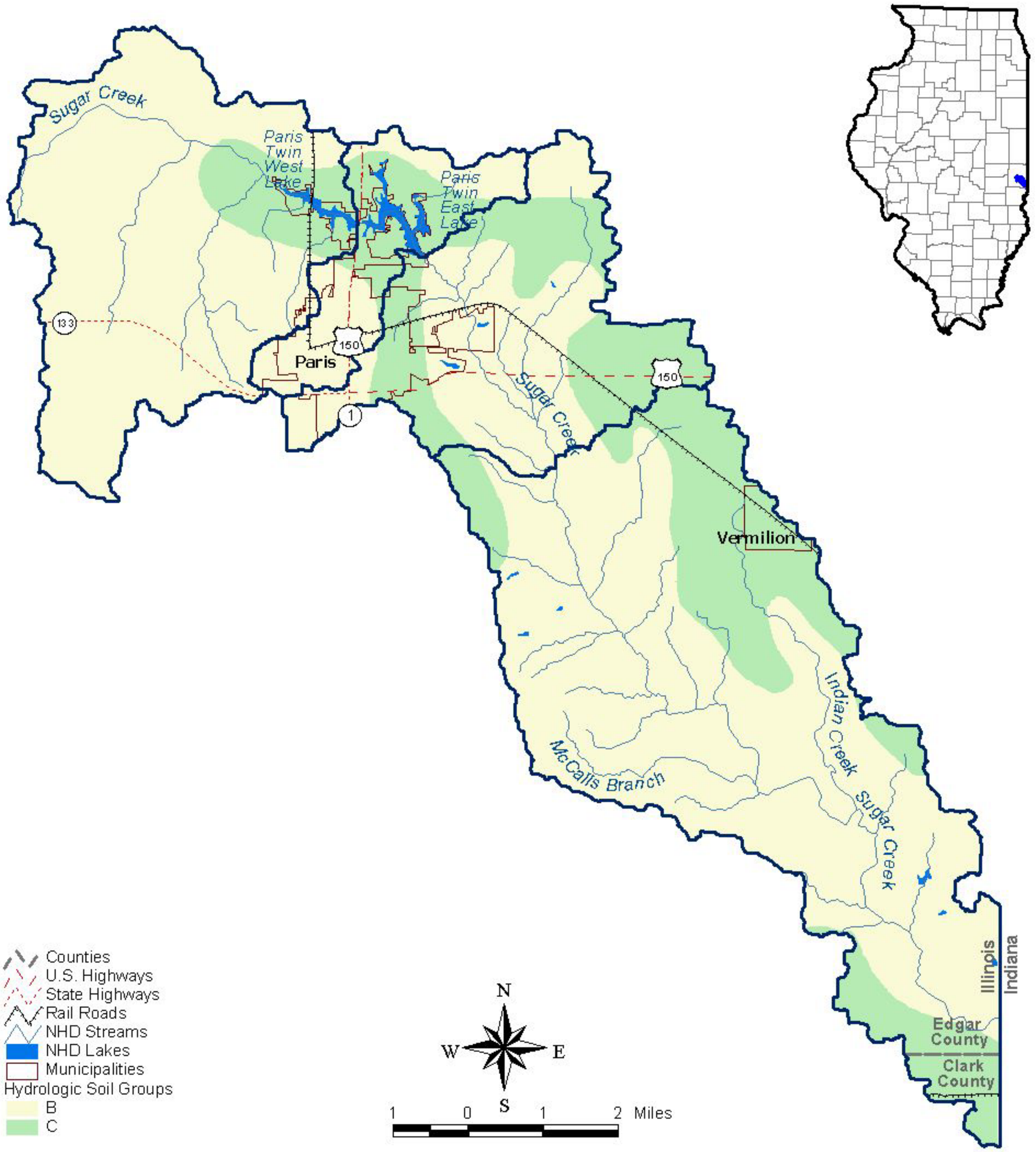

Figure 2-5. Hydrologic soil group distribution in the Sugar Creek watershed.

2.4.2 K-Factor

A commonly used soil attribute is the K-factor, a component of the USLE (Wischmeier and Smith, 1978). The K-factor is a dimensionless measure of a soil's natural susceptibility to erosion, and factor values may range from 0 for water surfaces, to 1.00 (although in practice, maximum factor values do not generally exceed 0.67). Large K-factor values reflect greater inherent soil erodibility. The distribution of K-factor values in the Sugar Creek watershed is shown in Figure 2-6. The figure indicates that soils with moderate erosion potential (e.g. K-factors that range in value from 0.20 to 0.37) are widely distributed throughout the watershed, and comprise approximately 66.83 percent of the soils in the basin. The figure also shows that only a small area contains soils where K-factor values exceed 0.37, suggesting that inherent erodibility does not exceed the moderate classification in the majority of the basin. Interestingly, low and low-to-moderate K-factor values share equal proportions of the watershed, each occupying approximately 16 percent of the watersheds soils. These low erosion susceptibility areas occur throughout the watershed and are typically associated with sandy soils with high infiltration rates.

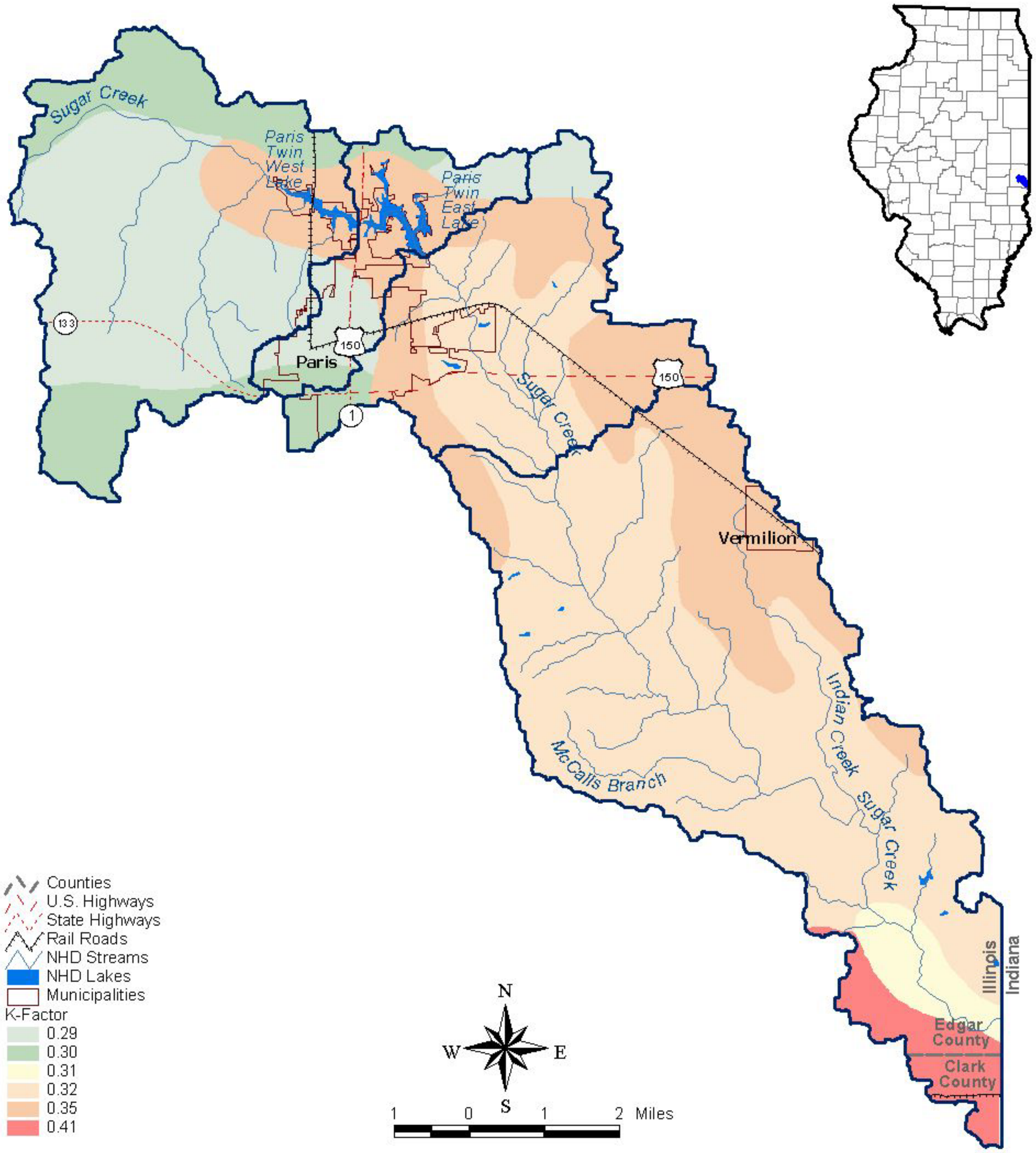

Figure 2-6. USLE K-Factor distribution in the Sugar Creek watershed.

2.4.3 Depth to Water Table

Water table depth as described in the STATSGO database is the range in depth to the seasonally high water table level for a specified month. The STATSGO database reports depth to water table as both a minimum and maximum depth. Values were summarized to reflect the weighted sum of the minimum depth to water table for the surface layer of all soil sequences composing a single STATSGO map unit. Figure 2-7 displays the distribution of depth to water table for the basin and shows that depths range from 1.0 foot to 5.0 feet. Minimum depths occur along the northwest margin of the watershed and maximum depths occur along the middle reaches of Sugar Creek.

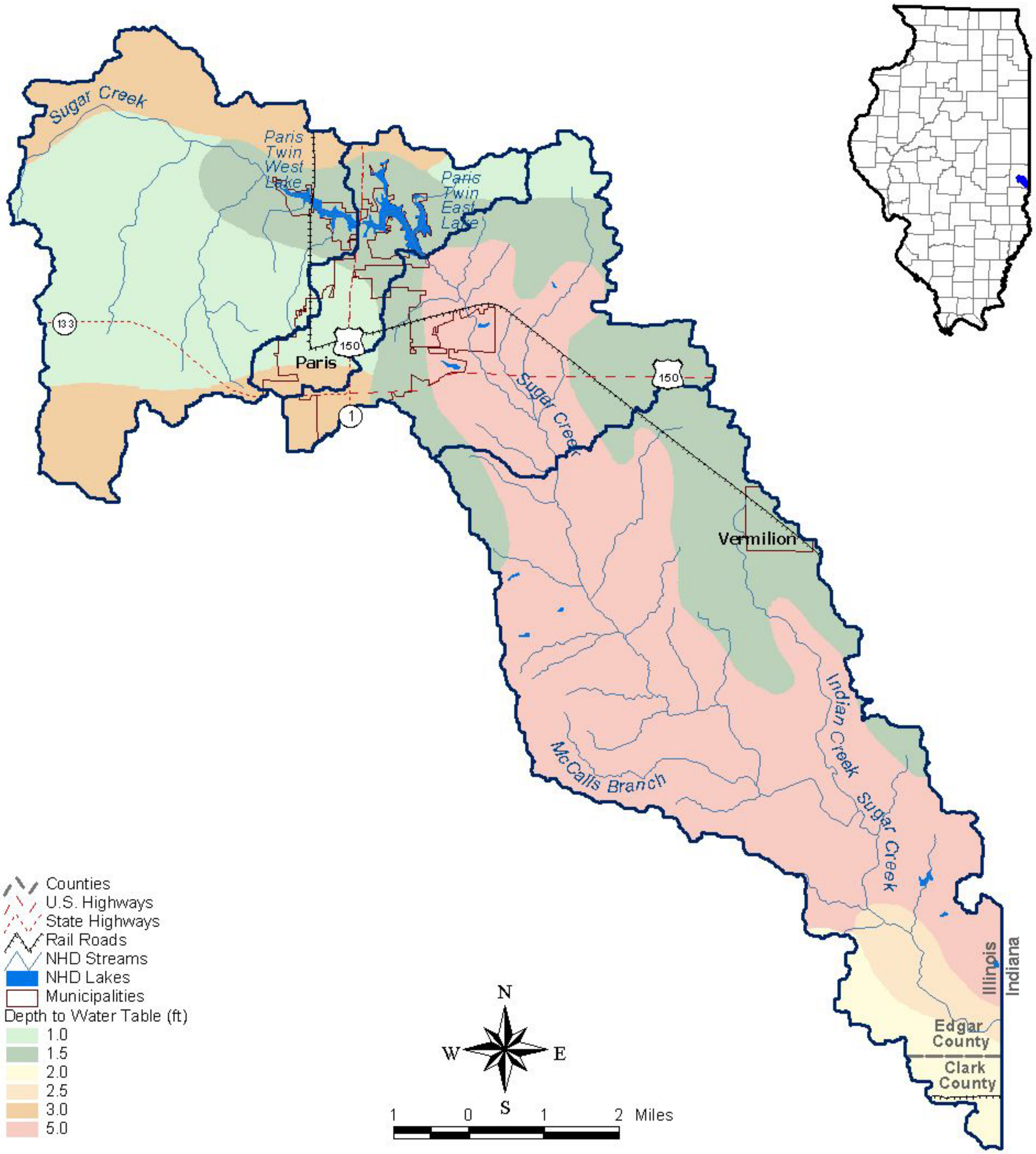

Figure 2-7. Depth to water table in the Sugar Creek watershed

2.5 Population

Total watershed population is not directly available but may be calculated from the 2000 U.S. Census data. The 2000 U.S. Census data were downloaded for all towns, cities, and counties whose boundaries lie wholly or partially in the watershed (Census, 2000). Urban and nonurban populations were estimated for the watershed area and were summed to obtain an estimate of total watershed population. The following paragraphs describe how urban and nonurban population estimates were determined from town, city, and county Census data.

Urban watershed population is the sum of population for all towns and cities located entirely in the watershed. In the instance where a city or town is located partially in the watershed, a population weighting method was used to estimate a place's contribution to urban watershed population. First, the proportion of the place's area in the watershed was determined using spatial overlay of the town and city boundaries with the watershed boundary in a geographic information system (GIS). Assuming an even distribution of population throughout each place, the city and town populations were multiplied by the proportion of the place encompassed by the watershed. The product was assumed to reflect an urban area's contribution to total watershed population. Finally, contributing population for each place was summed to obtain total urban watershed population.

Nonurban watershed population is defined as the portion of watershed population excluding urban population. Nonurban population for each county was determined by first subtracting the total county urban population from the total county population. Some cities and towns are not entirely included in a single county and their contribution to total county urban population was estimated using the same method described in the previous paragraph. Since only portions of counties are found in the watershed, a nonurban population weighting method was also used to estimate each county's contribution of nonurban population to the total watershed population. The proportion of county to watershed nonurban area was determined from spatial overlay of county boundaries and the watershed boundary in a GIS. Nonurban area for each county and watershed were calculated by subtracting the total urban area from the total area, respectively. It is assumed that the nonurban population for each county is uniformly distributed throughout the nonurban portion of the county. The nonurban county population was multiplied by the county's nonurban proportional watershed area and the product was assumed to reflect the county's contribution to the nonurban watershed population.

2.5.1 Watershed Population

Watershed population is summarized in Table 2-7 for the ILBM02 watershed. Approximately 9,202 people reside in the ILBM02 watershed. The watershed's urban and nonurban population totals are given for each county in Table 2-7. Figure 2-1 displays the locations of counties, cities, and towns. Table 2-7 indicates that 717 people, or 7.79 percent of the population, live in nonurban areas, while 8,486 people (92.21 percent) reside in urban areas.

Table 2-7. ILBM02 Watershed Population Summarized by County

County	Watershed Population	Percent Watershed Population [a]	Nonurban Population	Percent Nonurban Population [a]	Urban Population	Percent Urban Population [a]
Edgar County	9,187	99.83	701	7.62	8,486	92.21
Clark County	16	0.17	16	0.17	0	0.00
Total	**9,202**	**100.00**	**717**	**7.79**	**8,486**	**92.21**

[a] Percentages are a proportion of the total watershed population.
Source: U.S. 2000 Census and GIS analysis.

The urban population centers in the ILBMC2 watershed are shown in Figure 2-1 and Table 2-8.
The city of Paris is the only urban population center in the BMC2 watershed and contributes 8,336 people to total watershed population. There are no urban population centers contributing to urban population in Clark County.

Table 2-8. Urban Population Centers in the ILBM02 Watershed

Waterbody Segment/ County	Municipality	Total Urban Population
Edgar County	City of Paris	8,336
	Village of Vermilion	150
Clark County	NA	NA
	Total	**8,486**

Source: U.S. 2000 Census and GIS analysis.

2.5.2 Population Growth

Table 2-9 demonstrates population change, calculated for the ten-year period between 1990 and 2000, for nonurban and urban populations in the Sugar Creek watershed. The population remained fairly stable during this period.

Table 2-9. Population Change in the Sugar Creek Watershed

County	Municipality	1990 Population	2000 Population	Absolute Change	Percent Change
Edgar County	Nonurban	705	701	-4	-0.57
	City of Paris	8,253	8,336	83	1.00
	Village of Vermilion	177	150	-27	-18.00
Clark County	Nonurban	14	16	2	12.50
	Total	**9,149**	**9,202**	**53**	**0.58**

3 Climate and Hydrology

3.1 Climate

East central Illinois has a temperate climate with hot summers and cold, snowy winters. Average annual precipitation is 41.6 inches. On average there are 124 days with at least 0.01 inches of precipitation. Annual average snowfall is 28.5 inches. Monthly variation of total precipitation, snowfall, and temperature is presented for the Paris Waterworks (Cooperative ID 116610) in Figure 3-1. The figure shows that although precipitation occurs throughout the year, April through August are the months with the most precipitation per month. Much of the annual snowfall occurs in the months of December through February, with the greatest snowfalls occurring in January.

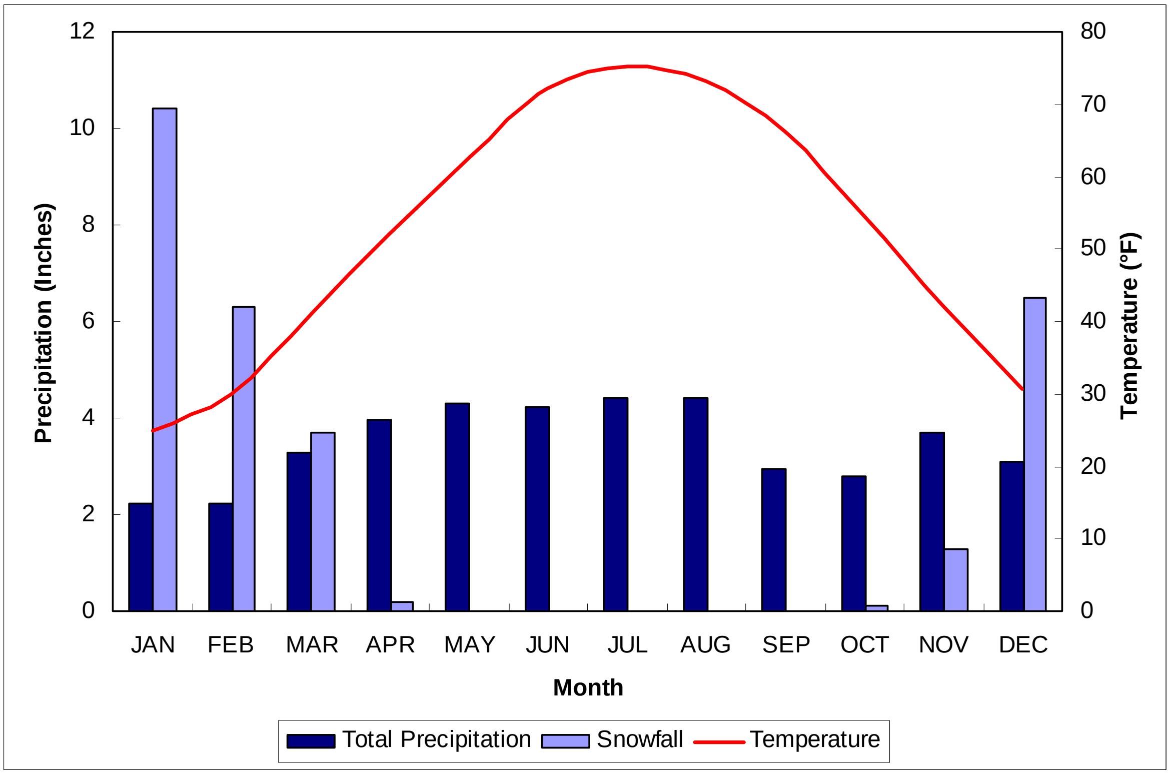

Figure 3-1. Climate summary for the Paris Waterworks station (116610).

3.2 Hydrology

This section presents information related to the general hydrology, streams types, and subbasins found within the Sugar Creek watershed.

3.2.1 Reservoir Hydrology

Two reservoirs, West Lake and East Lake, are located on Sugar Creek. West Lake, built in 1894 has a surface area of 62 acres with an average depth of 3.3 feet. West Lake was supplemented with East Lake, which was built in 1917 and expanded to its present configuration in 1960 following a dam failure in 1957. East Lake has a surface area of 162.8 acres and an average depth of 10.2 feet.

The reservoirs are owned by the City of Paris, Illinois, and serve as the water supply for the City. The lakes also provide recreational opportunities such as fishing, boating, and swimming. An earthen embankment and a dam divide West Lake from East Lake. Consequently, the West Lake has acted as a sedimentation basin, allowing considerable amounts of sediment to accumulate.

Groundwater exchange between the lake and underlying materials is difficult to calculate. However, given the relatively slow soil infiltration rates and very flat topography, it can be assumed that groundwater flow is not an important component in the overall hydrologic budget of the lakes. In a previous study (Illinois EPA, 1992) groundwater inflows and outflow were calculated and the average difference between the two was found to be 3.8 percent of total outflows. Additionally, the study concluded that the greatest amount of groundwater inflow to the lakes occurred during May and June, and the greatest amount of groundwater outflow occurred during November and January.

3.2.2 Stream Types

The National Hydrography Data (NHD) provided by USEPA and USGS identified three different stream types in the Sugar Creek Basin (Figure 3-2) (NHD, 2003). Most streams were classified as intermittent streams (Table 3-1). Intermittent streams have flow only for short periods during the course of a year, which is usually initiated by rainfall. Artificial paths are the NHD line features in the basin that designate the location of a lake.

Table 3-1. Summary of Stream Type in the Sugar Creek Basin

Stream Type	Stream Length (m)	Percent
Intermittent Streams	90,691.5	69.49
Perennial Streams	33,821.5	25.92
Artificial Paths	5,991.7	4.59
Total	**130,504.6**	**100.00**

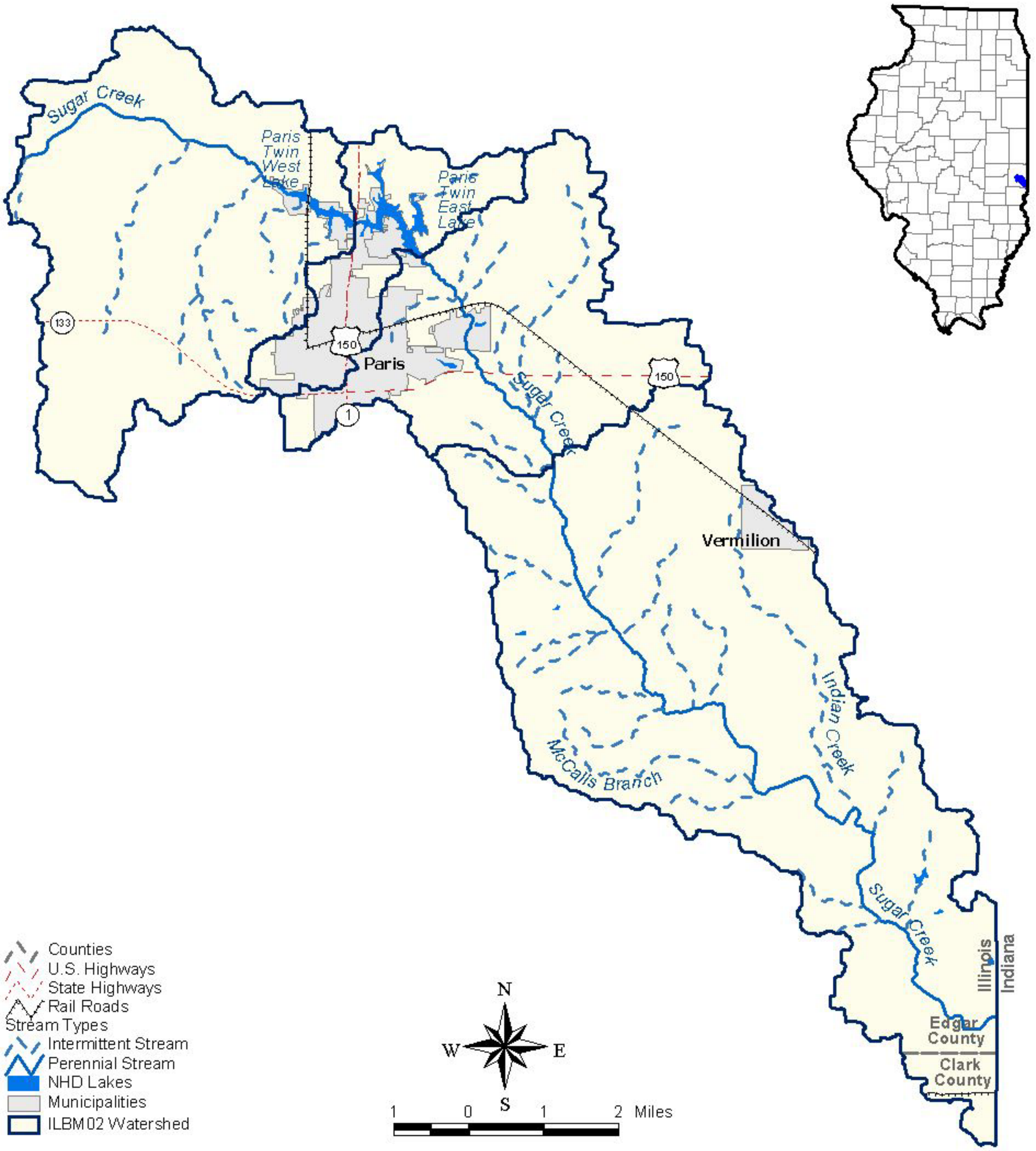

Figure 3-2. Stream types in the Sugar Creek watershed.

3.2.3 Subbasin Delineation

Subbasins were delineated using the ArcView interface for the Soil Water Assessment Tool (SWAT) model. The interface requires digital elevation data (DEM) covering the entire area of the Sugar Creek watershed. Thirty-meter DEM data, representing 7.5 minute U.S. Geological Survey (USGS) quadrangle maps, were downloaded from the GEOCommunity <www.geocomm.com> web site. Subbasin delineation is based on the DEM data coupled with a "burn-in" of the National Hydrography Data set (NHD) spatial database of stream reaches. This approach ensures that the subbasin boundaries conform to topographic characteristics while requiring that catalogued stream segments connect in the proper order and direction. The delineated subbasins, shown in Figure 2-1 and later watershed figures, conform very well to the drainage divides given by the Illinois 12-digit Hydrologic Unit Codes. These subbasins will be useful for implementation planning.

3.2.4 Tile Drainage

The watershed is extensively underlain by drain tile designed to remove standing water from the soil surface. Tile drainage affects the water table by reducing the volume of water entering the soil profile. This type of drainage includes land leveling and smoothing; the construction of surface water inlets to subsurface drains; and the construction of shallow ditches and grass waterways, which empty into open ditches and streams. Subsurface drainage is designed to remove excess water from the soil profile. The water table level is controlled through a series of drainage pipes (tile or tubing) that are installed below the soil surface, usually just below the root zone. In Illinois, subsurface drainage pipes are typically installed at a depth of 3 to 4 feet and at a spacing of 80 to 120 feet. The subsurface drainage network generally outlets to an open ditch or stream.

Researchers at the University of Illinois and elsewhere have studied the impact of tile drainage on hydrology and water quality. Some impacts are relatively well understood while others are not. Zucker and Brown (1998) provided the following summary of the impacts (statements compare agricultural land with subsurface drainage to that without subsurface drainage):

- The percentage of rain that falls on a site with subsurface drainage and leaves the site through the subsurface drainage system can range up to 63 percent.
- The reduction in the total runoff that leaves the site as overland flow ranges from 29 to 65 percent.
- The reduction in the peak runoff rate ranges from 15 to 30 percent.
- Total discharge (total of runoff and subsurface drainage) is similar to flows on land without subsurface drainage, if flows are considered over a sufficient period of time before, during, and after the rainfall/runoff event.
- The reduction in sediment loss by water erosion from a site ranges between 16 to 65 percent. This reduction relates to the reduction in total runoff and peak runoff rate.
- The reduction in loss of phosphorus ranges up to 45 percent, and is related to the reductions in total runoff, peak runoff rate, and soil loss. However, in high phosphorus content soils, dissolved phosphorus levels in tile flow can be high.
- In terms of total nutrient loss, by reducing runoff volume and peak runoff rate, the reduction in soil-bound nutrients is 30 to 50 percent.
- In terms of total nitrogen losses (sum of all N species), there is a reduction. However, nitrate-N, a soluble nitrogen ion, has great potential to move wherever water moves. Numerous studies throughout the Midwest and southeast U.S., and Canada document that the presence of a subsurface drainage system enhances the movement of nitrate-N to surface waters. Proper management of drainage waters along with selected in-field BMPs helps reduce this potential loss.

3.2.5 Flow Data

There are no USGS stream flow monitoring stations within the watershed. No other sources of continuous stream flow data have been identified.

4 Inventory and Assessment of Water Quality Data

This section presents the 2002 303(d) list information for all listed waterbodies in the ILBM02 watershed. A description of the parameters of concern and the applicable water quality standards is presented. Additionally, an analysis of the available water quality (or other watershed monitoring) data to confirm the impairment and a summary of existing water quality conditions is provided. A complete listing of the water quality data is provided in Appendix B.

4.1 Illinois 303(d) List Status

The Illinois 2002 303(d) list for the ILBM02 watershed is given in Table 1-1. The table shows that Paris Twin West Lake and Paris Twin East Lake are listed for impairments related to nutrients. Sugar Creek is listed for impairments related to dissolved oxygen and fecal coliform.

4.2 Previous Studies

Previous study in the Sugar Creek watershed has focused on water quality in the Paris Twin Lakes.
The Illinois State Water Survey conducted a sedimentation survey of Paris West Twin Lake in the early 1990s (Bogner, 1992). The study found that sedimentation had reduced the original lake storage capacity by 53 percent, which in turn had reduced the sediment trap efficiency of the lake from the designed efficiency of 77 percent to 63 percent. The study recommended that in-lake rehabilitation programs, such as dredging and improved wetland vegetation to enhance sediment filtering, be implemented to improve general water quality in the lake.

A Phase I Diagnostic and Rehabilitation Feasibility study (Illinois EPA, 1992) of the Twin Lakes was completed under the USEPA Clean Lakes Program in 1992. The Phase I study investigated the physical and social characteristics of the Twin Lakes drainage, assessed numerous water quality parameters and biological resources, and examined the feasibility of lake restoration. The study found high rates of sediment delivery from Sugar Creek to West Lake, high suspended solids levels in the lake, and diminished sediment storage capacity of West Lake. Additionally, high levels of nitrogen and phosphorus, particularly in the West Lake, were contributed from Sugar Creek, which caused frequent algal growth. Total phosphorus and dissolved phosphorus concentration tended to decrease from upstream locations (West Lake) to downstream (East Lake). Total phosphorus concentration in the Twin lakes exceeded the State criteria of 0.05 mg/L. The West Lake averaged 0.093 mg/L, while the East Lake averaged 0.060 mg/L. The study also found low dissolved oxygen levels in the lakes, particularly near the bottom of West Lake, and below a depth of eight to nine feet in the East Lake during periods of thermal stratification.

Additional problems identified were shoreline erosion, due to insufficient shoreline vegetation and wave action from wind and boats, and poor fisheries population and habitat. The primary restoration alternative recommended for the project was hydraulically dredging 450,000 cubic yards of sediment from West Lake. Additional recommendations included the enhancement of the upper end of the lake to function as a sediment basin, various shoreline erosion control and protection measures, fisheries management, watershed land treatment practices, and the installation of an aeration system.

A Phase II Implementation study (Illinois EPA, 1998) examined the differences between pre-implementation and post-implementation periods. The study found that shoreline protection and stabilization measures suggested in the Phase I report proved to be successful in reducing shoreline erosion, and that dredging operations increased overall storage capacity by over 200 percent. Additionally, the study found that dredging operations resulted in an estimated 26.5% reduction in sediment load. However, a majority of the chemical parameters have remained approximately the same.

In particular, nitrogen concentrations averaged above 0.30 mg/L and mean phosphorus levels remained above 0.05 mg/L. The levels of these nutrients were sufficient to increase algal biomass and subsequently contribute to low dissolved oxygen levels during summer months.

4.3 Parameters of Concern

The following sections provide a summary of the parameters identified on Illinois 2002 303(d) list as causing impairments to the Sugar Creek watershed. The purpose of these sections is to provide an overview of the parameters, units, sampling methods, and potential sources. The relevance of the parameter to the various beneficial uses is also briefly discussed.

4.3.1 Nutrients/Organic Enrichment/Low DO/Excessive Algal Growth

The term *nutrients* usually refers to the various forms of nitrogen and phosphorus found in a waterbody. Both nitrogen and phosphorus are necessary for aquatic life, and both elements are needed at some level in a waterbody to sustain life. The natural amount of nutrients in a waterbody varies depending on the type of system. A pristine mountain spring might have little to almost no nutrients, whereas a lowland, mature stream flowing through wetland areas might have naturally high nutrient concentrations. Various forms of nitrogen and phosphorus can exist at one time in a waterbody, although not all forms can be used by aquatic life. Common phosphorus sampling parameters are total phosphorus (TP), dissolved phosphorus, and orthophosphate.

The dissolved phosphorus component of total phosphorus is the form that is most readily available to plants. It consists of soluble phosphorus that is not bound to particulates. In waterbodies with relatively short residence times, such as fast-flowing streams, dissolved phosphorus is of greater interest than TP because it is the only form that is readily available to support algal growth. However, in lakes and reservoirs, where residence times are much longer, particulate phosphorus can be transformed to dissolved phosphorus through microbial action. TP is therefore considered an adequate estimation of bioavailable phosphorus (USEPA, 1999).

Common nitrogen sampling parameters are total nitrogen (TN), nitrite (NO_2), nitrate (NO_3), total Kjeldahl nitrogen (TKN), and ammonia (NH_3). Concentrations are measured in the lab and are typically reported in milligrams per liter.

Nutrients generally do not pose a direct threat to the beneficial uses of a waterbody. However, excess nutrients can cause an undesirable abundance of plant and algae growth. This process is called eutrophication or organic enrichment. Organic enrichment can have many effects on a stream or lake. One possible effect of eutrophication is low dissolved oxygen concentrations. Aquatic organisms need oxygen to live and they can experience lowered reproduction rates and mortality with lowered dissolved oxygen concentrations. Dissolved oxygen concentrations are measured in the field and are typically reported in milligrams per liter. Ammonia, which is toxic to fish at high concentrations, can be released from decaying organic matter when eutrophication occurs. Recreational uses can be impaired because of eutrophication. Nuisance plant and algae growth can interfere with swimming, boating, and fishing. Nutrients generally do not pose a threat to agricultural uses.

Nitrogen and phosphorus exist in rocks and soils and are naturally weathered and transported into waterbodies. Organic matter is also a natural source of nutrients. Systems rich with organic matter (e.g., wetlands and bogs) can have naturally high nutrient concentrations. Phosphorus and nitrogen are potentially released into the environment through different anthropogenic sources including septic systems, wastewater treatment plants, fertilizer application, and animal feeding operations.

4.3.2 Sedimentation/Siltation

Extreme sedimentation can impair aquatic life, drinking water, and recreational designated uses. Excessive sediments deposited on the bottom of streams and lakes can choke spawning gravels, thereby reducing fish survival and growth rates, impair fish food sources, and reduce habitat complexity in stream channels. Furthermore, high sediment levels can clog fish gills, causing direct physical harm. Related to drinking water supply, sediments can cause taste and odor problems, block water supply intakes, foul treatment systems, and fill reservoirs. High levels of sediment can impair swimming and boating by altering channel form, creating hazards due to reductions in water clarity, and adversely affecting the general aesthetics of the waterbody.

Sediment is delivered to a receiving waterbody through various erosional processes such as sheetwash, gully and rill erosion, wind, landslides, and human excavation. Additionally, sediments are often produced through the stream channel and stream bank erosion, and by channel disturbance.

4.3.3 Fecal Coliform

Fecal coliform is a widely-used indicator organism for the potential contamination from other, more harmful septic-effluent and manure-borne microorganisms. High levels of fecal coliform can impair recreational uses by inducing human illness. Infections due to fecal coliform-contaminated recreational waters include gastrointestinal, respiratory, eye, ear, nose, throat, and skin diseases (USEPA, 1986). Drinking water supplies may become contaminated and unsafe for consumption. Although chlorination or other disinfectants inactivate fecal coliform under normal circumstances, high loadings in the source water may require more expensive treatment techniques, such as ozone, membranes or ultraviolet radiation. In aquatic systems, excessive fecal coliform may contaminate filter-feeding fish, such as clams, oysters, mussels, and other shellfish. Microbial contaminants may concentrate in their tissues and may be harmful to humans when consumed raw or undercooked.

Fecal coliform is generated by point and nonpoint sources and then transported by a pipe, storm water runoff, groundwater, or other mechanisms to receiving water. Typical point sources of fecal coliform include discharges from wastewater treatment plants (WWTP) and combined sewer overflows (CSOs). CSOs occur when wet weather flows exceed the conveyance and storage capacity of the combined stormwater and sanitary sewage system. During a CSO, raw sewage can bypass the WWTP and enter directly into a receiving waterbody. Tetra Tech is not aware of any CSO discharges into Sugar Creek. Other point sources include concentrated animal feeding operations, and slaughterhouses and meat processing facilities.

Nonpoint sources of fecal coliform are dominated by wet weather, and do not enter waterbodies at a single point. Furthermore, nonpoint sources may be from rural or urban areas. Urban and suburban nonpoint sources include surface litter, contaminated refuse, domestic pet and wildlife excrement, and failing sanitary sewer lines. Rural nonpoint source loadings originate from both land use-specific and natural sources. The primary rural nonpoint source for fecal coliform is confined animal operations, such as a feedlot. Other significant sources include leaking septic systems and land application of manure and sewer sludge. Lastly, another significant source of fecal coliform loadings is wildlife. Beaver, deer, and waterfowl, such as ducks, geese, and heron, can contaminate surface water with microbial organisms.

4.4 Applicable Water Quality Standards

A description of the designated use support for waters within Illinois and a narrative of IEPA’s water quality standards are presented in this section. Additionally, numerical water quality criteria for the parameters of interest in this TMDL are listed as well.

4.4.1 Use Support Guidelines

To assess the designated use support for Illinois waterbodies the Illinois EPA uses rules and regulations adopted by the Illinois Pollution Control Board (IPCB). The following are the use support designations provided by the IPCB for the Paris Twin Lakes:

a. *General Use Standards* - These standards protect for aquatic life, wildlife, agricultural, primary contact (where physical configuration of the waterbody permits it, any recreational or other water use in which there is prolonged and intimate contact with the water involving considerable risk of ingesting water in quantities sufficient to pose a significant health hazard, such as swimming and water skiing), secondary contact (any recreational or other water use in which contact with the water is either incidental or accidental and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, commercial and recreational boating, and any limited contact incident to shoreline activity), and most industrial uses. These standards are also designed to ensure the aesthetic quality of the state's aquatic environment.

b. *Public and Food Processing Water Supply Standards* - These standards protect for any water use in which water is withdrawn from surface waters of the state for human consumption or for processing of food products intended for human consumption.

4.4.2 Numeric Standards

Numeric water quality standards for the State of Illinois for general use and Public and food processing and water supply are presented in Table 4-2.

Table 4-2. Illinois Numeric Water Quality Standards

Parameter	Units	General Use	Public and Food Processing Water Supply
Nutrients/Organic Enrichment/Low DO/Excessive Algal Growth			
Total Phosphorus[1]	mg/L	0.05	0.05
Dissolved Oxygen	mg/L	5.0 minimum	5.0 minimum
Chlorophyll-a	µg/L	None	None
Sedimentation/Siltation			
Sedimentation/Siltation		None	None
Total Suspended Solids			
Total Suspended Solids		None	None
Pathogens			
Fecal Coliform	#/100 mL	200 (geometric mean)/400 (instantaneous)[2]	2000[3]

[1] The total phosphorus standard only applies to lakes.

[2] The general use fecal coliform standard reads as follows: “During the months May through October, based on a minimum of five samples taken over not more than a 30 day period, fecal coliform shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10% of the samples during any 30 day period exceed 400 per 100 ml in protected waters.” (Source: Illinois Administrative Code. Title 35. Subtitle C. Part 302.209)

[3] The public and food processing water supply fecal coliform standard reads as follows: “Notwithstanding the provisions of Section 302.209, at no time shall the geometric mean, based on a minimum of five samples taken over not more than a 30 day period, of fecal coliform exceed 2000 per 100 mL.” (Source: Illinois Administrative Code. Title 35. Subtitle C. Part 302.306).

4.5 Water Quality Assessment

Water quality data for Paris Twin West Lake, Paris Twin East Lake, and Sugar Creek were downloaded from the STORET and USGS NWIS databases. Additionally, sampling data from the Paris Waste Water Treatment Plant are available. The location of the monitoring stations located within the watershed is shown in Figure 4-1. Figure 4-2 displays the monitoring stations located in the Paris Twin West Lake and the Paris Twin East Lake. Summary statistics, including the period of record, for all available water quality data are presented in this section, and are organized by impaired waterbody segment. The individual results of each sampling event are provided in Appendix B.

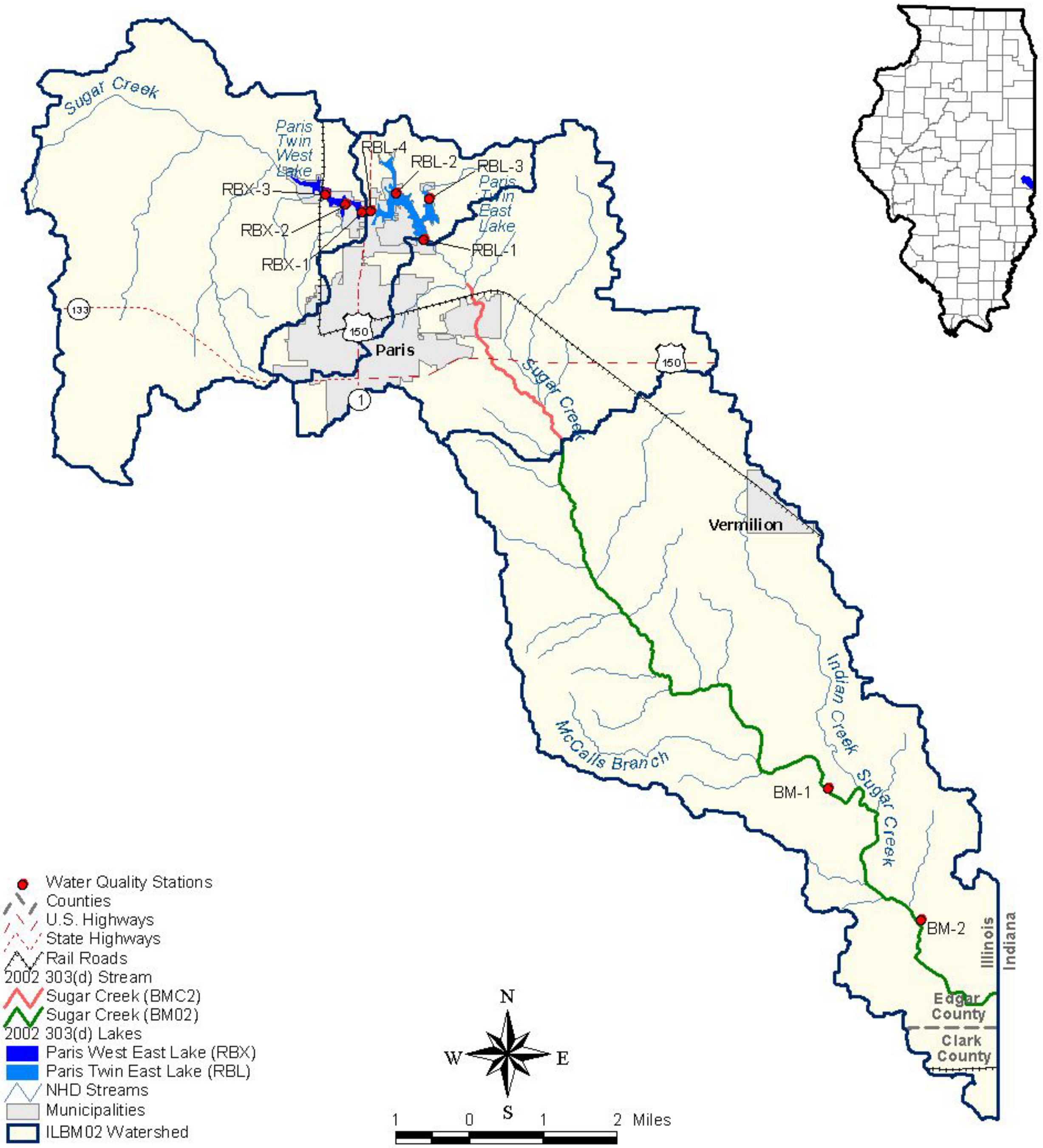

Figure 4-1. Water quality sampling stations in the Sugar Creek watershed.

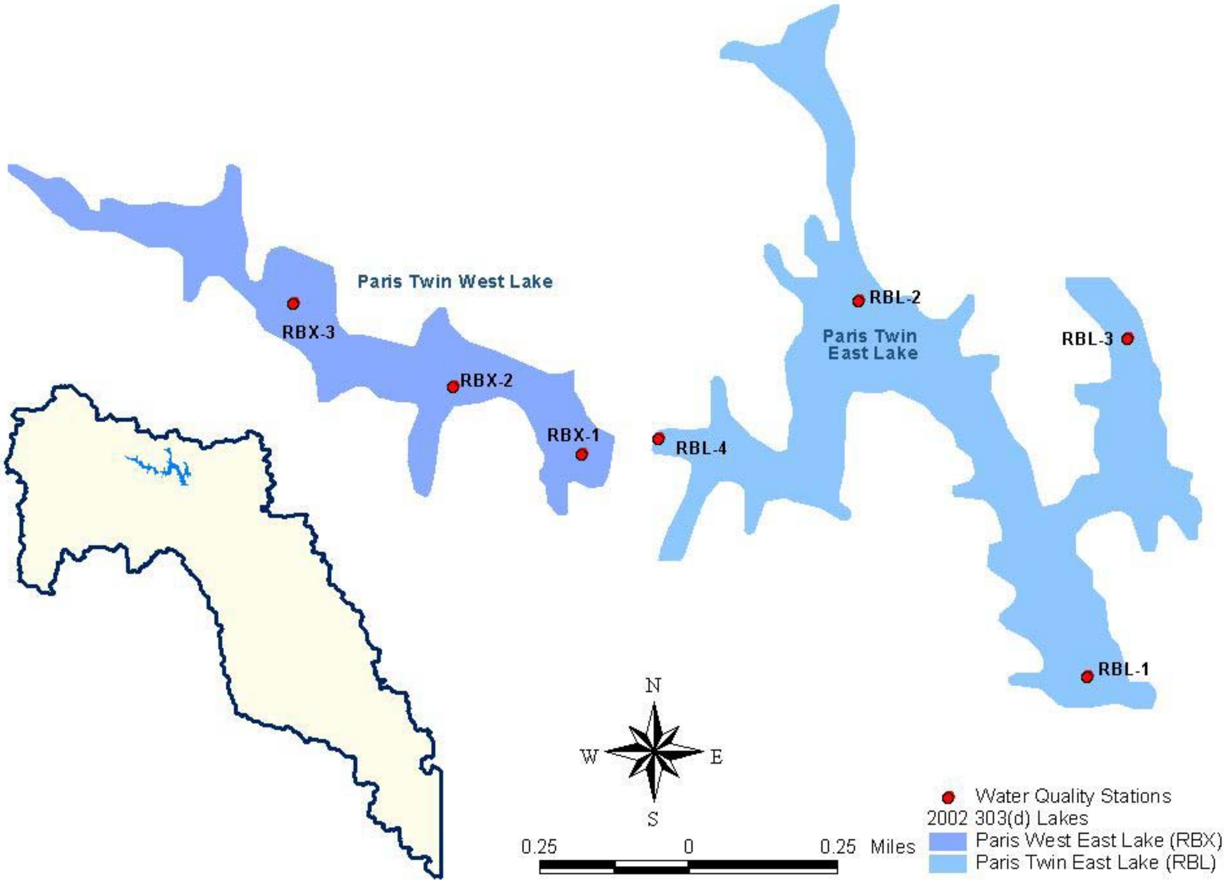

Figure 4-2. Water quality sampling stations in the Paris Twin Lakes.

4.5.1 Paris Twin West Lake (RBX)

Water quality data collected in the Paris Twin West Lake at IEPA monitoring stations RBL4, RBX, RBX-1, RBX-2, and RBX-3 are available from 1979 to 2002. A summary of these data is presented in the sections below. It should be noted that RBL-4, RBL-5, and RBL-6 are located in Paris Twin West Lake even though they have the "RBL" prefix. Data from these stations are included in Appendix B.

4.5.1.1 Total Phosphorus

The applicable water quality standard for total phosphorus (TP) in Illinois lakes is 0.05 mg/L. Table 4-3 presents the period of record and a statistical summary for all available TP and other nutrient-related parameters. Additionally, Figure 4-3 presents a graphical representation of the TP sampling activity in Paris Twin West Lake. A review of the data reveals that 83 percent of TP samples violated the water quality standard, including 98 percent of recent samples (Table 4-4). TP concentrations at the surface (one foot depth) are typically similar to TP concentrations at deeper samples, probably due to the shallowness of the lake.

Table 4-3. Summary of total phosphorus parameters for Paris Twin West Lake.

Parameter	Samples (Count)	Start	End	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	CV*
Total Phosphorus	272	6/18/1979	10/22/2001	0.02	0.12	1.80	1.23
Dissolved Phosphorus	159	6/18/1979	10/22/2001	0.00	0.04	0.54	1.50

*CV = standard deviation divided by mean

Table 4-4. Violations of the total phosphorus standard in Paris Twin West Lake.

Parameter	Samples (Count)	Violations (Count)	Percent Violating	Samples (Count), 1998 to Present	Violations (Count), 1998 to present	Percent Violating, 1998 to Present
Total Phosphorus (All Depths)	272	226	83%	48	47	98%
Total Phosphorus (1-foot Depth)	234	194	83%	32	31	97%

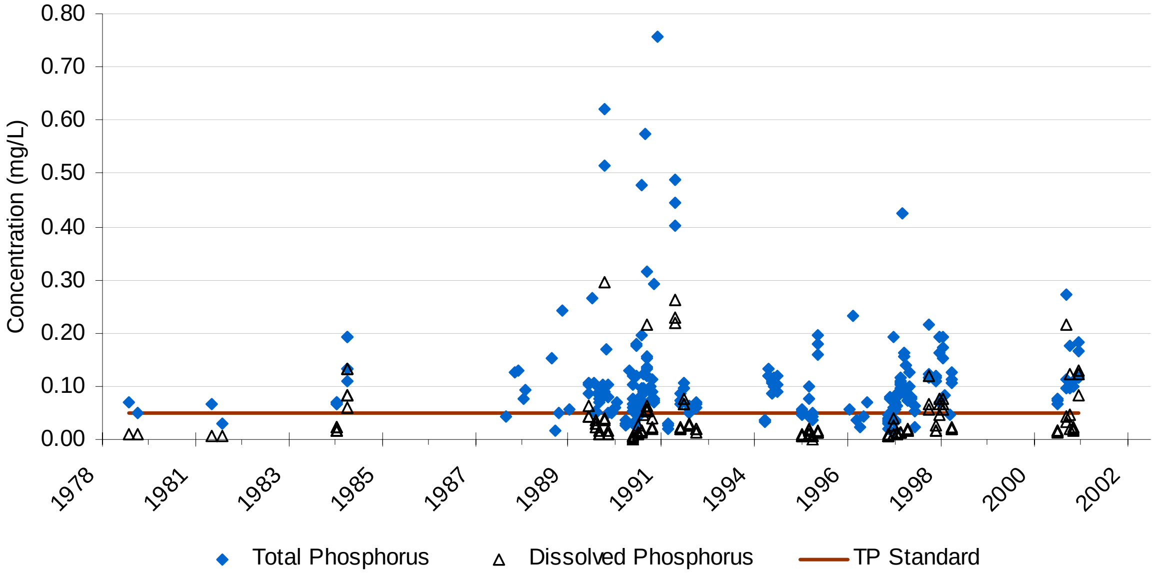

Figure 4-3. Total phosphorus and dissolved phosphorus sampling observations in the Paris Twin West Lake.

Monthly median and mean TP concentrations for the period of record are presented in Figure 4-4. Data are not available for the month of January. The figure shows that the water quality standard of 0.05 mg/L is exceeded in all months except February. Additionally, median and mean monthly TP concentrations display seasonal variability. Median and mean monthly TP concentrations are elevated yet fairly steady during late winter (March) through early summer (June). TP concentrations increase in the mid-summer months of July through September, then decrease in the month of October and continue to decrease through December.

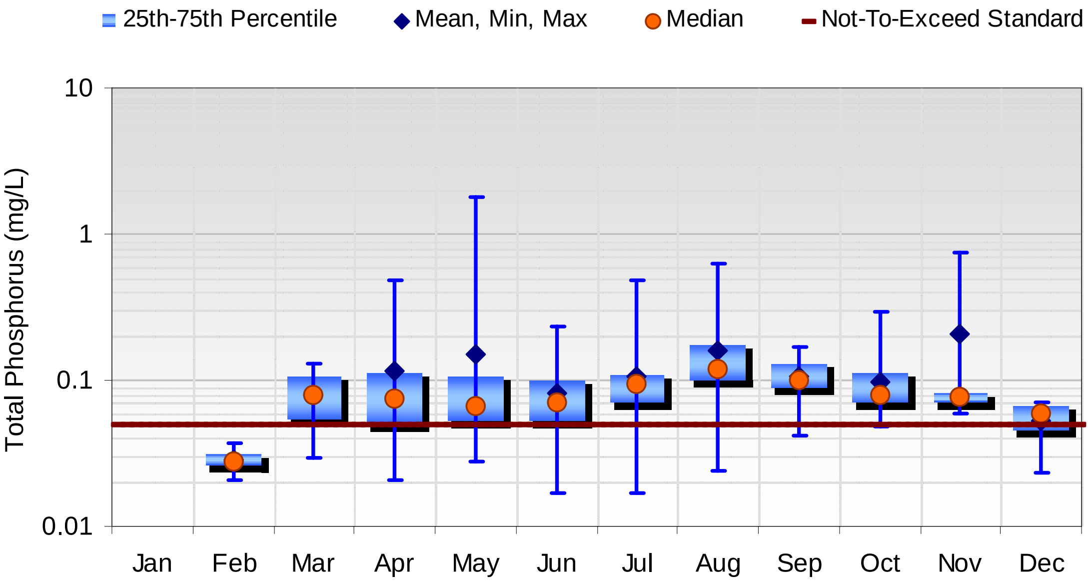

Figure 4-4. Monthly statistics for total phosphorus in the Paris Twin West Lake, 1978–2002.

4.5.1.2 Dissolved Phosphorus

As stated in section 4.3.1, dissolved phosphorus (DP) is an important component of the total phosphorus (TP) measure. Mean and median dissolved phosphorus concentrations sampled in the Paris West Twin Lake are shown in Figure 4-5. DP data are available from April through August, and October. The figure shows that median DP concentrations are lowest in April, increase in May, reach their maximum in August, and decrease in October to levels comparable to early summer. The median DP concentration exceeds the total phosphorus criteria of 0.05 mg/L in August. Mean DP concentrations are significantly greater for the months of April, July, August and October, which leads to greater variability of dissolved phosphorus concentrations in these months. Furthermore, mean DP concentrations exceed the total phosphorus criteria in April and August.

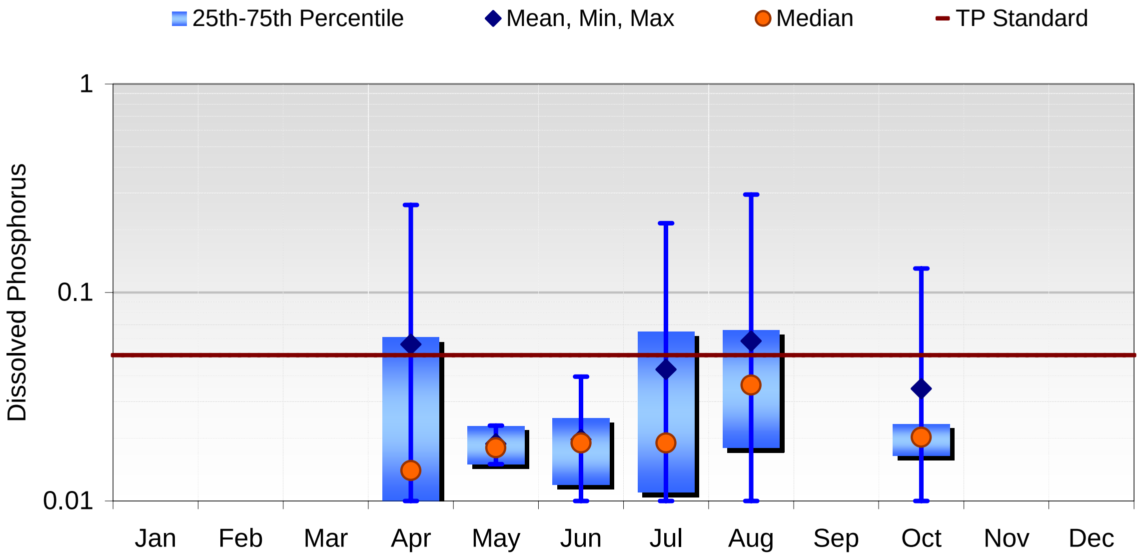

Figure 4-5. Dissolved phosphorus monthly statistics in the Paris Twin West Lake, 1978–2002.

The proportion of DP to TP is quite variable over the period of record as shown in Figure 4-6. The percentage of DP ranges from less than five percent to nearly 80 percent. A significant number of observations record dissolved phosphorus contributions greater than 30 percent of TP in Paris West Twin Lake.

The monthly percent contribution of DP to TP is quite variable, yet the greatest monthly contributions occur in April, July and August, as illustrated in Figure 4-7.

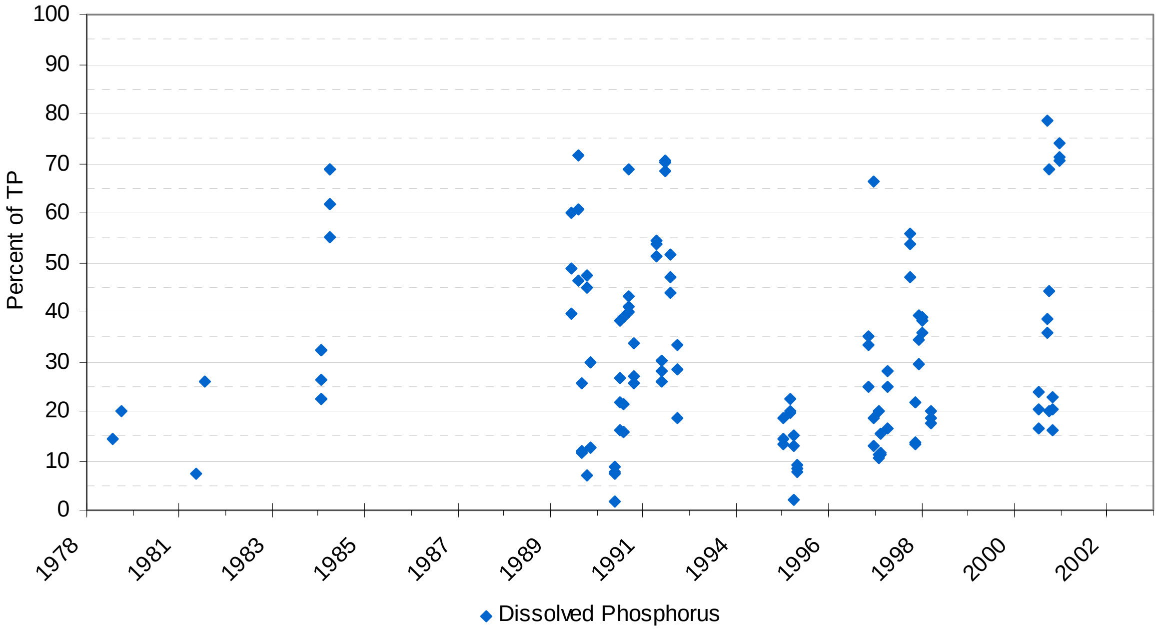

Figure 4-6. Proportion of dissolved phosphorus in total phosphorus for the Paris Twin West Lake.

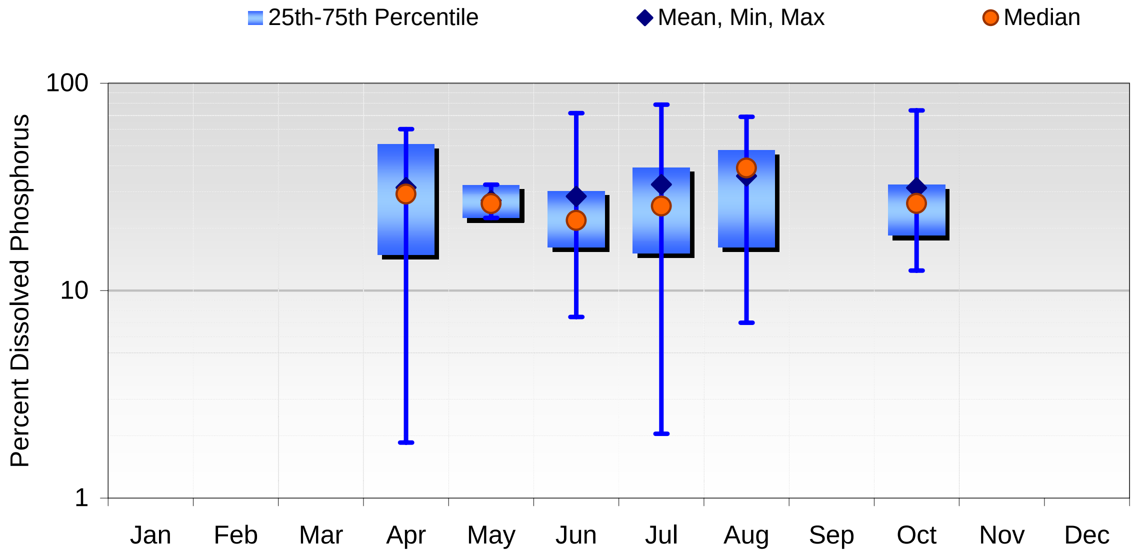

Figure 4-7. Monthly mean and median percentage of dissolved phosphorus comprising total phosphorus for the Paris Twin West Lake, 1978–2002.

4.5.1.3 Total Nitrogen (TN)-to-Total Phosphorus (TP) Ratio

Eutrophication in freshwater systems is typically controlled by either nitrogen or phosphorus. The limiting nutrient is defined as the nutrient that limits plant growth when it is not available in sufficient quantities. Controlling this nutrient can often slow the rate of eutrophication and improve conditions in the waterbody. An initial identification of the limiting nutrient can be made by comparing the levels of nutrients in the waterbody with the plant stoichiometry. The ratio of nitrogen to phosphorus in biomass is approximately 7.2:1. Therefore, a nitrogen:phosphorus ratio in water that is less than 7.2 suggests that nitrogen is limiting. In contrast, a ratio greater than 7.2 suggests that phosphorus is the limiting nutrient (Chapra, 1997).

The variability of the TN:TP ratios in Paris Twin West Lake are presented in Figure 4-8. Figure 4-9 illustrates that TN:TP ratios are quite variable over the period of record, as well as over the course of a year. Most TN:TP ratios are greater than 10, strongly suggesting that phosphorus is the limiting nutrient in the Paris Twin West Lake.

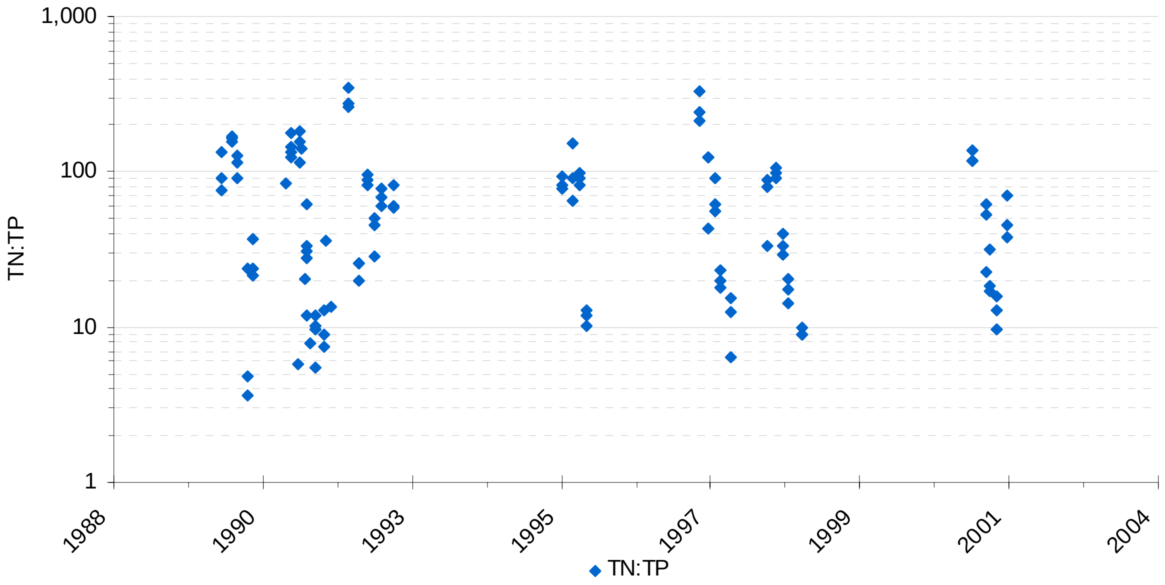

Figure 4-8. TN:TP ratios over the period of record in the Paris Twin West Lake.

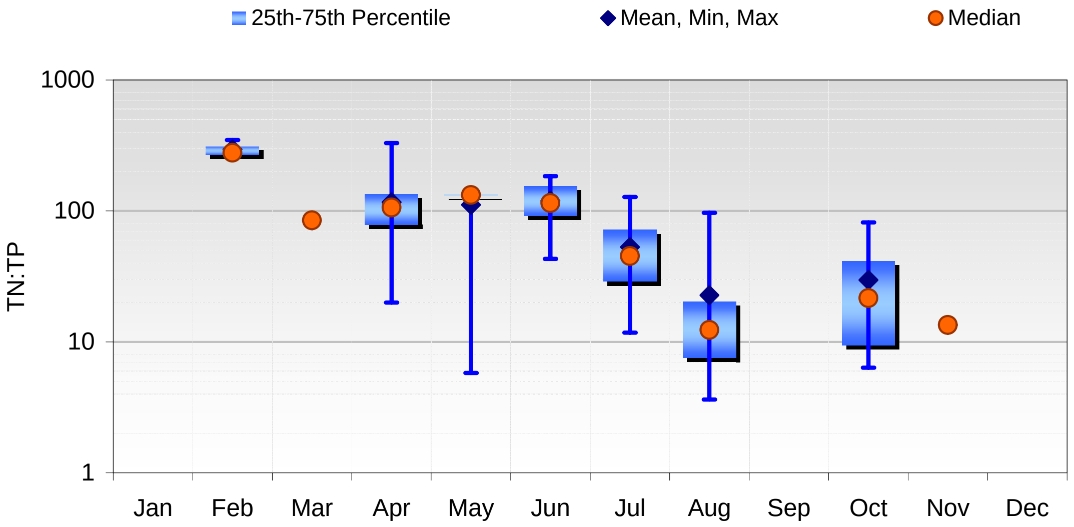

Figure 4-9. Monthly median and mean TN:TP ratios in the Paris West Twin Lake, 1989–2002.

4.5.1.4 Excessive Algal Growth

The dominant pigment in algal cells is chlorophyll-*a*, which is easy to measure and is a valuable surrogate measure for algal biomass. Chlorophyll-*a* is desirable as an indicator because algae are either the direct (e.g. nuisance algal blooms) or indirect (e.g. high/low dissolved oxygen, pH, and high turbidity) cause of most problems related to excessive nutrient enrichment. Both seasonal mean and instantaneous maximum concentrations can be used to determine impairments. The Illinois water quality standard for general use states that “waters of the state shall be free from algal growth of other than natural origin” (Section 302.203). Table 4-5 presents a summary of the chlorophyll-*a* collected in Paris Twin West Lake. Data are not available for the months of January, February, and March. Figure 4-10 displays the sampling frequency for chlorophyll-*a* in Paris Twin West Lake and indicates an increasing trend over the period of record. Monthly median and mean chlorophyll-*a* concentrations are presented in Figure 4-11, which shows that median and mean chlorophyll-*a* increase in magnitude and variability during the summer months of June through August, remain relatively high in September and August, and then decrease sharply in November through December. The relationship between chlorophyll-*a* and TP is graphically displayed in Figure 4-12. The figure shows that in general, as the concentration of TP increases, the concentration of chlorophyll-*a* correspondingly increases.

Table 4-5. Summary Statistics for Chlorophyll-*a* in the Paris Twin West Lake.

Parameter	Samples (Count)	Start	End	Minimum (µg/L)	Average (µg/L)	Maximum (µg/L)	CV*
Chlorophyll-a	148	6/18/1979	10/22/2001	0.00	39.17	295.00	0.98

*CV = standard deviation divided by mean

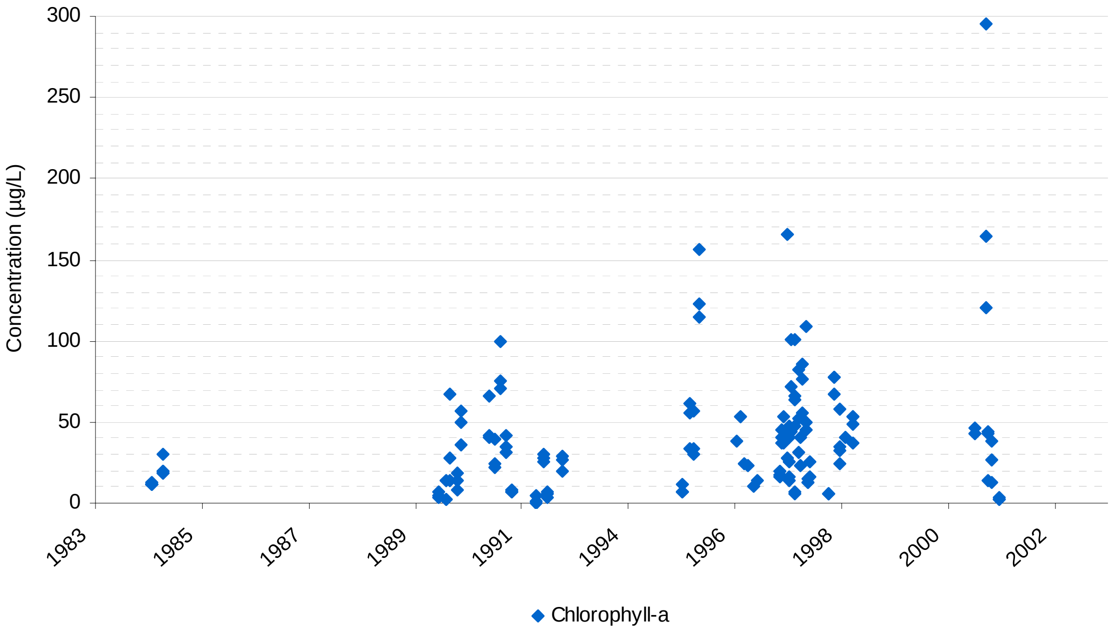

Figure 4-10. Chlorophyll-*a* sampling observations in the Paris Twin West Lake.

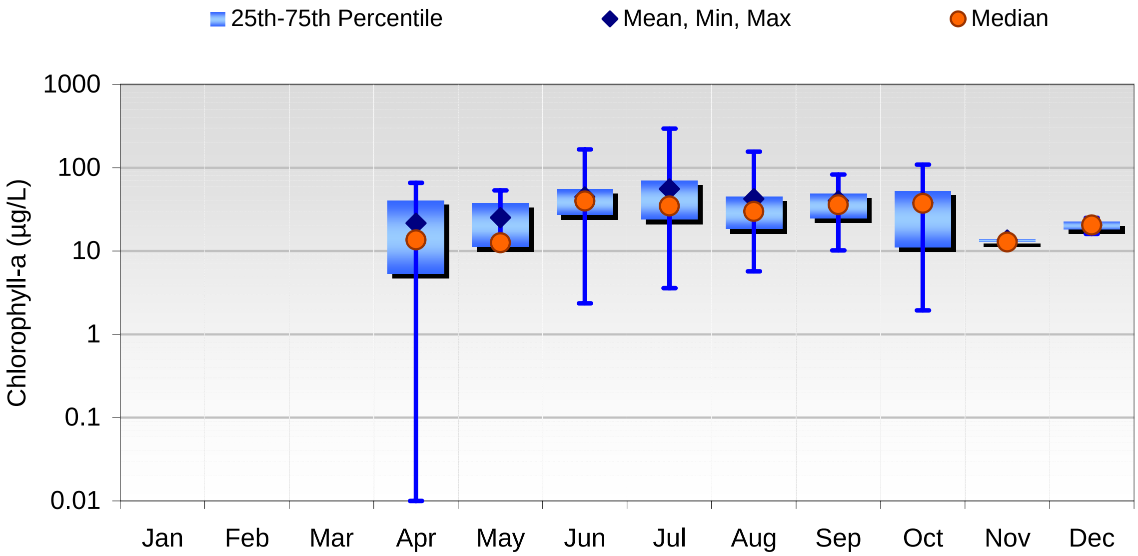

Figure 4-11. Monthly mean and median chlorophyll-*a* concentrations in the Paris Twin West Lake, 1979–2002.

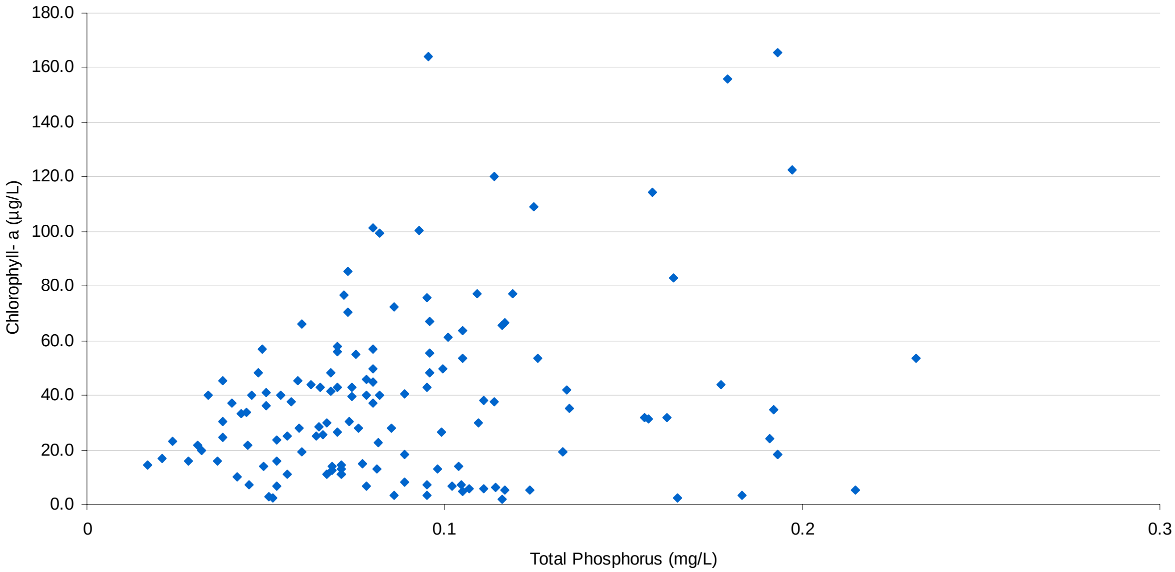

Figure 4-12. Relationship between chlorophyll-a concentration and TP concentration in the Paris Twin West Lake, 1979–2002.

4.5.1.5 Total Suspended Solids

A summary of the total suspended solids (TSS) data collected in Paris Twin West Lake is given in Table 4-6. Data are not available for the month of January. Figure 4-13 displays the sampling frequency for TSS in Paris Twin West Lake, and indicates that TSS concentrations are highly variable over the period of record. Monthly median and mean TSS concentrations are presented in Figure 4-14. The figure shows that median and mean TSS concentrations are slightly lower in the month of February, then increase in March and remain fairly constant throughout the remaining months of the year.

Table 4-6. Summary Statistics for Total Suspended Solids in the Paris Twin West Lake.

Parameter	Samples (Count)	Start	End	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	CV*
Suspended Solids	277	6/18/1979	10/22/2001	1.00	21.01	124.00	0.92

*CV = standard deviation divided by mean

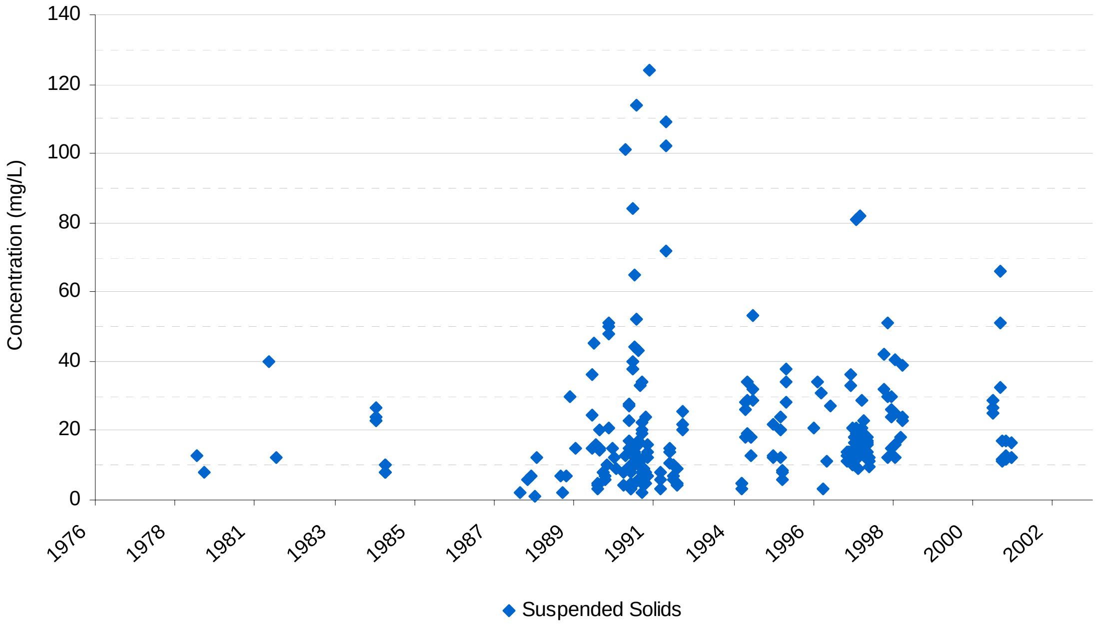

Figure 4-13. Total suspended solids sampling observations in the Paris Twin West Lake.

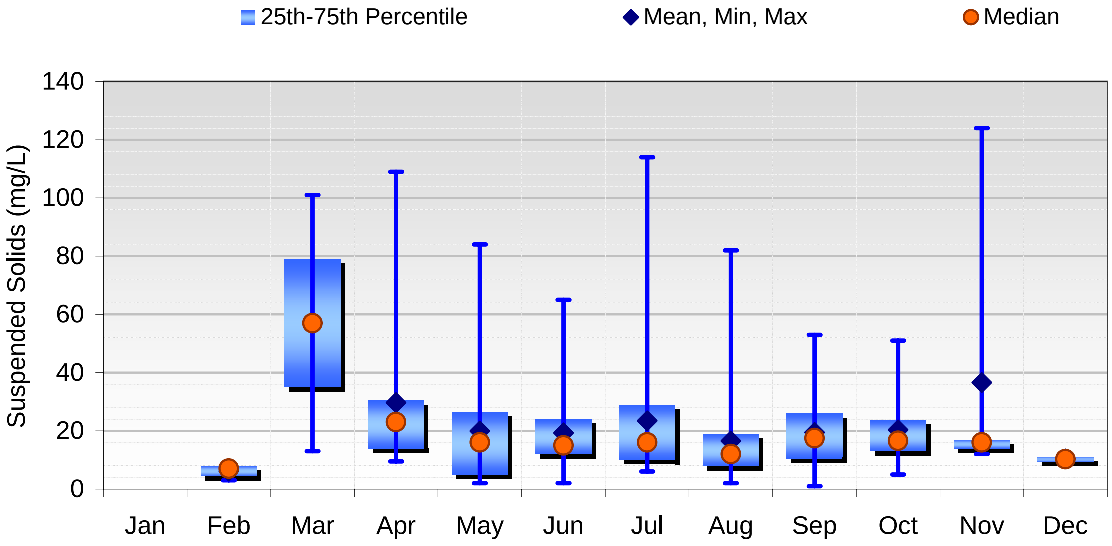

Figure 4-14. Monthly mean and median total suspended solids concentrations in the Paris Twin West Lake, 1979–2002.

4.5.2 Paris Twin East Lake (RBL)

A summary of the water quality data for Paris Twin East Lake is presented below.

4.5.2.1 Total Phosphorus

The applicable water quality standard for TP in Illinois is 0.05 mg/L. Table 4-7 presents the period of record and a statistical summary for all available TP data. Additionally, Figure 4-15 presents a graphical representation of the TP sampling activity in Paris Twin East Lake. A review of the data reveals that nearly 67 percent of TP samples violated the water quality standard, and all recent samples (data post-1997), exceed the TP water quality standard. There does not appear to be a significant increasing or decreasing trend represented by the data. TP concentrations at the surface (one foot depth) are typically similar to TP concentrations at deeper samples.

Table 4-7. Summary of total phosphorus parameters in Paris Twin East Lake.

Parameter	Samples (Count)	Start	End	Minimum	Average	Maximum	CV*
Dissolved Phosphorus	175	6/18/1979	10/22/2001	0.001	0.06	0.92	1.97
Total Phosphorus	338	6/29/1977	10/22/2001	0.001	0.10	1.10	1.15

*CV = standard deviation divided by mean

Table 4-8. Violations of the total phosphorus standard in Paris Twin East Lake.

Parameter	Samples (Count)	Violations (Count)	Percent Violating	Samples (Count), 1998 to Present	Violations (Count), 1998 to present	Percent Violating, 1998 to Present
Total Phosphorus (All Depths)	338	229	68%	47	47	100%
Total Phosphorus (1-Foot Depth)	277	178	64%	32	32	100%

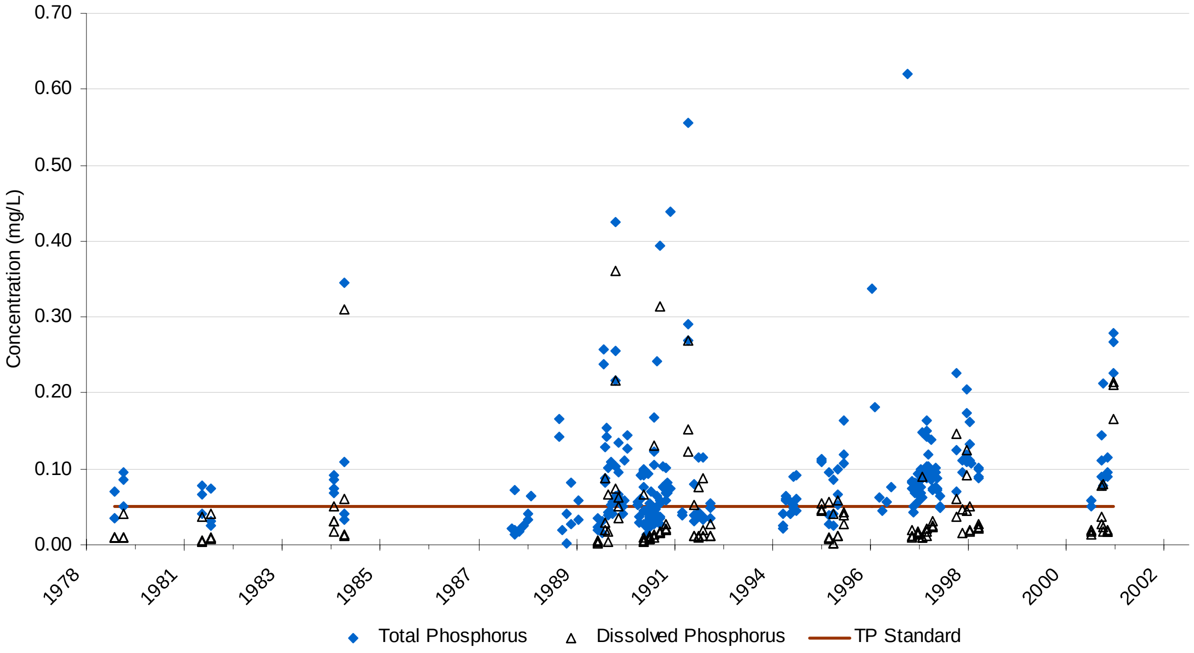

Figure 4-15. Total phosphorus and dissolved phosphorus sampling observations in the Paris Twin East Lake.

Monthly median and mean TP concentrations for the period of record are presented in Figure 4-16. Data are not available for the month of January. The figure shows that the water quality standard of 0.05 mg/L is exceeded in all months except February. Additionally, mean monthly TP concentrations display seasonal variability. Mean monthly TP concentrations are greatest in March, and then steadily decrease from April through June. TP concentrations begin to rise in July and reach a secondary peak in August, and afterward decrease in the fall months of September and October. A third peak in mean TP concentration occurs in November, with a decrease in concentration following in the month of December.

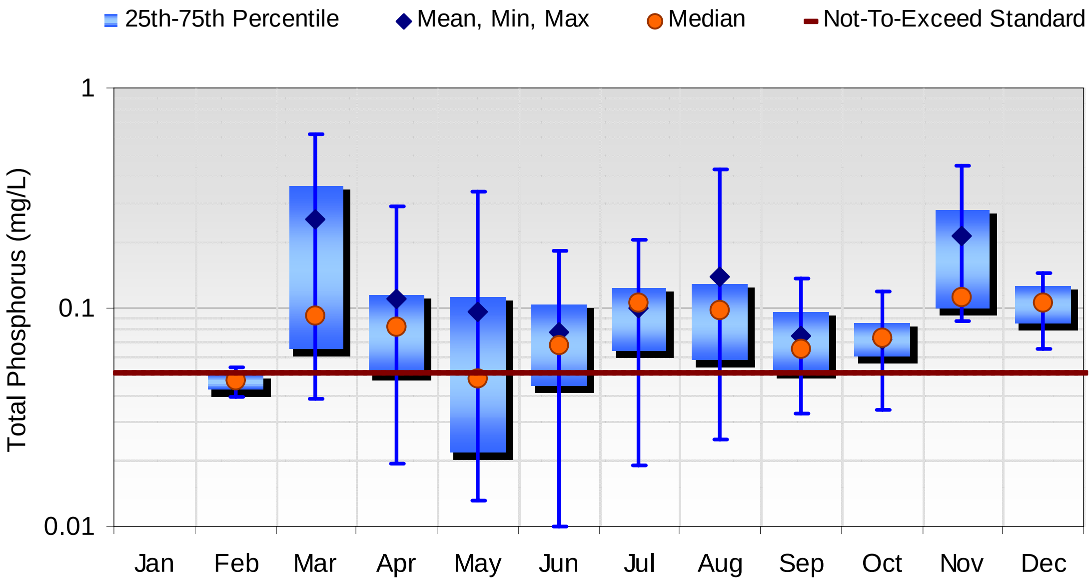

Figure 4-16. Monthly total phosphorus statistics in the Paris Twin East Lake, 1977–2002.

4.5.2.2 Dissolved Phosphorus

Dissolved phosphorus (DP) is an important component of the total phosphorus (TP) measure (see section 4.3.1). Mean and median dissolved phosphorus concentrations sampled in the Paris East Twin Lake are shown in Figure 4-17. DP data are available from April through August, and October. The figure shows that mean DP concentrations follow the general seasonal trend as TP presented in the previous section: mean DP concentrations are greatest in April and then decrease through June and reach a secondary peak in August. Mean DP concentrations exceed the total phosphorus criteria of 0.05 mg/L in April, July, August and November. Additionally, DP concentrations are highly variable for each month of available data.

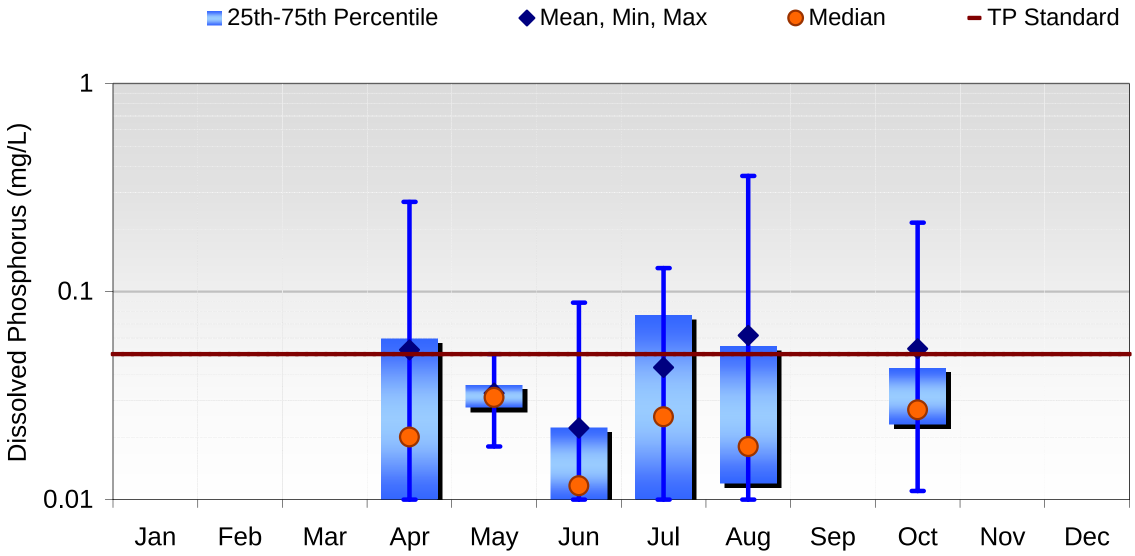

Figure 4-17. Dissolved phosphorus monthly statistics in the Paris Twin East Lake, 1977–2002.

The proportion of DP to TP is quite variable over the period of record as shown in Figure 4-18. The percentage of DP comprising the TP load ranges from less than five percent to nearly 90 percent. A significant number of observations record dissolved phosphorus contributions greater than 30 percent of the TP in the Paris West Twin Lake.

The monthly percent contribution of DP to TP varies greatly, yet the greatest monthly contributions occur in April, July, August, and October as illustrated in Figure 4-19. Indeed, the mean DP contribution to TP exceeds 65 percent for the month of August.

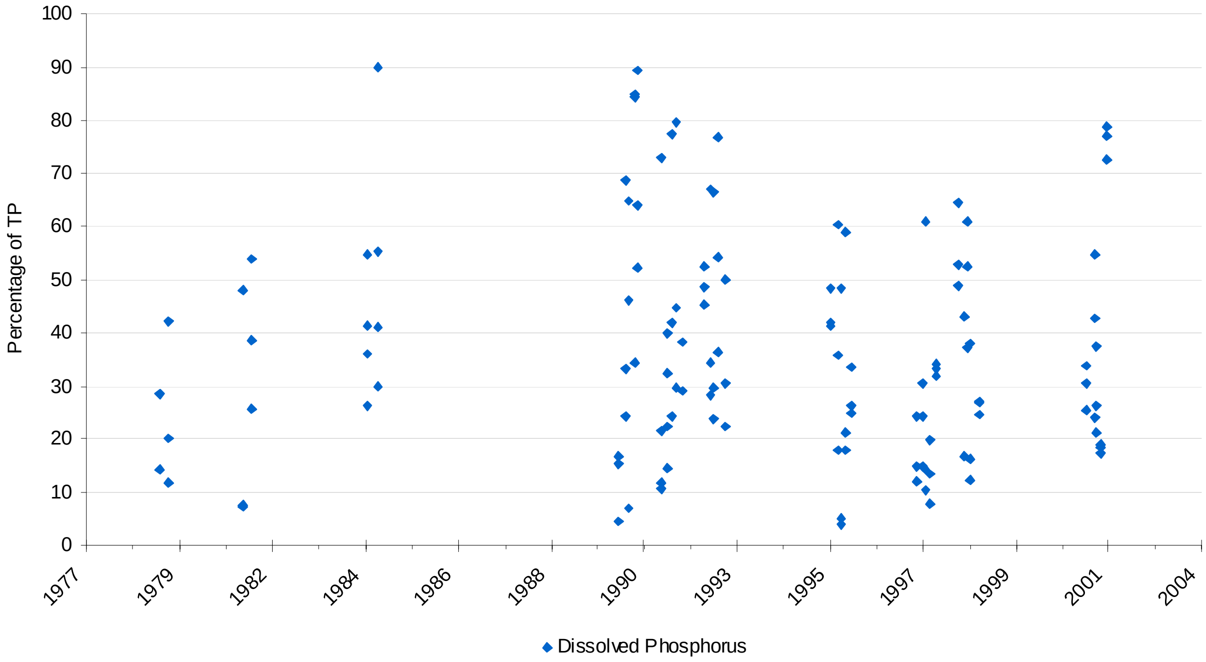

Figure 4-18. Proportion of dissolved phosphorus in total phosphorus for the Paris Twin East Lake.

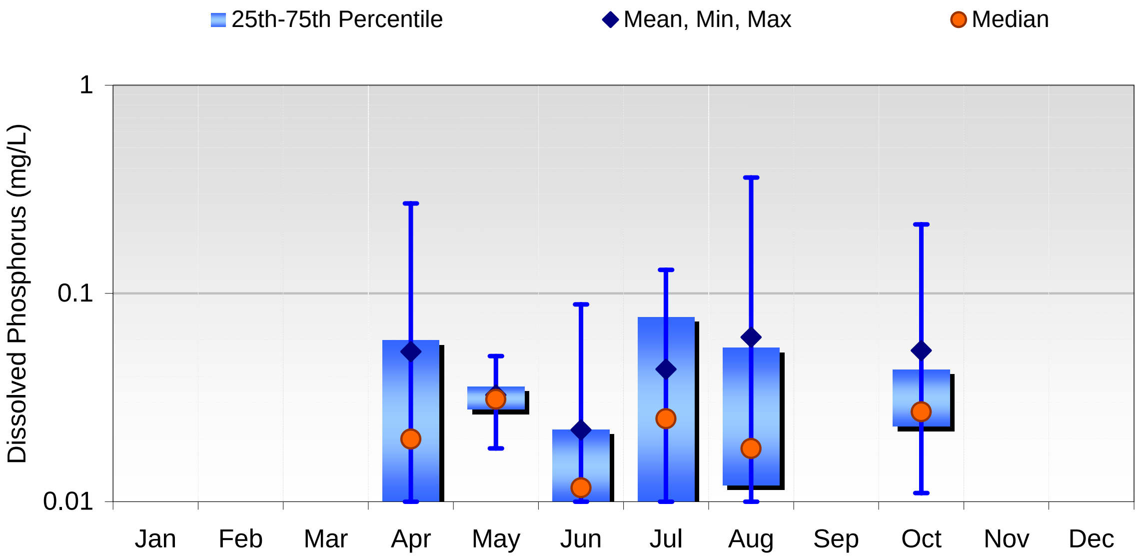

Figure 4-19. Monthly mean and median percentage of dissolved phosphorus comprising total phosphorus for the Paris Twin East Lake, 1977–2002.

4.5.2.3 Total Nitrogen (TN)-to-Total Phosphorus (TP) Ratio

The importance of the TN:TP ratio is discussed in section 4.5.1.3. The variability of the TN:TP ratios is presented in Figure 4-20, and monthly median and mean TN:TP ratios are shown in Figure 4-21. These figures illustrate that TN:TP ratios are quite variable over the period of record, as well as over the course of a year. Mean spring and summer TN:TP ratios are greater than 20, strongly suggesting that phosphorus is the limiting nutrient in the Paris Twin East Lake.

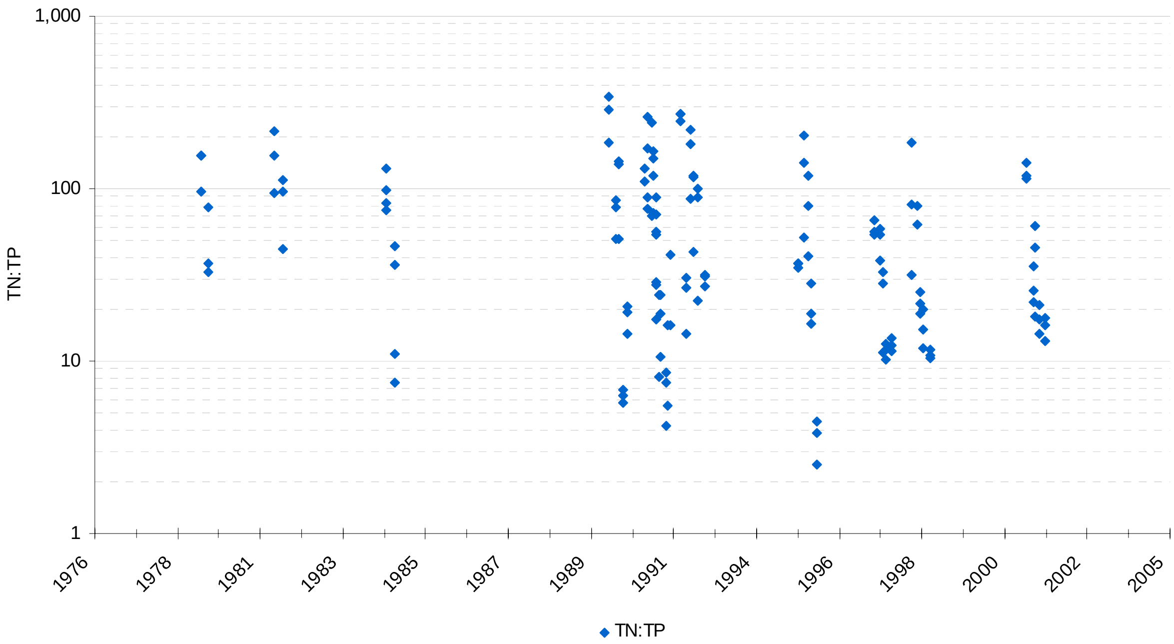

Figure 4-20. TN:TP ratios over the period of record in the Paris Twin East Lake.

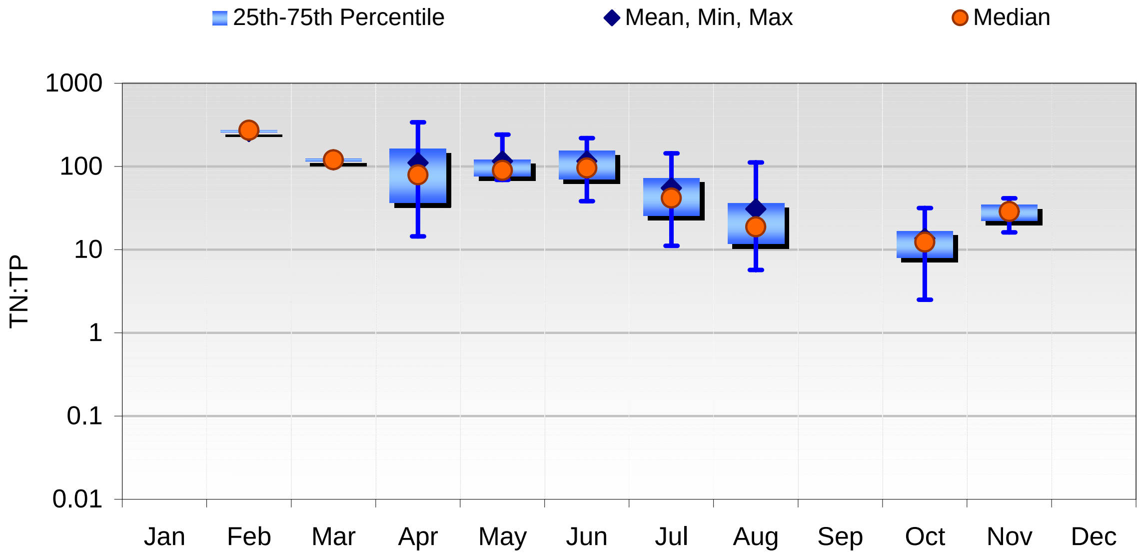

Figure 4-21. Monthly median and mean TN:TP ratios in the Paris East Twin Lake, 1989–2002.

4.5.2.4 Excessive Algal Growth

The importance of algal growth, and specifically chlorophyll-*a* is discussed in section 4.5.1.4. Table 4-9 presents a summary of the chlorophyll-*a* collected in Paris Twin East Lake. Data are not available for the months of January, February, and March. Figure 4-22 displays the sampling frequency for chlorophyll-*a* in Paris Twin West Lake and indicates a slight increasing trend over the period of record. Monthly median and mean chlorophyll-*a* concentrations are presented in Figure 4-23, which shows that median and mean chlorophyll-*a* concentrations are slightly increased from June through November, relative to spring months. A weak relationship exists between TP concentrations and chlorophyll-a concentrations, as displayed in Figure 4-24. Chlorophyll-*a* is a commonly used surrogate measure of algal biomass.

Typically, as TP concentrations increase, concentrations of chlorophyll-*a* increase as well. Figure 4-23 shows that as TP concentrations increase in the Paris East Twin Lake, chlorophyll-*a* concentrations do not always correspondingly increase. Thus, the relationship between chlorophyll-*a* and TP concentrations is characterized as weak for the Paris East Twin Lake.

Table 4-9. Summary Statistics for Chlorophyll-*a* in the Paris Twin East Lake.

Parameter	Samples (Count)	Start	End	Minimum (µg/L)	Average (µg/L)	Maximum (µg/L)	CV*
Chlorophyll-a	158	6/18/1979	10/22/2001	1	43.20	450.10	1.01

*CV = standard deviation divided by mean

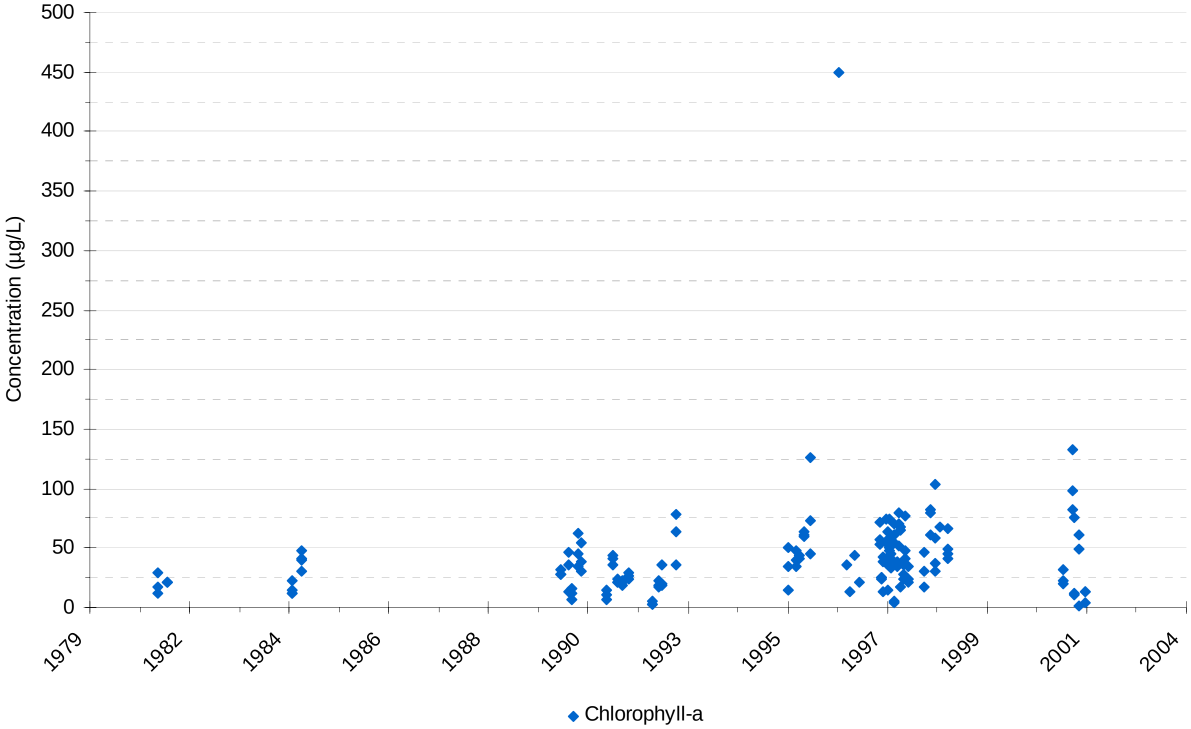

Figure 4-22. Chlorophyll-*a* sampling observations in the Paris Twin East Lake.

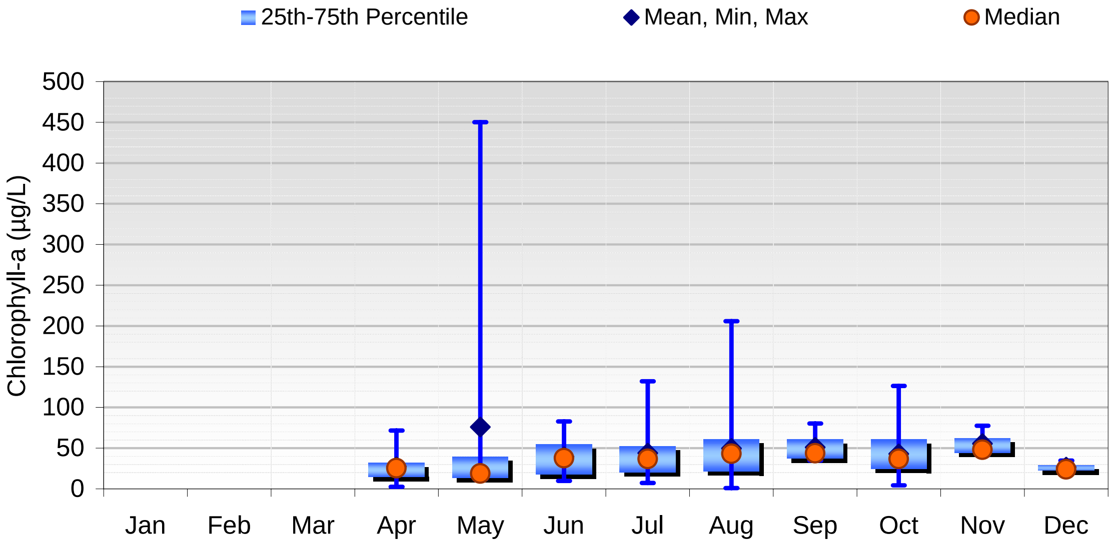

Figure 4-23. **Monthly mean and median chlorophyll-*a* concentrations in the Paris Twin East Lake, 1979–2001.**

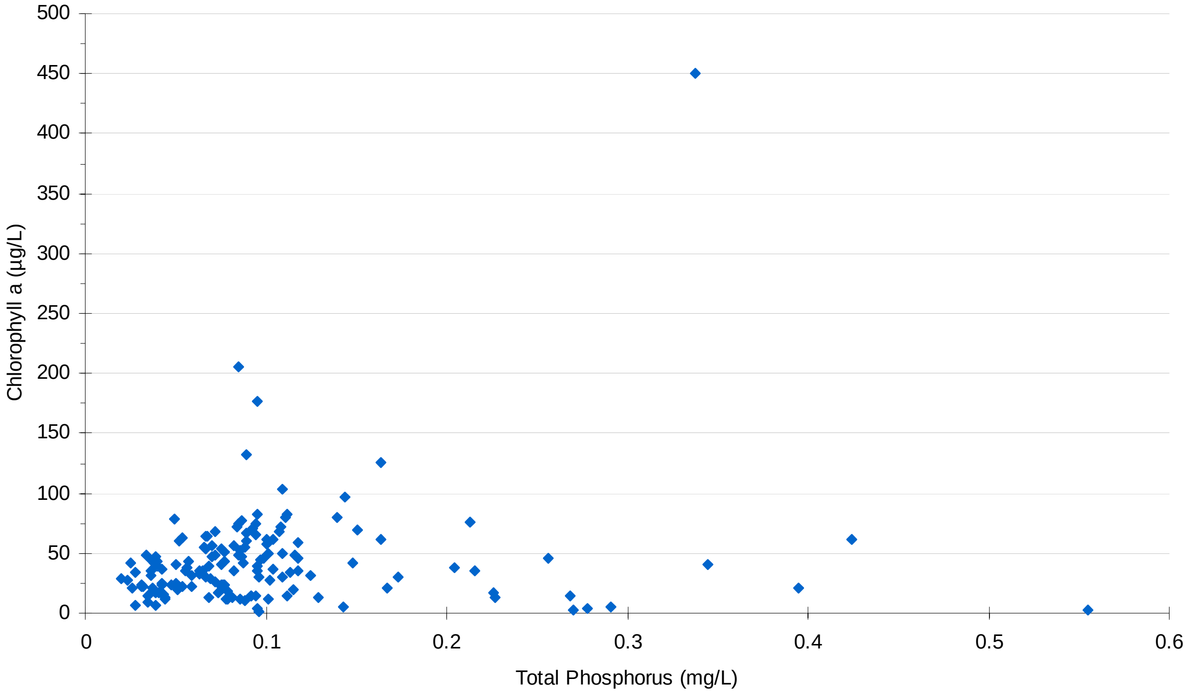

Figure 4-24. **Relationship between chlorophyll-a concentration and TP concentration in the Paris Twin East Lake, 1979-2001.**

4.5.2.5 Total Suspended Solids

A summary of the total suspended solids (TSS) data collected in Paris Twin East Lake is given in Table 4-10. Data are not available for the month of January. Figure 4-25 displays the sampling frequency for TSS in Paris Twin East Lake, and indicates that TSS concentrations are highly variable over the period of record. Monthly mean and median TSS concentrations are presented in Figure 4-26. The figure shows that mean and median TSS concentrations are greatest in March and April, then decrease and remain at lower levels from May through February.

Table 4-10. Summary Statistics for Total Suspended Solids in the Paris Twin East Lake.

Parameter	Samples (Count)	Start	End	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	CV*
Suspended Solids	335	6/29/1977	10/22/2001	1.00	15.67	240.00	1.22
*CV = standard deviation divided by mean							

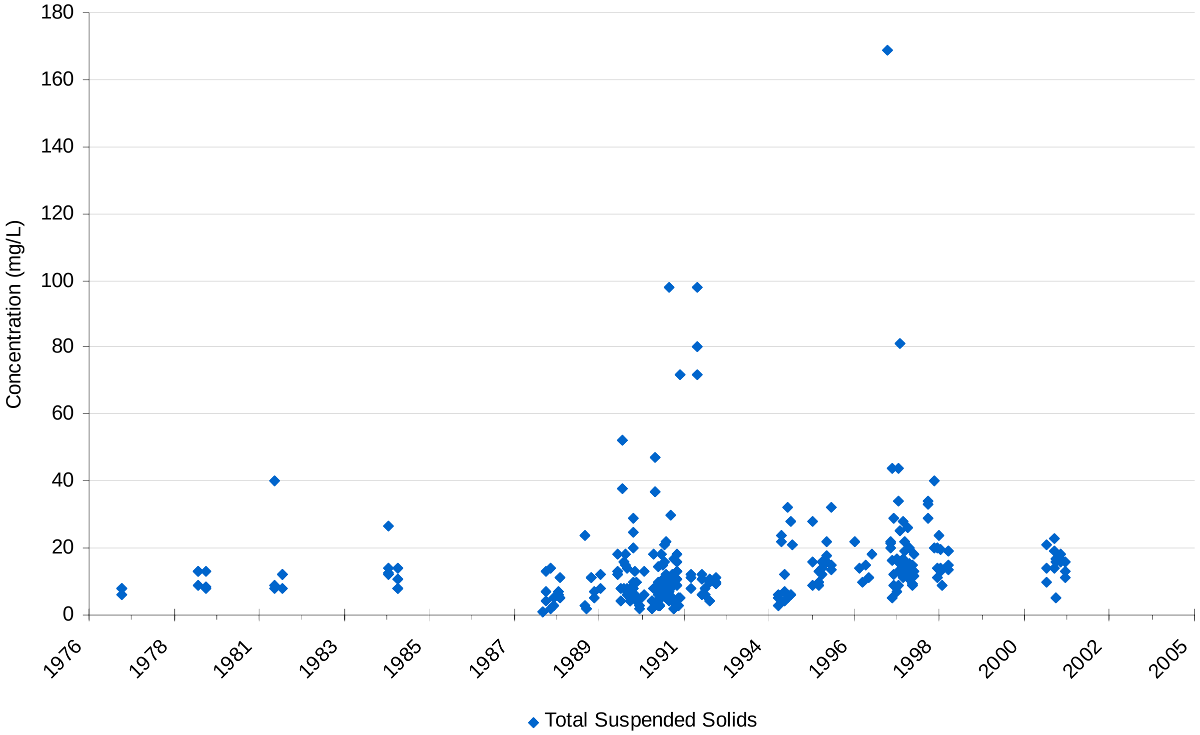

Figure 4-25. Total suspended solids sampling observations in the Paris Twin East Lake.

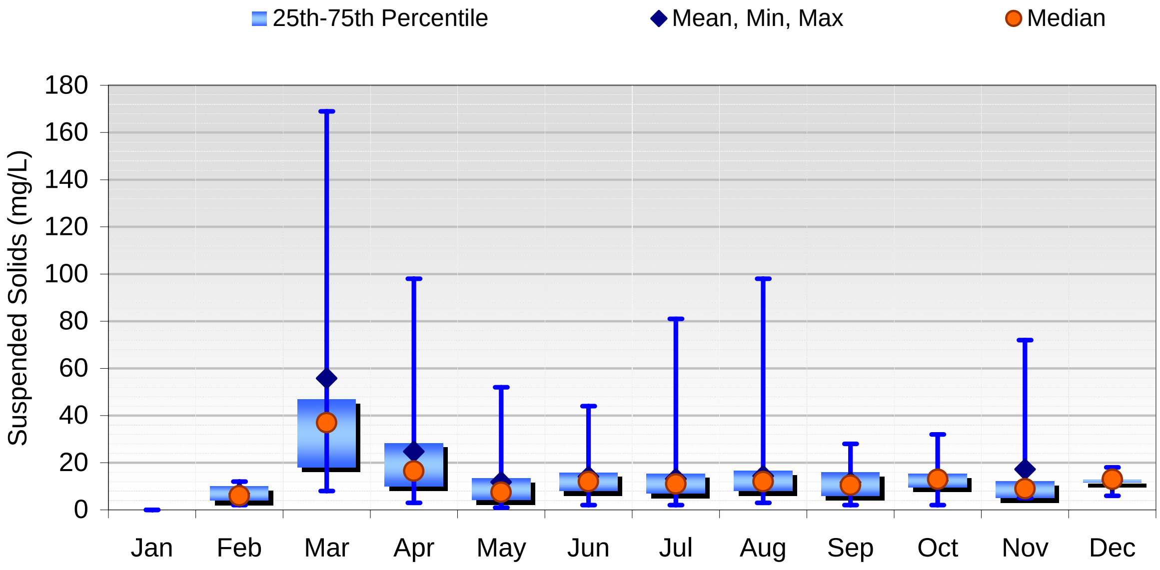

Figure 4-26. Monthly mean and median suspended solids concentrations in the Paris Twin East Lake, 1979–2002.

4.5.3 Sugar Creek (BMC2)

Water quality data collected in Sugar Creek at IEPA monitoring stations BM-1 and BM-2 are available from 1972 to 2002. Additionally, a Facility-Related Stream Survey (FRSS) was conducted in 1994 on Sugar Creek both upstream and downstream of the Paris-South sewage treatment plant (STP). The FRSS was a longitudinal survey comprised of six sampling locations, where each location was a specified distance from the Paris-South STP. Water quality constituents included sediment, nutrients, dissolved oxygen, and metals. A summary of all the water quality data is presented in the following sections. This stream segment is listed for dissolved oxygen (DO) and unspecified nutrients.

4.5.3.1 Dissolved Oxygen

The applicable water quality standard for DO in Illinois is a minimum concentration of 5.0 mg/L. Table 4-11 and Table 4-12 present the period of record, a statistical summary, and summary of violations for all available DO data in Sugar Creek. Additionally, Figure 4-27 presents a graphical representation of the DO sampling activity in Sugar Creek and Figure 4-28 presents monthly mean and median DO sample concentrations. It should be noted that data from downstream of the listed segment are included in these tables and figures for reference purposes because so few data are available for the impaired segment.

A review of the data and inspection of Figure 4-27 and Figure 4-28 reveals that only one violation of the DO standard occurred in Sugar Creek over the period of record. This single sample occurred during the FRSS sampling in 1994 at a location approximately 75 yards upstream of the Paris-South STP. Biological monitoring also indicated degraded aquatic communities. Low flows might have contributed to the low DO concentration. The monitoring report states that “Negligible flow was observed upstream of the Paris-South facility…” and “…flow over the Paris Twin Lakes spillway was negligible and the Paris-North facility was not discharging during the survey.” Additional DO data are necessary to confirm current DO conditions.

Table 4-11. Summary Statistics for Dissolved Oxygen in Sugar Creek.

Parameter	Samples (Count)	Start	End	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	CV*
Dissolved Oxygen	218	3/9/1972	11/18/2002	5.23	10.85	17.20	0.23
Dissolved Oxygen (FRSS Data)	6	8/31/1994	8/31/1994	3.00	6.35	8.90	0.31

*CV = standard deviation divided by mean

Table 4-12. Dissolved Oxygen Violations

Parameter	Samples (Count)	Violations (Count)	Percent Violating	Samples (Count), 1998 to Present	Violations (Count), 1998 to present	Percent Violating, 1998 to Present
Dissolved Oxygen	218	0	0%	25	0	0%
Dissolved Oxygen (FRSS Data)	6	1	17%	0	0	0%

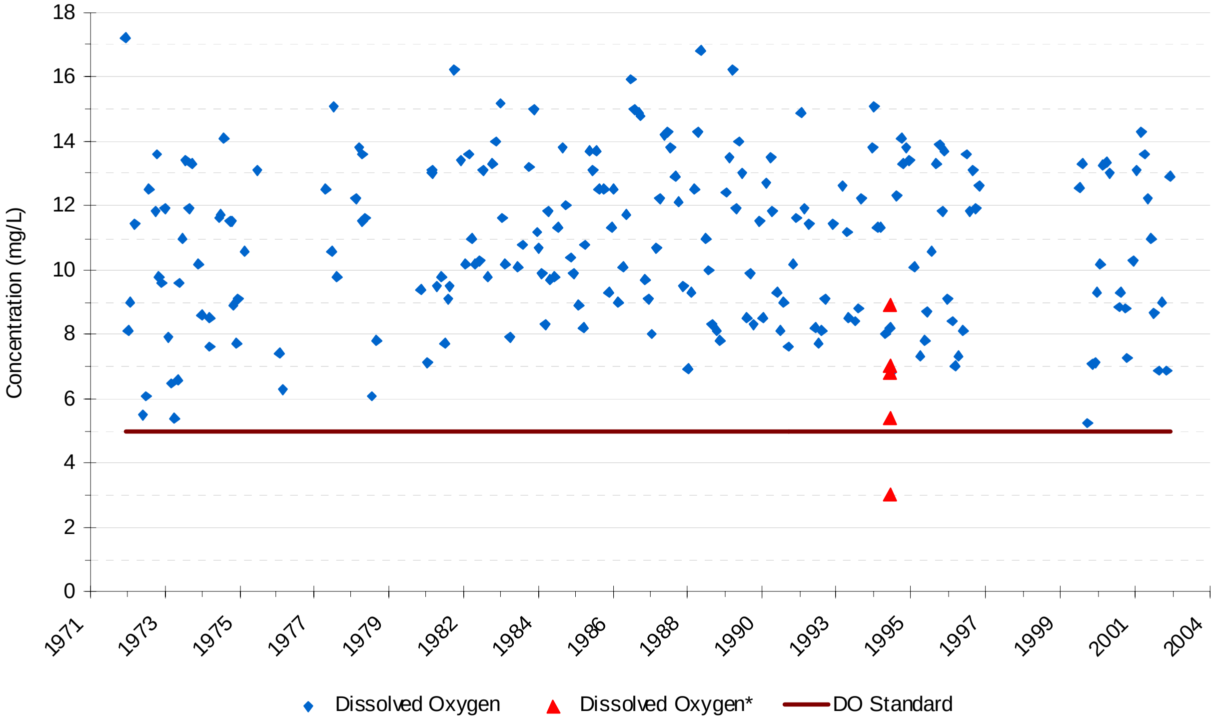

Figure 4-27. Dissolved oxygen sampling observations in Sugar Creek (* indicates FRSS data).

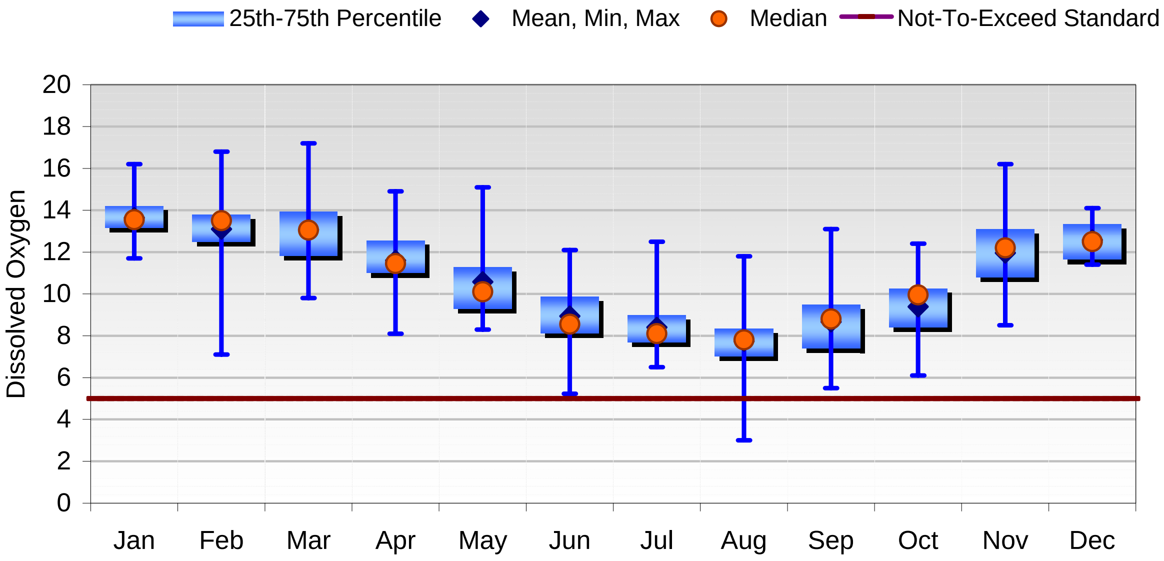

Figure 4-28. Dissolved oxygen (mg/L) monthly statistics in Sugar Creek, 1977-2002.

4.5.3.2 Nutrients

Various nutrients can contribute to excessive algal growth and ultimately low dissolved oxygen levels. Table 4-13 summarizes all available nutrient sampling in Sugar Creek. Figure 4-29 displays historic the phosphorus sampling activity for Sugar Creek. It should be noted that the following tables and graphs primarily represent data taken from IEPA monitoring stations BM-1 and BM-2, which are located several miles downstream of the listed segment. However, the FRSS data (six samples on one day in 1994) are the only data available for the listed segment.

Table 4-13. Summary of Nutrient Data Collected in Sugar Creek.

Parameter	Samples (Count)	Start	End	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	CV*
Total Phosphorus	201	3/9/1972	11/18/2002	0.01	0.40	4.80	1.69
Total Phosphorus (FRSS Data)	6	8/31/1994	8/31/1994	0.17	0.70	1.20	0.52
Dissolved Phosphorus	159	9/10/1980	11/18/2002	0.01	0.22	3.90	1.62
Total Nitrogen	3	10/18/1978	12/20/1978	2.90	3.63	4.40	0.21
Nitrate + Nitrite	264	3/9/1972	11/18/2002	0.01	3.14	14.00	0.56
Nitrate + Nitrite (FRSS Data)	6	8/31/1994	8/31/1994	0.29	3.62	6.50	0.64
TKN	3	10/18/1978	12/20/1978	0.50	0.63	0.90	0.36
Ammonia	248	10/10/1974	11/18/2002	0.00	0.12	1.60	1.37
Ammonia (FRSS Data)	6	8/31/1994	8/31/1994	0.07	0.15	0.28	0.47
Un-ionized Ammonia	202	10/10/1974	12/9/1998	0.00	0.00	0.04	1.44
Un-ionized Ammonia (FRSS Data)	6	8/31/1994	8/31/1994	0.001	0.0015	0.002	0.36

*CV = standard deviation divided by mean

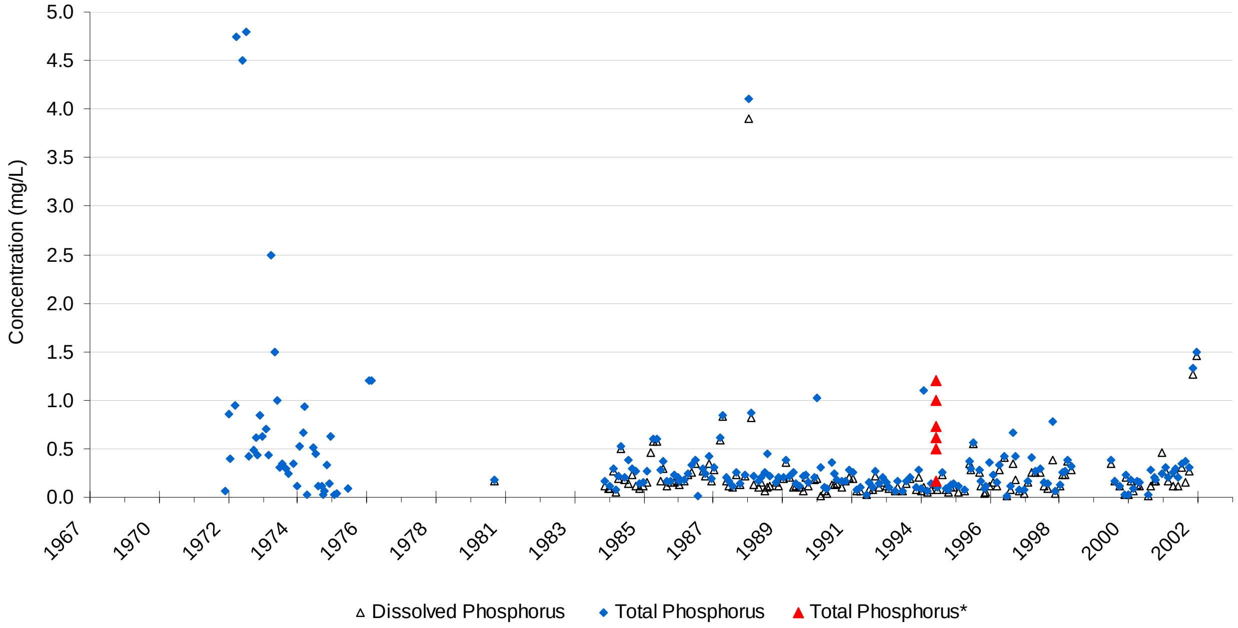

Figure 4-29. Total phosphorus and dissolved phosphorus sampling observations in Sugar Creek (* indicates FRSS data).

Monthly mean TP concentrations are presented in Figure 4-30. The figure shows that TP concentrations vary widely and are elevated in summer and fall months. In addition, dissolved phosphorus comprises an extremely large proportion of TP in Sugar Creek (Figure 4-31), with some observations comprising nearly 100 percent of TP. These high dissolved proportions remain relatively constant throughout the year, as presented in Figure 4-32.

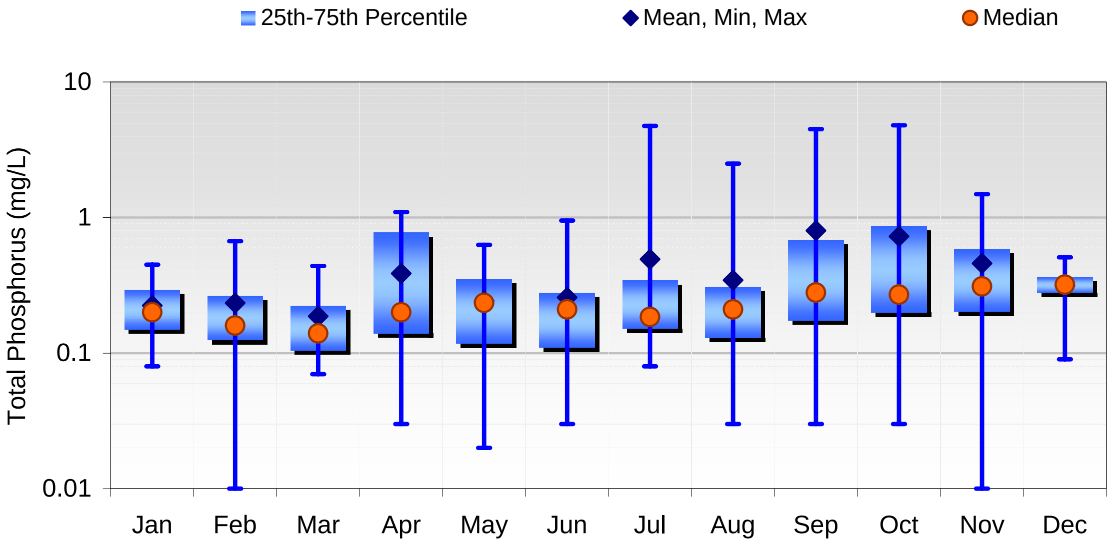

Figure 4-30. Monthly statistics for total phosphorus in Sugar Creek, 1972–2002.

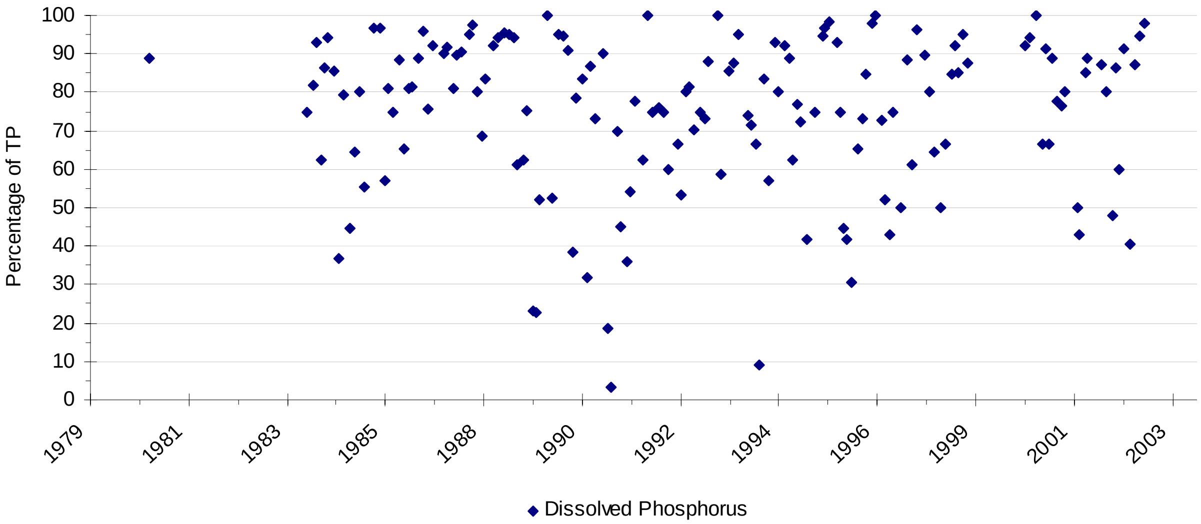

Figure 4-31. Proportion of dissolved phosphorus in total phosphorus in Sugar Creek.

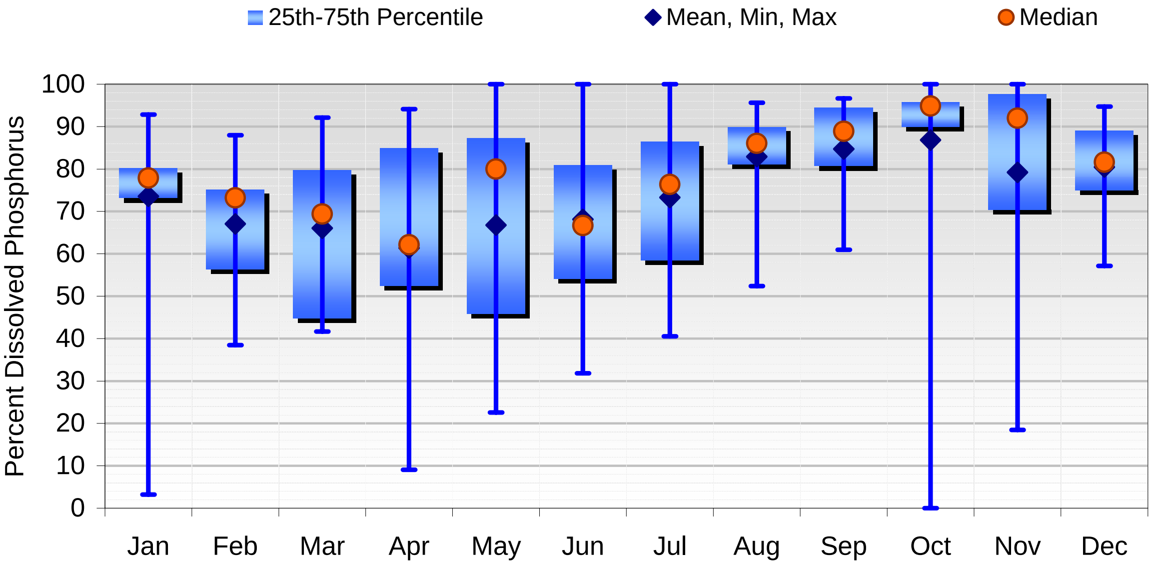

Figure 4-32. Dissolved phosphorus monthly statistics in Sugar Creek, 1972–2002.

Another important nutrient is nitrogen. The historic sampling frequency of nitrate plus nitrite in Sugar Creek is given in Figure 4-33, and monthly statistics are presented in Figure 4-34. Figure 4-34 shows that mean and median nitrate plus nitrite concentrations are higher and relatively steady in winter and spring months, with mean concentrations reaching their peak in June. Concentrations then decrease in July to levels less than those in winter and spring, and remain steady through December.

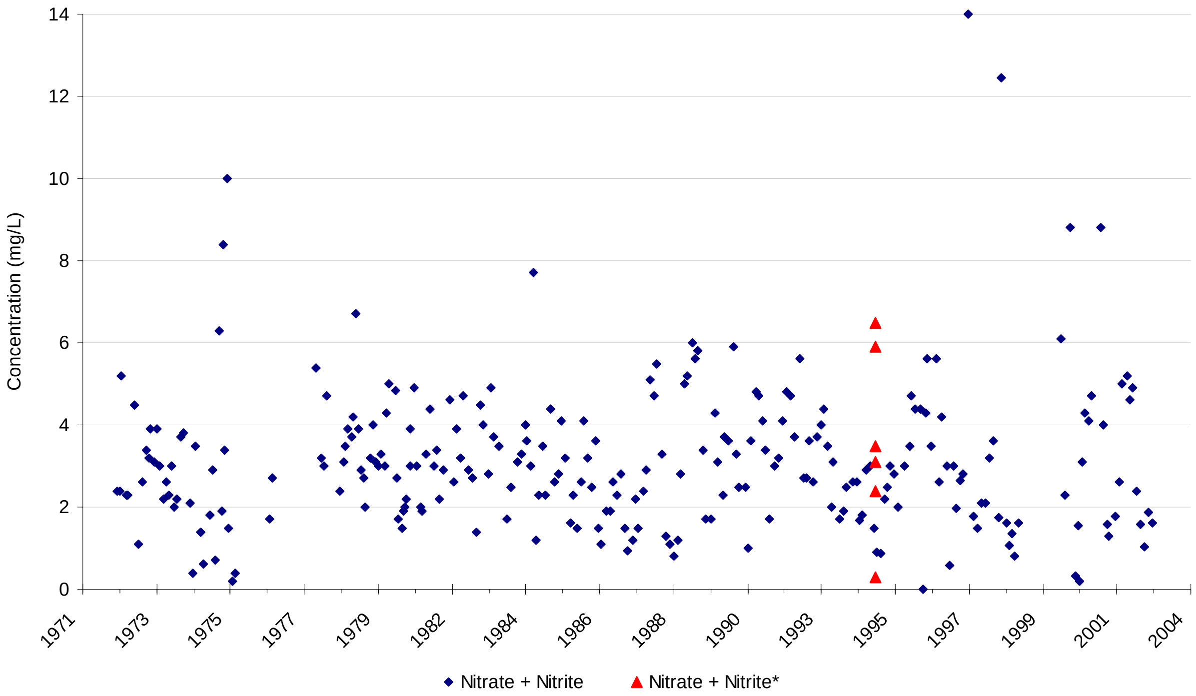

Figure 4-33. Nitrate + nitrite sampling frequency in Sugar Creek (* indicates FRSS data).

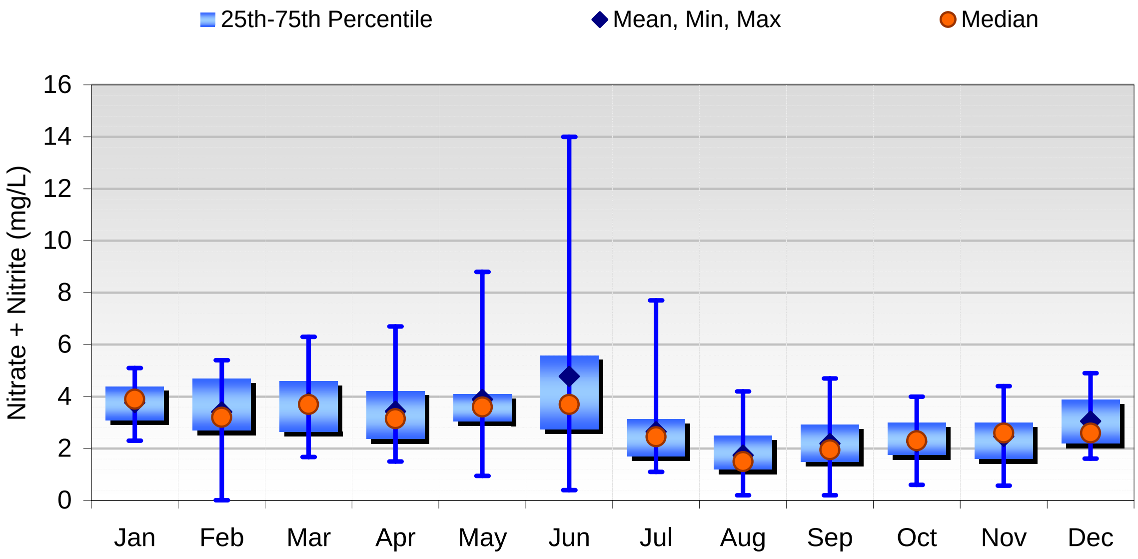

Figure 4-34. Monthly nitrate + nitrite statistics for Sugar Creek, 1972–2002.

Historic ammonia sampling data are shown graphically in Figure 4-35. Monthly ammonia concentrations are summarized in Figure 4-36. Figure 4-36 shows that ammonia levels are variable and slightly higher in winter months.

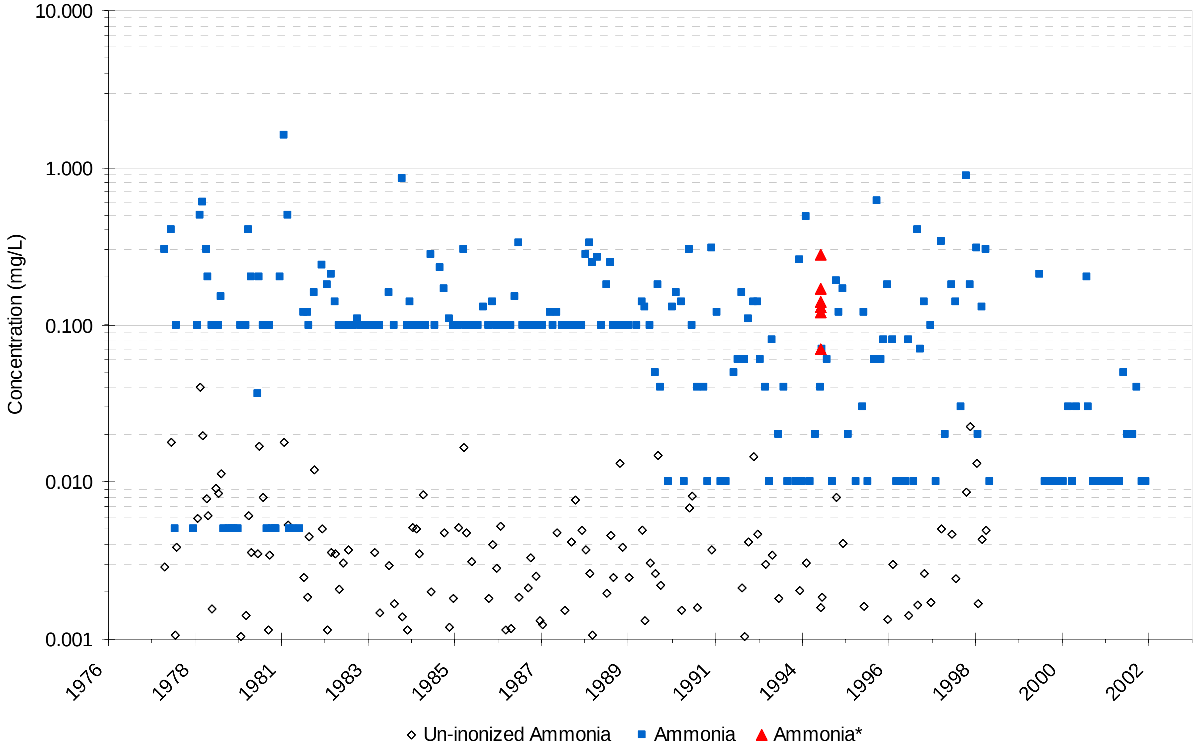

Figure 4-35. Ammonia sampling observations in Sugar Creek (* indicates FRSS data).

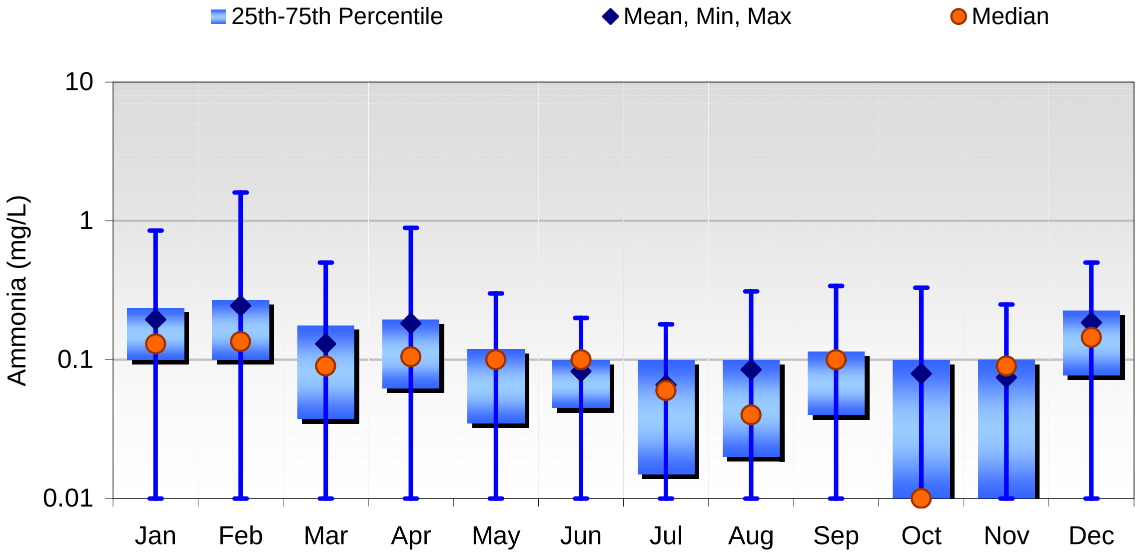

Figure 4-36. Monthly ammonia statistics in Sugar Creek, 1972-2002.

4.5.3.3 Sedimentation/Siltation

The sampling frequency of total suspended solids (TSS) for Sugar Creek is presented in Figure 4-37. A summary of monthly TSS data is presented graphically in Figure 4-38. TSS concentrations vary greatly (Figure 4-38) and the greatest mean TSS levels occur in April and September, while the lowest TSS levels occur in October and November.

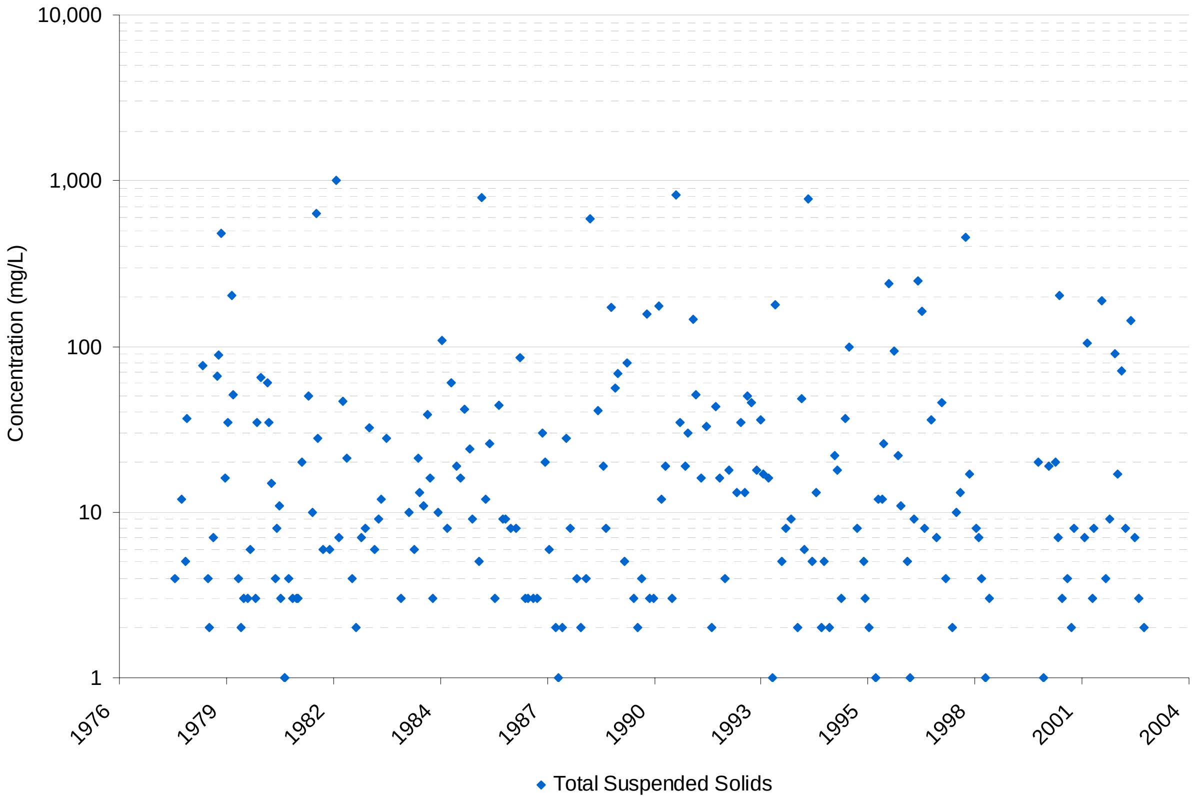

Figure 4-37. Sampling observations for total suspended solids in Sugar Creek.

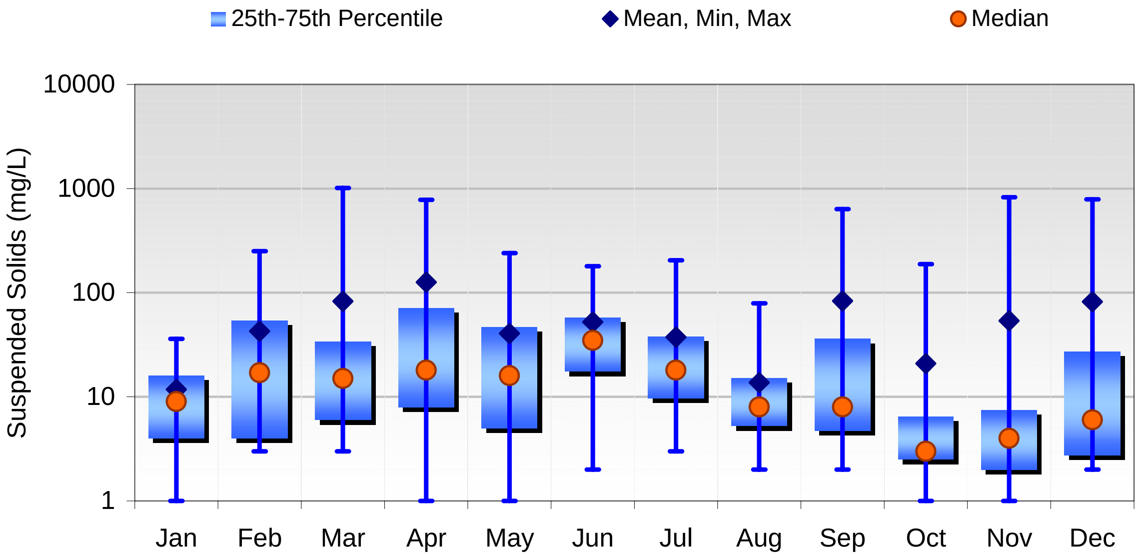

Figure 4-38. Monthly statistics for total suspended solids in Sugar Creek, 1972–2002.

4.5.4 Sugar Creek (BM02)

Water quality data collected in Sugar Creek at IEPA monitoring stations BM01 and BM02 are available from 1972 to 2002. A summary of these data is presented in Table 4-14. This segment is listed as impaired by fecal coliform.

4.5.4.1 Fecal Coliform

Table 4-14 presents a data summary of fecal coliform data collected in Sugar Creek. The applicable water quality standard for fecal coliform in Illinois is 200 colonies per 100 mL. This is the general use standard and is the more stringent applicable fecal coliform standard. The standard is based on a geometric mean of five samples collected over a 30-day period and only applies from May through October. However, no more than two samples in any month have been collected by IEPA, and most months have only one sample. Therefore it is not possible to evaluate the fecal coliform data against the standard. A significant number of the individual fecal coliform samples exceed 200 colonies/100 mL, however, and the geometric mean for all samples in most months exceeds the standard (Table 4-14).

Table 4-14. Summary statistics for fecal coliform in Sugar Creek.

Fecal Coliform	Samples (Count)	Start	End	Minimum (count/100mL)	Geometric Mean (count/100 mL)[1]	Maximum (count/100mL)
All Data	253	3/9/1972	6/21/04	0	325	180,000
May	27	5/3/1972	5/26/04	10	526	34,100
June	22	6/20/1972	6/20/04	10	528	6,600
July	20	7/13/1972	7/21/04	30	591	6,900
August	20	8/23/1973	8/26/02	0	306	7,000
September	25	9/20/1972	9/10/04	40	409	52,000
October	19	10/31/1972	10/15/03	10	228	11,600

[1] The reported value reflects the geometric mean calculated from all fecal coliform samples collected within a given month.

Figure 4-39 presents a graphical representation of the fecal coliform sampling activity in Sugar Creek, and Figure 4-40 presents monthly mean and median fecal coliform sample concentrations. Figure 4-40 shows that greater fecal coliform counts occur in the months of April, May, November and December, while lower counts occur in the summer months of June and July. This pattern suggests that fecal coliform loading to Sugar Creek is associated with the typically wetter months. However, an examination of instantaneous flow and fecal coliform counts, shown in Figure 4-41, does not display any general relationship.

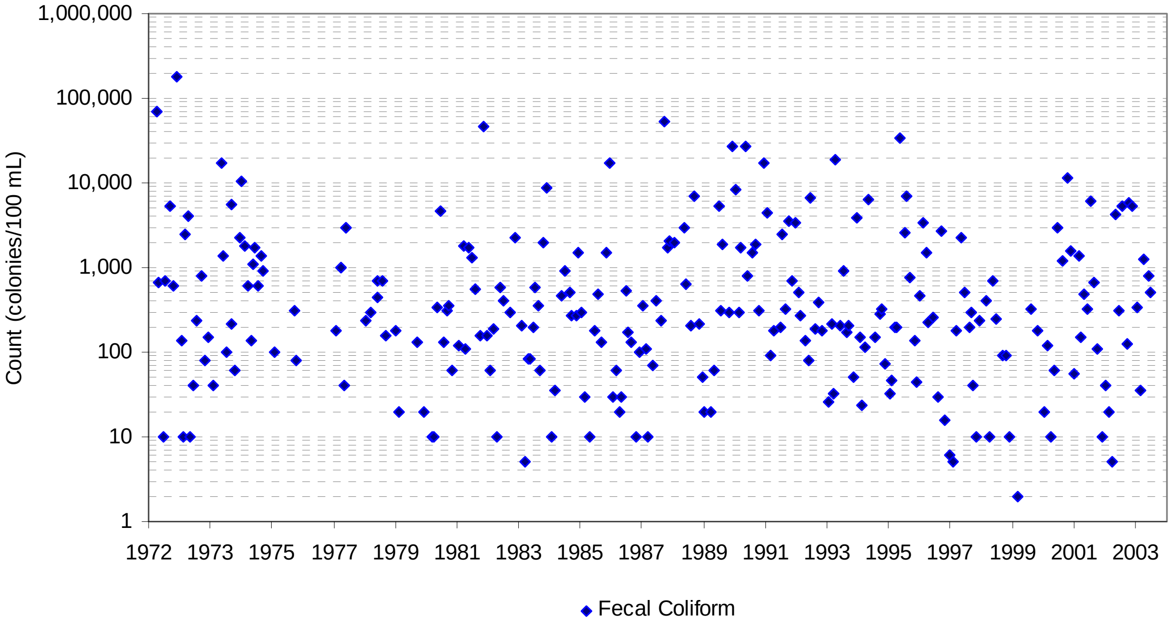

Figure 4-39. Fecal coliform sampling observations in Sugar Creek.

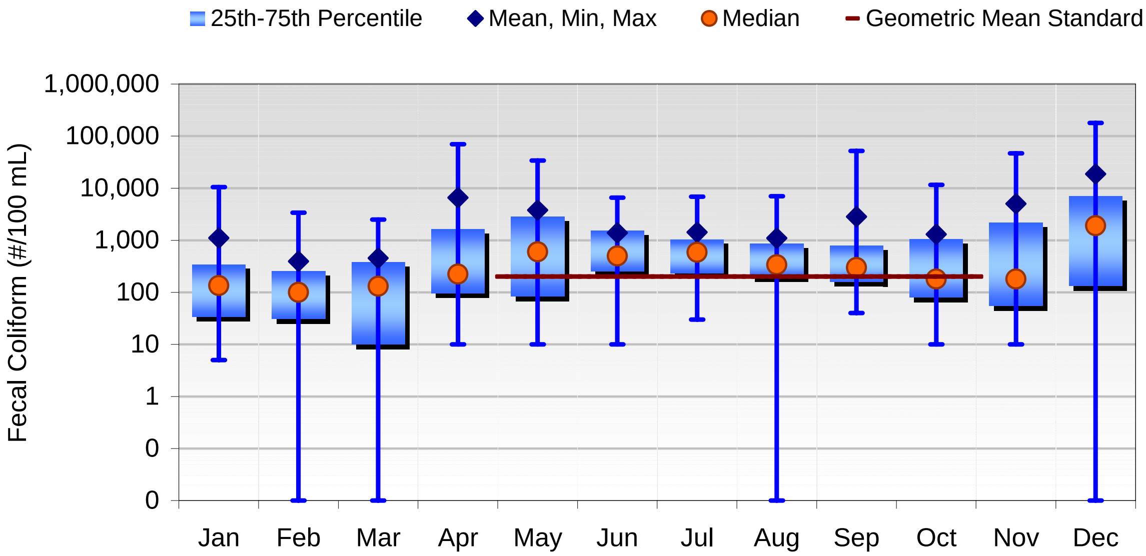

Figure 4-40. Fecal coliform monthly statistics in Sugar Creek, 1972–2004.

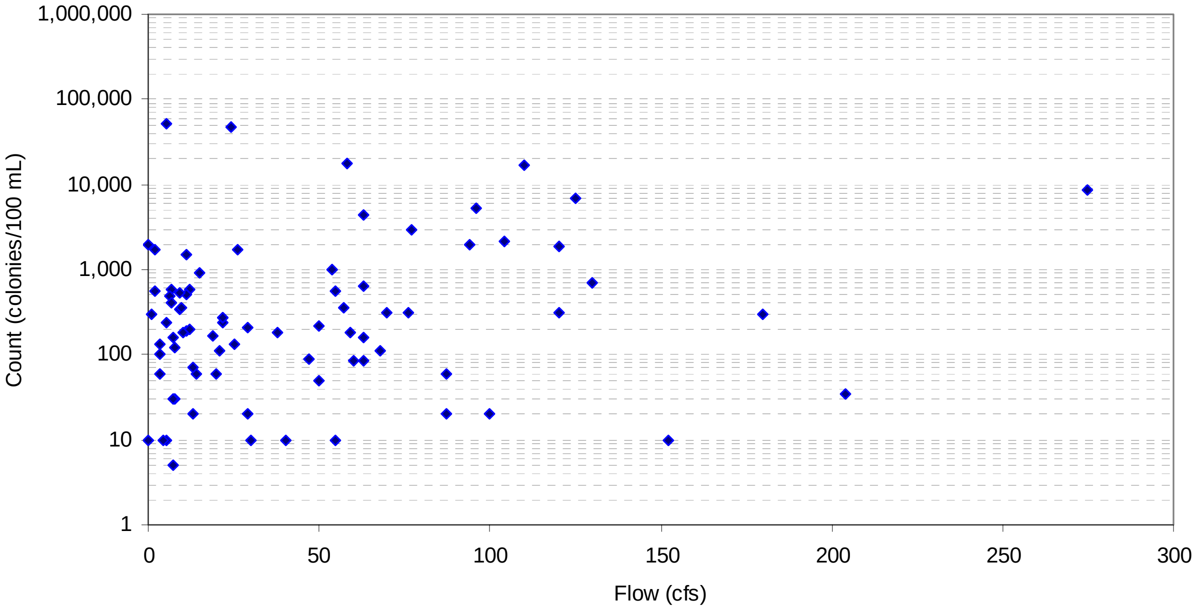

Figure 4-41. Relationship between fecal coliform concentration and flow.

5 Identification of Data Gaps

Several data gaps were identified in the Sugar Creek watershed as a result of the Stage One activities. Additional dissolved oxygen data are required in segment BMC2 at two to three locations to evaluate current conditions and to confirm whether or not the segment is still impaired. The stations should be located upstream and downstream of the sewage treatment plant outfall location and at the end of segment BMC2. Additional fecal coliform data are also required in segment BM02 to allow for a direct comparison to the water quality standards. Five samples should be collected within a 30-day period during the summer, preferably during a month with critically high historical fecal coliform counts (such as June or July).

The identified data gaps will be filled with Stage Two sampling that is scheduled to occur in 2005 and 2006.

6 Technical Approach

Potential technical approaches for developing phosphorus TMDLs for Paris Twin Lakes were identified at the end of Stage One and are summarized in this section. Both simple and more advanced technical approaches were identified and are described below.

6.1.1 Simple Approach

A simple approach to TMDL development would be to use a mass balance analysis to assess the extent to which TP loadings need to be reduced in the lake. Necessary reductions would essentially be calculated based on a comparison of existing concentrations to the standard. For example, if the existing TP concentration is twice the standard, loads would need to be reduced by 50 percent (plus perhaps a margin of safety). Existing loads from the tributaries would be estimated using the available flow and water quality data and other sources (e.g., shoreline erosion) would need to be estimated separately.

The advantages of the simple approach are that it would be easy to apply and therefore could be done quickly. The disadvantages include the fact that loadings and water quality response are not always linearly related (as is assumed with the approach) and limited information would be available on certain other potential sources of the pollutants (e.g., TP from the lake bottom sediments). Dissolved oxygen concentrations would also not be simulated using the simple approach.

6.1.2 Detailed Approach

Under a more detailed approach both a watershed and a lake model would be developed and applied for the Paris Twin Lakes TP TMDL. The purpose of the lake model would be to estimate the extent to which lake bottom sediments contribute phosphorus loads and to assess the potential water quality response of reduced loadings. A watershed model would be useful for the following:

1) Help estimate existing inflows to the lake to complement the available flow data.
2) Help estimate existing sediment and nutrient loads to the lakes by complementing the available water quality data.
3) Provide additional perspective on the relative magnitude of the various sediment and nutrient sources.
4) Assess the potential benefit of various best management practices.

Output from the watershed model would then be linked to either the BATHTUB or LAKE2K models to simulate impacts in the lake. BATHTUB performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network and has previously been used for TMDL development in Illinois. LAKE2K is a recently released model that was designed to compute seasonal trends of water quality in stratified lakes (Chapra and Martin, 2004). LAKE2K is a more data-intensive model but an advantage to BATHTUB is that it provides daily predictions of water quality.

Based on input from stakeholders and the Science Advisory Committee, IEPA decided to use the BATHTUB model to develop the Paris Twin Lakes TP TMDL. Loads to the BATHTUB model were estimated based on data from a comparable watershed rather than from a watershed model (refer to Section 8 for more detail).

Stage Three Report: TMDL Development for Paris Twin Lakes

(Stage Three TMDL Development for Sugar Creek is Available in a Separate Report)

7 Source Assessment

This section of the report briefly identifies potential sources of TP. An implementation plan will be prepared that will address these sources in more detail.

7.1 Point Sources

There are no point sources upstream of the Paris Twin Lakes.

7.2 Nonpoint Sources

Phosphorus is attached to soil particles and therefore sheet and rill erosion, lake shoreline erosion, and streambank erosion are all potential sources of phosphorus to Paris Twin Lakes. Commercial fertilizers and human waste also contains phosphorus and therefore manured fields, failing septic systems, and sewage treatment plants are additional potential sources. Internal recycling of phosphorus is another potential source of TP. No animal confinements are located in the watershed and the majority of livestock are cattle on pasture (Edgar County Soil and Water Conservation District, personal communications). One of the purposes of the Implementation Plan will be to assess the relative significance of each of the various nonpoint sources of TP and the extent to which they can be controlled.

8 Technical Analysis

Establishing the link between pollutant loads and resulting water quality is one of the most important steps in developing a TMDL. This link can be established through a variety of techniques ranging from simple mass balance analyses to sophisticated computer modeling. The objective of this section of the report is to describe the approach that was used to link the sources of phosphorus with the resulting concentrations in the Paris Twin Lakes.

8.1 Modeling Approach and Model Selection

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

8.2 Model Setup

The BATHTUB model requires the following data to configure and calibrate: tributary flows and concentrations, reservoir bathymetry, in-lake water quality concentrations, and global parameters such as evaporation rates and annual average precipitation. Lake bathymetry data were available from the Phase II Implementation study (Illinois EPA, 1998) and are summarized in Table 8-1.

Table 8-1. Bathymetry Data for Paris Twin Lakes

Parameter	West Lake	East Lake
Surface Area (ha)	25.1	65.9
Maximum Depth (m)	2.6	8.1
Mean Depth (m)	1.0	3.1
Average Retention Time (yr)	0.156	1.99

Tributary flows and corresponding phosphorus concentrations are not available for Sugar Creek upstream of the Paris Twin Lakes. Daily stream flow and phosphorus loading into the Paris West Twin Lake were therefore estimated from a USGS monitoring station where both flow and phosphorus data are available. Suitable surrogate monitoring stations are limited, however, the West Okaw River station (USGS 05591700) was deemed acceptable. The station drains an area of 112 square miles devoted mostly to corn and soybean production. Additionally, there are no NPDES permitted dischargers above the monitoring station. Furthermore, the station has water quality data available from 1980 through 1997.

Stream flow for the drainage above the Paris Twin Lakes was estimated from observed West Okaw River daily stream flows. Stream flows were calculated as proportional flow at Paris Twin Lakes based upon the ratio of drainage area of the lakes to the West Okaw River drainage area. The ratio of the Paris Twin Lakes drainage area to the West Okaw River drainage area is 22 mi^2 to 112 mi^2 or 0.196. Thus, the West Okaw River daily stream flows were multiplied by 0.196 to estimate daily tributary inflow for the Paris Twin Lakes.

A daily stream flow and total phosphorus time series of tributary flows entering the Paris Twin Lakes was calculated using the following procedure:

1. Computed percentile-rank flow for daily stream flow at West Okaw River USGS gage 5591700.
2. Divided percentile flows into 5-percent increments (e.g. all flows up to the 5th percentile, all flows from 5.1 to the 10th percentile, etc.)
3. Matched date of observed TP observation with date and mean daily flow from West Okaw River data.
4. Selected all observed West Okaw River TP data within each percentile flow range and calculated a median TP for each range.
5. Assigned calculated median TP concentrations for each flow percentile range to corresponding flow observations observed at West Okaw River.
6. Calculated new flow estimates for Paris Twin Lakes through use of unit area weighting method and flow data observed at West Okaw River.

The estimated watershed loading and total annual flow volumes to West Lake are reported in Table 8-2. Loads to East Lake are estimated from the yearly flow volumes through West Lake and the average nutrient concentrations. These loads are reported with the results.

Table 8-2. Watershed Loading To West Lake

Year	Stream flow (cm*km2)	TP (1000 kg)	TP (lbs)
1990	2433.1	4.9	10,800
1991	1558.6	2.4	5,290
1992	2062.7	4.3	9,480
1993	3329.7	6.4	14,110
1994	1736.0	3.2	7,050
1995	1596.4	2.9	6,390
1996	2317.2	5.9	13,010
1997	1196.4	1.8	3,970
1998	2886.6	6.7	14,770
1999	1856.7	3.4	7,500
2000	1190.4	1.4	3,090
2001	2132.4	3.7	8,160

The BATHTUB model requires input of the fraction of inorganic nutrient load. Inorganic fractions for West Lake were assumed 0.3 for phosphorus based on the long-term median of observed data at the most upstream sampling station in West Lake (RBX-3). Water quality data at the outlet of West Lake (station RBX-1) were used to obtain inorganic fractions to East Lake by year (Table 8-3). When data were not available to calculate a yearly fraction, the average of all observed fractions was used.

Table 8-3. Inorganic Nutrient Fractions to East Lake

Year	Inorganic Phosphorus Fraction
1990	0.44
1991	0.33
1992	0.45
1993	0.35[a]
1994	0.35[a]
1995	0.18
1996	0.35[a]
1997	0.33
1998	0.35
1999	0.35[a]
2000	0.35[a]
2001	0.45

[a]. Data not available to calculate inorganic fraction; used overall average.

The BATHTUB model was set up to simulate nutrient responses in the two Paris Twin Lakes for the years 1990 through 2001 to correspond with available water quality data. Several of the nutrient response routines available within BATHTUB were tested. These included the Canfield and Bachman, Vollenweider, Simple First Order, and Second Order Decay routines. The Second Order Decay routine was selected for the modeling because it provided the best calibration to the observed data. For West Lake, nutrient calibration factors were set to 3 for nitrogen and 2 for phosphorus. (Both nitrogen and phosphorus were modeled to fully assess lake eutrophication, even though the TMDL is only for phosphorus). For East Lake the calibration factors were both set to 0.5. Calibration factors were adjusted within the default range so that the average ratio of simulated to observed nutrient concentrations was close to 1.

Table 8-4 and Figure 8-1 compares the simulated and observed nutrient concentrations in West Lake. A relatively good match between predicted and observed concentrations was obtained for almost all years given the limitations regarding the loading data. Note that no observations are available in 1993, 1999, or 2000.

Table 8-4. Simulated and Observed Nutrient Concentrations in West Lake

Year	Simulated TP (mg/L)	Observed TP (mg/L)	Relative Error
1990	0.130	0.137	-5.1%
1991	0.097	0.148	-34.5%
1992	0.129	0.135	-4.4%
1993	0.133		N/A
1994	0.113	0.095	18.9%
1995	0.112	0.085	31.8%
1996	0.154	0.077	100.0%
1997	0.092	0.082	12.2%
1998	0.151	0.137	10.2%
1999	0.116		N/A
2000	0.074		N/A
2001	0.114	0.124	-8.1%
1990 to 2001 Average	0.118	0.113	4.0%

Notes: Relative error equals (Simulated TP – Observed TP)/(Observed TP); N/A = Not Applicable

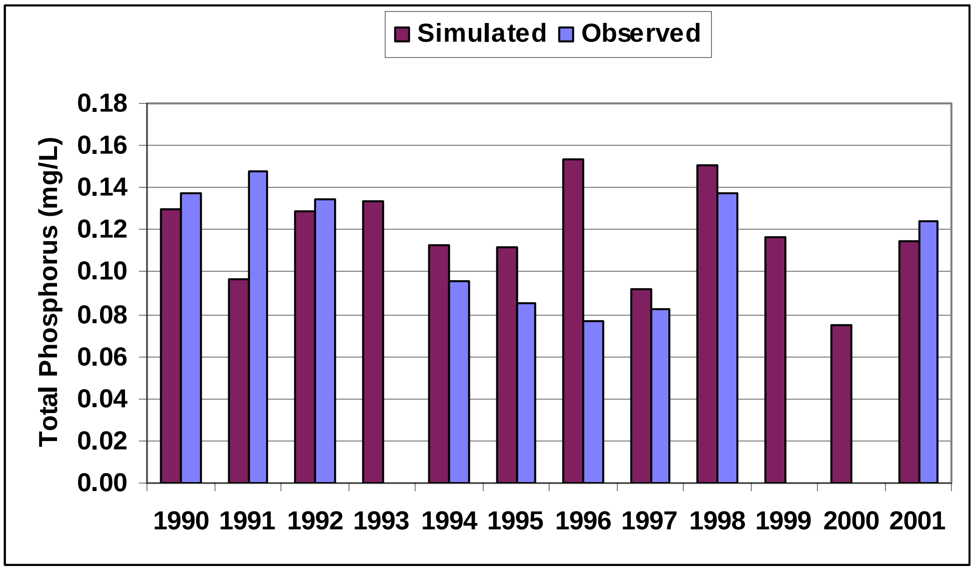

Figure 8-1. Comparison of Simulated and Observed Total Phosphorus Concentrations in West Lake

Average annual nutrient concentrations and flow volumes from the BATHTUB West Lake modeling were used to estimate annual loads to East Lake. These are summarized in Table 8-5.

Table 8-5. Nutrient Loading To East Lake

Year	TP load (1000 kg)	TP load (lbs)
1990	3.2	7,050
1991	1.5	3,310
1992	2.7	5,950
1993	4.4	9,700
1994	2.0	4,410
1995	1.8	3,970
1996	3.6	7,940
1997	1.1	2,430
1998	4.4	9,700
1999	2.2	4,850
2000	0.9	1,980
2001	2.4	5,290

Simulated and observed nutrient concentrations in East Lake are summarized in Table 8-6 and Figure 8-2. A moderate match between simulated and observed concentrations was obtained. The poorer performance of the model for East Lake is likely due to errors in the estimates of upstream watershed loadings and in the modeling of West Lake being propagated downstream. The implications of this poorer performance are mitigated by the fact the TMDL allocations are driven by the results of the West Lake modeling; see Section 9.1).

Table 8-6. Simulated and Observed Nutrient Concentrations in East Lake

Year	Simulated TP (mg/L)	Observed TP (mg/L)	Relative Error
1990	0.100	0.111	-9.9%
1991	0.065	0.082	-20.7%
1992	0.098	0.111	-11.7%
1993	0.096		N/A
1994	0.076	0.053	43.4%
1995	0.055	0.089	-38.2%
1996	0.101	0.127	-20.5%
1997	0.060	0.104	-42.3%
1998	0.103	0.130	-20.8%
1999	0.078		N/A
2000	0.053		N/A
2001	0.090	0.1308	-31.2%
1990 to 2001 Average	0.08125	0.1042	-22.0%

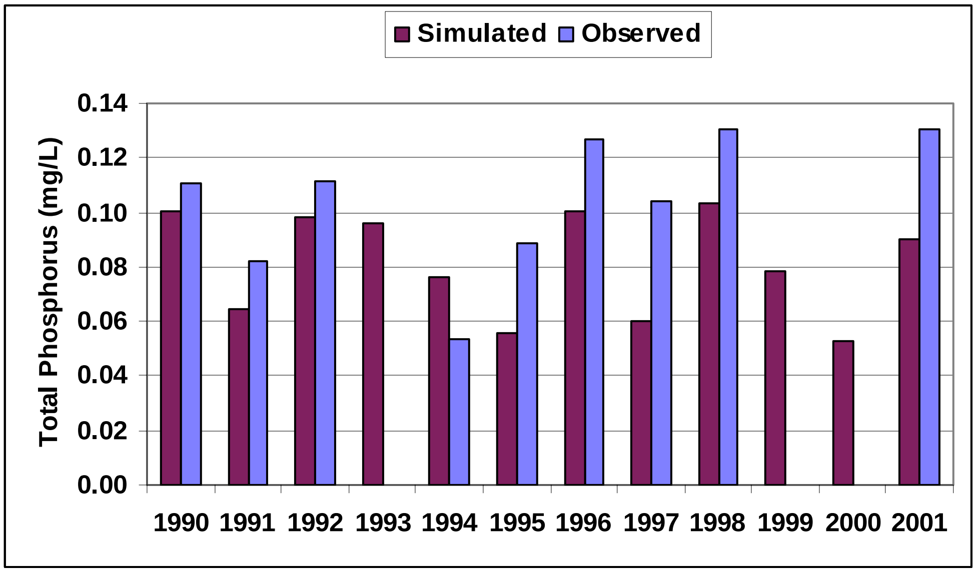

Figure 8-2. Comparison of Simulated and Observed Total Phosphorus Concentrations in East Lake

9 TMDL

This section of the report presents the various components of the Paris Twin Lakes total phosphorus TMDL, as required by the Clean Water Act.

9.1 Loading Capacity

The calibrated BATHTUB model was used to identify the load reductions necessary to achieve a target concentration of 0.05 mg/L phosphorus. In order to meet the target during all years in both lakes, a 75 percent reduction of phosphorus loading is required. Table 9-1 shows the predicted annual average total phosphorus concentrations in both lakes if a 75 percent reduction is implemented. The table also indicates that during most years a 75 percent reduction in loads will result in lake water quality being significantly less than the water quality standard, thus providing an added margin of safety (see Section 9.4 below).

Table 9-1. Average Total Phosphorus Concentration in the Paris Twin Lakes with 75 Percent Reduction in Loading.

Year	West Lake TP (mg/L)	West Lake Comparison to WQS	East Lake TP (mg/L)	East Lake Comparison to WQS
1990	0.04	-20%	0.04	-20%
1991	0.031	-38%	0.026	-48%
1992	0.041	-18%	0.04	-20%
1993	0.04	-20%	0.036	-28%
1994	0.036	-28%	0.031	-38%
1995	0.036	-28%	0.022	-56%
1996	0.05	0%	0.041	-18%
1997	0.03	-40%	0.025	-50%
1998	0.047	-6%	0.04	-20%
1999	0.037	-26%	0.032	-36%
2000	0.024	-52%	0.021	-58%
2001	0.036	-28%	0.036	-28%
1990 to 2001 Average	0.037333	-25%	0.0325	-35%

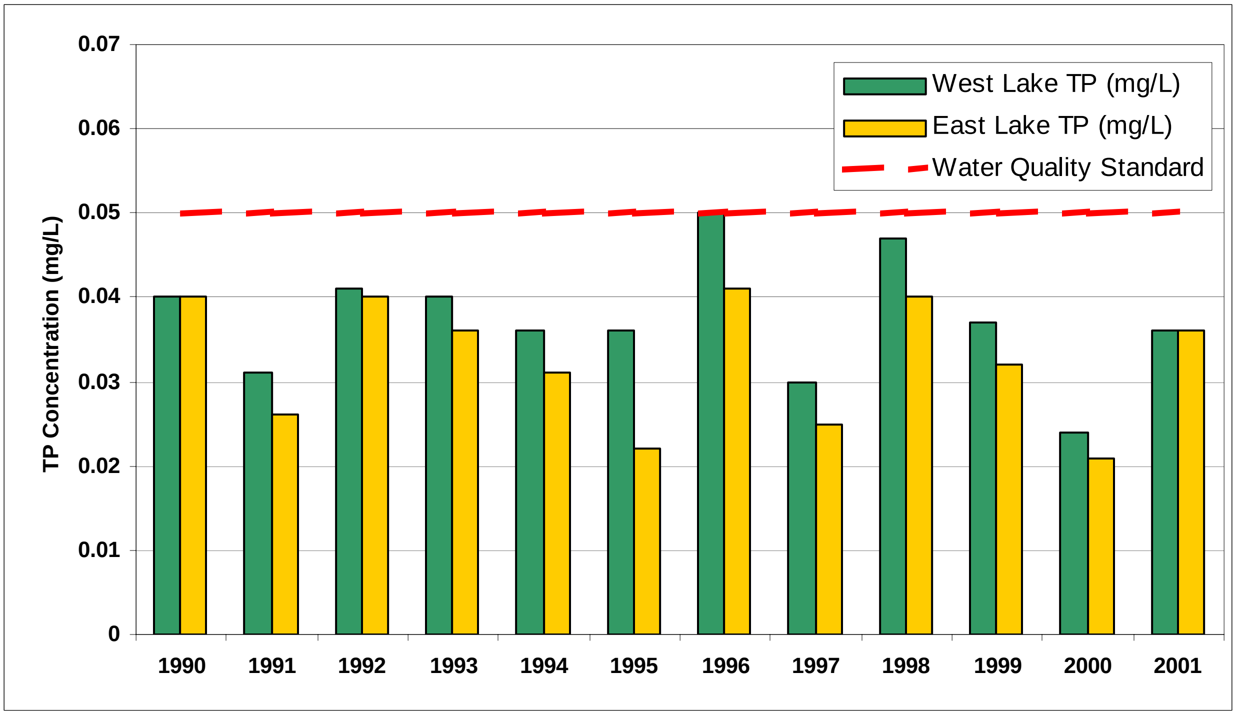

Figure 9-1. Predicted Average Total Phosphorus Concentration in the Paris Twin Lakes with 75 Percent Reduction in Loading.

9.2 Allocations

The allocations of loads for the Paris Twin Lakes TMDL are summarized in Table 9-2 and Table 9-3. The existing loads are the average loads to West and East Lake for the period 1990 to 2001 (to correspond to the modeling analysis). The loading capacity represents the 75 percent reduction from existing loads determined to be necessary from the modeling analysis. The wasteload allocation is zero because there are no point sources in the Sugar Creek watershed upstream of the lakes. Five percent of the loading capacity is reserved for a margin of safety (as required by the Clean Water Act; see Section 9.4).

It should also be noted that internal recycling of phosphorus could also likely be a significant factor affecting TP concentrations, especially for East Lake because of the known low dissolved oxygen concentrations. The significance of internal phosphorus recycling in both lakes and its implications for implementation activities will be further discussed in the Implementation Plan.

Table 9-2. TMDL Summary for West Lake.

Category	Phosphorus (kg/yr)
Existing Load	3,920
Loading Capacity	980
Wasteload Allocation	0
Margin of Safety	49
Load Allocation	931

Table 9-3. TMDL Summary for East Lake.

Category	Phosphorus (kg/yr)
Existing Load	2,520
Loading Capacity	630
Wasteload Allocation	0
Margin of Safety	32
Load Allocation	598

9.3 Seasonality

Section 303(d)(1)(C) of the Clean Water Act and USEPA's regulations at 40 CFR 130.7(c)(1) require that a TMDL be established that addresses seasonal variations normally found in natural systems. For the Paris Twin Lakes, the impact of seasonal and other short-term variability in loading is damped out by the fact that it is the long-term average TP concentrations that drives the biotic response. Since the residence time of East Lake is greater than one year, the TMDL can be adequately expressed in terms of an annual average load.

9.4 Margin of Safety

Section 303(d) of the Clean Water Act and USEPA's regulations at 40 CFR 130.7 require that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standards with seasonal variations and a margin of safety which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality." The margin of safety can either be implicitly incorporated into conservative assumptions used to develop the TMDL or added as a separate explicit component of the TMDL (USEPA, 1991). A 5 percent explicit margin of safety has been incorporated into the Paris Twin Lakes TMDL by reserving a portion of the loading capacity. A relatively low margin of safety was chosen based on the good match between the BATHTUB modeling results and observed data (i.e., the BATHUB model is believed to represent the system fairly well; see Table 8-4 and Table 8-5). An additional implicit margin of safety is associated with the loading capacity resulting in lake water quality being significantly less than the water quality standard in all but the most critical years.

9.5 Critical Conditions

The highest concentrations of TP and chlorophyll *a* are typically observed in Paris Twin Lakes in late summer (July/August). The BATHTUB model takes this into account when simulating average annual concentrations of both parameters. The highest loadings of TP are in the spring when streamflow is at its highest. This was accounted for because the annual loads used for BATHTUB are based on estimates of daily streamflows and TP concentrations.

10 Implementation

A project Implementation Plan will be prepared that will more fully address likely TP sources and potential implementation activities that can achieve the desired reductions in phosphorus loading. The implementation plan will include a range of alternatives along with their expected costs and benefits. BMPs will be recommended based on their ability to address the most significant sources and cost. IEPA believes that the identified load reductions will be achievable with broad adoption of BMPs. IEPA will work with local agencies and stakeholder groups to identify BMPs that will result in meeting water quality goals. Future monitoring recommendations will also be included in the Implementation Plan and will explain how the watershed will be routinely sampled as part of IEPA's Five-Year Intensive Basin Surveys (the watershed is due to be scheduled again in 2006). Since the Paris Twin Lakes are "core" lakes, they should also be sampled in 2007 and every three years thereafter, depending on available resources.

A separate public meeting will be held to specifically discuss issues related to implementation once the Implementation Plan is completed.

References

Bogner, W.C., 1992. Sedimentation Survey of Paris West Lake, Edgar County, Illinois. Illinois State Water Survey, SWS Contract Report 527. 47 pp.

Chapra, S. C., 1997. Surface Water Quality Modeling. McGraw Hill. Boston, Massachusetts.

Chapra, S.C. and Martin, J.L. 2004. LAKE2K: A Modeling Framework for Simulating Lake Water Quality (Version 1.2): Documentation and Users Manual. Civil and Environmental Engineering Dept., Tufts University, Medford, MA.

Illinois Department of Agriculture, 2000. 2000 Illinois Soil Conservation Transect Survey Summary, Springfield, Illinois.

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

Illinois EPA, 1992. Phase I Diagnostic/Feasibility Study of Paris Twin Lakes, Edgar County, Illinois. Springfield, Illinois.

Illinois EPA, 1998. Phase II Project Report of Paris Twin Lakes, Edgar County, Illinois. Springfield, Illinois.

Illinois EPA, 2002. Illinois 2002 Draft Section 303(d) List. Illinois Environmental Protection Agency. Springfield, Illinois.

Illinois EPA, 2004. Illinois 2004 Section 303(d) List. Illinois Environmental Protection Agency. Springfield, Illinois.

INHS, 2003. Illinois Natural History Survey's 1999-2000 1:100 000 Scale Illinois Gap Analysis Land Cover Classification, Raster Digital Data, Version 2.0, September 2003.

Newcombe, C.P., and J.O.T. Jensen. 1996. Channel suspended sediment and fisheries: A synthesis for quantitative assessment of risk and impact. *N. Am. J. Fish. Manage.* 16:693–627.

NHD, 2003. National Hydrography Dataset. U.S. Environmental Protection Agency, Washington, DC.

USEPA, 1986. *Ambient Water Quality Criteria for Bacteria–1986.* EPA-A440/5-84-002. U.S. Environmental Protection Agency, Washington, DC.

USEPA, 1999. Protocol for Developing Nutrient TMDLs. 1st edition. EPA-841-B-99-007. U.S. Environmental Protection Agency. Office of Water, Washington, D.C.

Wischmeier, W.H., and Smith, D.D., 1978. Predicting Rainfall Erosion Losses - A Guide to Conservation Planning. Agricultural Handbook No. 537. U.S. Department of Agriculture, Washington, D.C.

Zucker, L.A. and L.C. Brown (Eds.). 1998. Agricultural Drainage: Water Quality Impacts and Subsurface Drainage Studies in the Midwest. Ohio State University Extension Bulletin 871. The Ohio State University.

Appendix A: Illinois GAP Land Cover Description

Table A-1. Values and class names in the Illinois Gap Analysis Project Land Cover 1999-2000 Arc/Info GRID coverage.

GRID VALUE	LAND COVER CATEGORY
	AGRICULTURAL LAND
11	Corn
12	Soybeans
13	Winter Wheat
14	Other Small Grains and Hay
15	Winter Wheat/Soybeans
16	Other Agriculture
17	Rural Grassland
	FORESTED LAND
22	Dry Upland
23	Dry-Mesic Upland
24	Mesic Upland
25	Partial Canopy/Savannah Upland
26	Coniferous
	URBAN LAND
31	High Density
32	Low/Medium Density (excluding TM Scene 2331)
33	Medium Density (TM Scene 2331)
34	Low Density (TM Scene 2331)
35	Urban Open Space
	WETLAND
41	Shallow Marsh/Wet Meadow
42	Deep Marsh
43	Seasonally/Temporarily Flooded
45	Mesic Floodplain Forest
46	Wet-Mesic Floodplain Forest
47	Wet Floodplain Forest
48	Swamp
49	Shallow Water
	OTHER
51	Surface Water
52	Barren and Exposed Land
53	Clouds
53	Cloud Shadows

Appendix B: Water Quality Data for the Sugar Creek Watershed

Available Upon Request

Contact Illinois EPA at 217-782-3362

Appendix C: Responsiveness Summary

Responsiveness Summary

This responsiveness summary responds to substantive questions and comments received during the public comment period from July 29, 2005 through September 2, 2005 postmarked, including those from the August 16, 2005 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. The Paris Twin Lakes TMDL report contains a plan detailing the actions necessary to reduce pollutant loads to the impaired water bodies and ensure compliance with applicable water quality standards. The Illinois EPA implements the TMDL program in accordance with Section 303(d) of the federal Clean Water Act and regulations thereunder.

Background

The watershed targeted for TMDL development is Sugar Creek, which originates in Edgar County. The watershed encompasses an area of approximately 65 square miles. Land use in the watershed is predominately agriculture. Paris Twin West Lake has a surface area of approximately 57 acres and Paris Twin East Lake has a surface area of approximately 163 acres and is used as the drinking water source for the city of Paris. Both water bodies are listed on the Illinois EPA 2004 Section 303(d) List as being impaired for total phosphorus, excessive algal growth, and total suspended solids. The Clean Water Act and USEPA regulations require that states develop TMDLs for waters on the Section 303(d) List. Illinois EPA is currently developing TMDLs for pollutants that have numeric water quality standards. Therefore, TMDLs were only developed for total phosphorus. The Illinois EPA contracted with Tetra Tech, Inc., to prepare a TMDL report for the Sugar Creek watershed.

Public Meetings

Public meetings were held in the city of Paris on March 8, 2005, and August 16, 2005. The Illinois EPA provided public notice for both meetings by placing display ads in the Paris Beacon. This notice gave the date, time, location, and purpose of the meeting. The notice also provided references to obtain additional information about this specific site, the TMDL Program and other related issues. Approximately 198 individuals and organizations were also sent the public notice by first class mail. The draft TMDL Report was available for review at the Paris City Hall and also on the Agency's web page at http://www.epa.state.il.us/water/tmdl .

A public meeting started at 6:30 p.m. on Tuesday, August 16, 2005. It was attended by approximately 13 people and concluded at 7:25 p.m. with the meeting record remaining open until midnight, September 2, 2005.

Questions and Comments

1. Do data exist from the tributaries to West Lake?

   Response: Some limited nitrogen, phosphorus, and sediment data exist from tributary sampling that occurred in 1997 during Phase II of the Clean Lakes Study.

2. How much of the phosphorus is attributed to over-application of fertilizer on farm fields?

   Response: Since a watershed model was not used, the loads attributed to certain sources or land uses were not determined. Furthermore, producers' fertilizer use on a watershed basis is not readily available. If a producer does not regularly soil test and does not follow a nutrient management plan, it is possible that over-application may occur.

3. It is important for farmers to have nutrient management plans in place on their farms and perform regular soil testing. Nutrient management plans are becoming more important in terms of their requirements for qualification for certain Farm Bill programs.

   Response: Thank you for your comment.

4. West Lake was dredged several years ago. How long does it take for the sediment to settle out? Are we still seeing high phosphorus concentrations in the lake due to the dredging process?

   Response: The dredging operation was completed in the spring of 1996. The most recently available water quality data were taken in 2001. Sediment that was disturbed during the dredging would have settled out or been flushed through the system during the five-year period.

5. Since the dredging, it has been observed that West Lake doesn't get as low as it used to during low flows. Even during the drought this summer, the lake never got that low. There are natural springs in the area. Could it be that the dredging uncovered a spring that keeps the water level up and adding more flow?

   Response: Groundwater inflows and outflows were estimated in a previous study (Illinois EPA, 1992) and the average difference between the two was considered to be relatively small (3.8 percent of total lake outflows). However, it is possible that the dredging that was completed in 1996 uncovered a natural spring that is now contributing more significant groundwater flows. The impact of this new source of water does not appear to have lead to a significant change in water quality, though. Concentrations

of most pollutants, including total phosphorus, are not significantly different between the pre-dredging and post-dredging periods.

6. One major source of phosphorus could be the geese that inhabit the lake. The city has been dealing with a year-round geese problem, but nothing seems to work. They are federally protected, so not much can seem to be done about it.

   Response: It is true that geese feces is a source of phosphorus load to the lakes. This contribution would be considered as a natural background load. Solutions to this issue could be considered in developing the implementation plan.

7. There are no major livestock productions in the area upstream of the lakes, so livestock are probably not a source of phosphorus.

   Response: Thank you for your comment.

8. Is wind erosion a factor in causing phosphorus sediment loads to the lakes?

   Response: While wind erosion could potentially deliver sediment-bound phosphorus directly to the lake, it is unlikely a significant source.

Paris Twin Lakes TMDL Implementation Plan

FINAL REPORT

February 28, 2008

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

Submitted by:
Tetra Tech

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KEY FINDINGS

As part of the Section 303(d) listing process, the Illinois Environmental Protection Agency identified four waterbodies in the Sugar Creek watershed as impaired:

- Paris Twin West Lake (segment RBX)
- Paris Twin East Lake (segment RBL)
- Sugar Creek (segment BMC2)
- Sugar Creek (segment BM02)

A comprehensive review of the available water quality data confirmed the Paris Twin West and East Lake total phosphorus (TP) impairments and a Total Maximum Daily Load (TMDL) study was prepared and approved by USEPA in September 2005. The purpose of this report is to present an implementation plan for the Paris Twin Lakes TMDL. TMDLs developed for Sugar Creek can be found in a separate report.

Illinois water quality standards require that total phosphorus concentrations within lakes not exceed 0.05 mg/L. Historic sampling within both Paris Twin West Lake and East Lake indicate that this standard is routinely exceeded with TP concentrations averaging 0.12 mg/L in West Lake and 0.10 mg/L East Lake.

Continuous flow and TP data are not available for Sugar Creek upstream of the Paris Twin Lakes. Loads to the lakes were therefore estimated based on data from a comparable watershed and these loads were input to the BATHTUB model to determine the load reductions necessary to meet the 0.05 mg/L water quality standard. The BATHTUB analysis indicated that a 75 percent reduction in loads is necessary to meet the 0.05 mg/L standard during each of the modeled years. Potential sources of TP to the Paris Twin Lakes include upstream sheet and rill erosion, subsurface loadings, lake shoreline erosion, stream channel erosion, fertilizer use applied to both crops and lawns, failing septic systems, storm water runoff, internal lake recycling, and natural sources. This Implementation Plan provides information on various controls to address the loading from each of these potential sources and discusses alternatives for achieving the desired load reductions.

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1.0 INTRODUCTION

The Sugar Creek watershed (ILBM02) is located in east-central Illinois and trends in a southeasterly direction. The watershed drains approximately 65 square miles within the State of Illinois. Within Illinois, most of the watershed is in southeastern Edgar County, and a smaller portion of the basin is located in northeastern Clark County.

The Paris Twin West Lake and Paris Twin East Lake are located within the upstream portion of the Sugar Creek watershed (Figure 1-1). The Twin Lakes were created in 1894 by damming and flooding a portion of Sugar Creek. The lakes have a combined surface area of approximately 220 acres and drain approximately 22 square miles of primarily agricultural land. Paris West Twin Lake serves as a sedimentation basin to protect East Lake (Bogner, 1992) and the Twin Lakes serve as the community drinking water supply for Paris, Illinois. Water is obtained from one surface water intake in the lakes with average pumpage of 1.5 million gallons per day to approximately 4,115 service connections and an estimated population of 8,990 people.

As part of the 2004 Section 303(d) listing process, the Illinois Environmental Protection Agency (IEPA) identified four waterbodies in the ILBM02 watershed as impaired (Table 1-1):

- Paris Twin West Lake (RBX)
- Paris Twin East Lake (RBL)
- Sugar Creek (BMC2)
- Sugar Creek (BM02)

Table 1-1. 2004 303(d) List Information for the Sugar Creek Watershed (ILBM02)

Segment (Area)	Name	Designated Uses and Support Status	Causes of Impairment	Potential Sources of Impairment
RBX (56.7 acres)	Paris Twin West Lake	Overall Use (Not Assessed), Aquatic Life Support (Partial), Primary Contact /swimming (Partial), Secondary Contact/ recreation (Partial), Fish Consumption (Full), Drinking Water Supply (Full)	Total Phosphorus, Excessive Algal Growth, TSS	Agriculture (crop related sources, non–irrigated crop production), Habitat modification (Streambank Modification/destabilization, Highway Maintenance and Runoff), Waterfowl, Forest/grassland/parkland
RBL (162.8 acres)	Paris Twin East Lake	Overall Use (Full), Aquatic Life Support (Full), Primary Contact /swimming (Partial), Secondary Contact/recreation (Partial), Fish Consumption (Full), Drinking Water Supply (Full)	Total Phosphorus, Excessive Algal Growth, TSS	Agriculture (crop related sources, non–irrigated crop production), Habitat modification (Streambank Modification/destabilization, Highway Maintenance and Runoff), Waterfowl, Forest/grassland/parkland
BMC2 (2.9 miles)	Sugar Creek	Aquatic Life Support (Partial)	Dissolved Oxygen, Sedimentation/ Siltation, Unspecified Nutrients, Other Flow Alterations	Municipal Point Source, Hydrologic/Habitat Modification (flow regulation/modification)
BM02 (12.9 miles)	Sugar Creek	Aquatic Life Support (Full) Primary Contact/Swimming (Partial)	Pathogens	Source Unknown

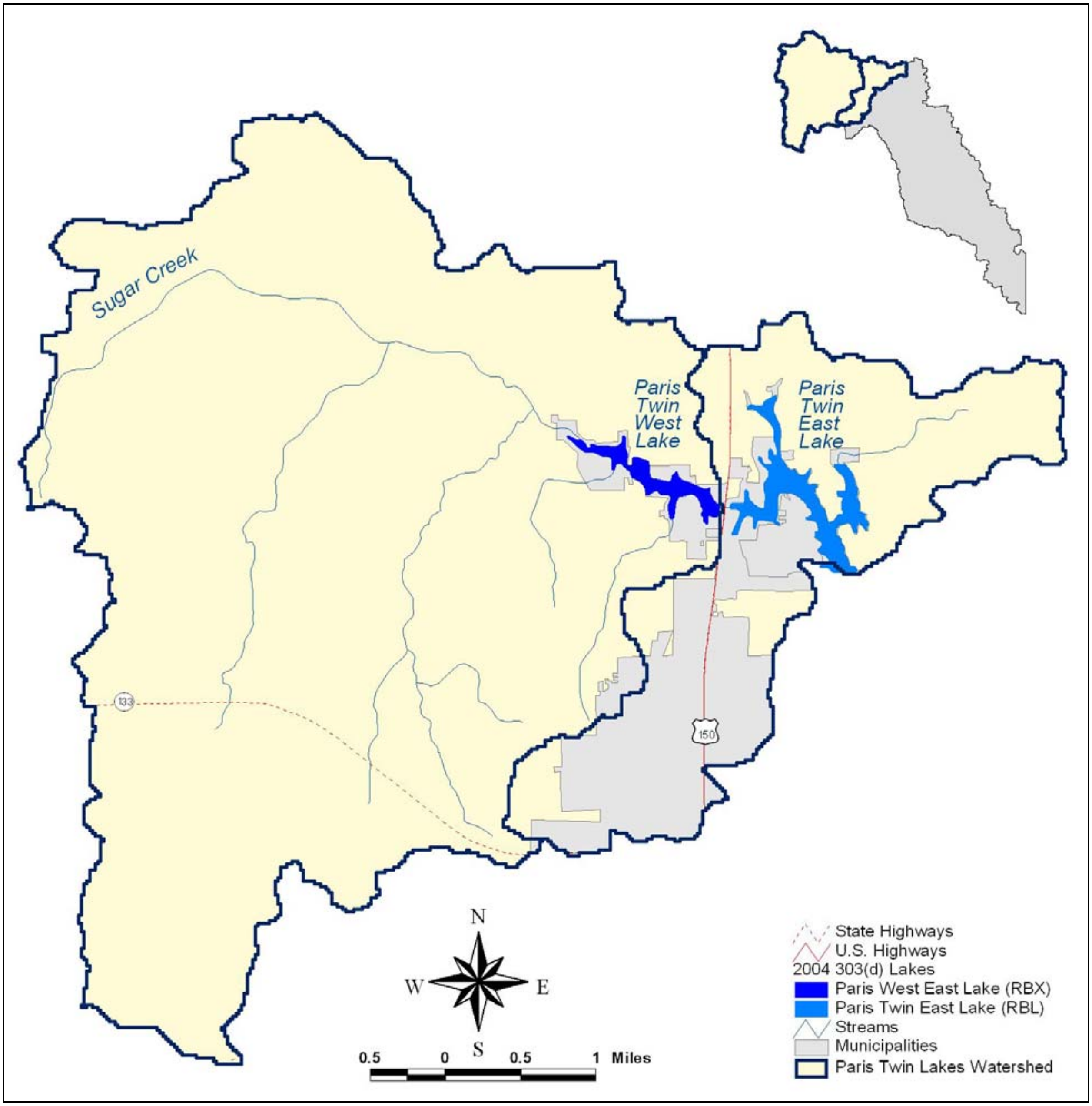

Figure 1-1. Location of the Sugar Creek watershed draining to Paris Twin Lakes.

The Clean Water Act and USEPA regulations require that states develop TMDLs for waters on the Section 303(d) lists. Illinois EPA is currently developing TMDLs for pollutants that have numeric water quality standards. Of the pollutants impairing Paris Twin West Lake and Paris Twin East Lake, phosphorus is the only parameter with a water quality standard. Illinois EPA believes that addressing the phosphorus impairment should lead to an overall improvement in water quality due to the interrelated nature of the other listed pollutants. For example, reducing loads of phosphorus should result in less algal growth.

The project is being initiated in three stages. Stage One was completed in the Spring of 2005 and involved the characterization of the watershed, an assessment of the available water quality data, and identification of potential technical approaches (see Appendix A). Stage Two was completed for the downstream Sugar Creek segments impaired for dissolved oxygen and fecal Coliform; Stage Two was not performed for the Paris Twin Lakes. Stage Three involves model development and calibration, TMDL scenarios, and implementation planning. The TMDL for Paris Twin Lakes was approved in September 2005. This report addresses the implementation plan portion of Stage Three.

The TMDL for Paris Twin Lakes was based on application of the U.S. Army Corps of Engineers BATHTUB model. The calibrated BATHTUB model was used to identify the load reductions necessary to achieve a target concentration of 0.05 mg/L phosphorus. In order to meet the target during all years in both lakes, a 75 percent reduction of phosphorus loading is required. Table 1-2 shows the predicted summer average total phosphorus concentrations if a 75 percent reduction is achieved. This table also shows the predicted annual average total phosphorus concentrations in both lakes if a 75 percent reduction is implemented. The table indicates that during most years a 75 percent reduction in loads will result in lake water quality being significantly less than the water quality standard, thus providing an added margin of safety.

Table 1-2. Average Total Phosphorus Concentration in Paris Twin Lakes with 75 Percent Reduction in Loading.

Year	West Lake TP (mg/L)	West Lake Comparison to WQS	East Lake TP (mg/L)	East Lake Comparison to WQS
1990	0.04	-20%	0.04	-20%
1991	0.031	-38%	0.026	-48%
1992	0.041	-18%	0.04	-20%
1993	0.04	-20%	0.036	-28%
1994	0.036	-28%	0.031	-38%
1995	0.036	-28%	0.022	-56%
1996	0.05	0%	0.041	-18%
1997	0.03	-40%	0.025	-50%
1998	0.047	-6%	0.04	-20%
1999	0.037	-26%	0.032	-36%
2000	0.024	-52%	0.021	-58%
2001	0.036	-28%	0.036	-28%
1990 to 2001 Average	0.037333	-25%	0.0325	-35%

The allocations of loads for the Paris Twin Lakes TMDL are summarized in Table 1-3 and Table 1-4. The existing loads are the average loads to West and East Lake for the period 1990 to 2001 (to correspond to the modeling analysis). The loading capacity represents the 75 percent reduction from existing loads determined to be necessary from the modeling analysis. The wasteload allocation is zero because there are no point sources in the Sugar Creek watershed upstream of the lakes. Five percent of the loading capacity is reserved for a margin of safety (as required by the Clean Water Act).

Table 1-3. TMDL Summary for West Lake.

Category	Phosphorus (kg/yr)	Phosphorus (lbs/yr)	Phosphorus (lbs/day)
Existing Load	3,920	8,642	23.7
Loading Capacity	980	2,161	5.9
Wasteload Allocation	0	0	0
Margin of Safety	49	108	0.3
Load Allocation	931	2,053	5.6

Table 1-4. TMDL Summary for East Lake.

Category	Phosphorus (kg/yr)	Phosphorus (lbs/yr)	Phosphorus (lbs/day)
Existing Load	2,520	5,556	15.2
Loading Capacity	630	1,389	3.8
Wasteload Allocation	0	0	0
Margin of Safety	32	71	0.2
Load Allocation	598	1,318	3.6

The TMDL report for Paris Twin Lakes, which was approved by USEPA in September 2005, suggests a 75 percent reduction in phosphorus loadings to meet the water quality standard in both the lakes. This report presents a draft Implementation Plan that identifies feasible and cost-effective management measures capable of reducing phosphorus loads to the required levels. The intent of the Implementation Plan is to provide information to local stakeholders regarding the selection of cost-effective best management practices (BMPs).

2.0 DESCRIPTION OF WATERBODY AND WATERSHED CHARACTERISTICS

The purpose of this section of the report is to provide a brief background of the Paris Twin Lakes and their corresponding watershed.

2.1 Paris Twin Lakes

The Paris Twin Lakes are located north of Paris, Illinois and drain the upstream portion of the Sugar Creek watershed. Paris West Lake was built in 1894 and was supplemented with East Lake in 1917. East Lake was expanded to its present configuration in 1960 following a dam failure in 1957. East Lake is larger and deeper than West Lake and has a longer residence time (almost two years compared to almost two months).

The reservoirs are owned by the City of Paris, Illinois, and serve as the water supply for the City. The lakes also provide recreational opportunities such as fishing, boating, and swimming. An earthen embankment and a dam divide West Lake from East Lake. Consequently, the West Lake has acted as a sedimentation basin, allowing considerable amounts of sediment to accumulate.

Groundwater exchange between the lake and underlying materials is difficult to calculate. However, given the relatively low-impermeable soils and very flat topography, it can be assumed that groundwater flow is not an important component in the overall hydrologic budget of the lakes. In a previous study (Illinois EPA, 1992) groundwater inflows and outflow were calculated and the average difference between the two was found to be 3.8 percent of total outflows. Additionally, the study concluded that the greatest amount of groundwater inflow to the lakes occurred during May and June, and the greatest amount of groundwater outflow occurred during November and January.

The Illinois State Water Survey conducted a sedimentation survey of Paris West Twin Lake in the early 1990s (Bogner, 1992). The study found that sedimentation had reduced the original lake storage capacity by 53 percent, which in turn had reduced the sediment trap efficiency of the lake from the designed efficiency of 77 percent to 63 percent. The study recommended that in-lake rehabilitation programs, such as dredging and improved wetland vegetation to enhance sediment filtering, be implemented to improve general water quality in the lake.

A Phase I Diagnostic and Rehabilitation Feasibility study (Illinois EPA, 1992) of the Twin Lakes was completed under the USEPA Clean Lakes Program in 1992. The Phase I study investigated the physical and social characteristics of the Twin Lakes drainage, assessed numerous water quality parameters and biological resources, and examined the feasibility of lake restoration. Similar to the Illinois State Water Survey study, the Phase I study found high rates of sediment delivery from Sugar Creek to West Lake, high suspended solids levels in the lake, and diminished sediment storage capacity of West Lake. Additionally, high levels of nitrogen and phosphorus, particularly in the West Lake, were contributed from Sugar Creek, which caused frequent algal growth. Total phosphorus and dissolved phosphorus concentration tended to decrease from upstream locations (West Lake) to downstream (East Lake). The study also found low dissolved oxygen in the lakes, particularly near the bottom of West Lake, and below a depth of eight to nine feet in the East Lake during periods of thermal stratification.

Additional problems identified were shoreline erosion, due to insufficient shoreline vegetation and wave action from wind and boats, and poor fisheries population and habitat. The primary restoration alternative recommended for the project was hydraulically dredging 450,000 cubic yards of sediment from West Lake. Additional recommendations included the enhancement of the upper end of the lake to function as a sediment basin, various shoreline erosion control and protection measures, fisheries management, watershed land treatment practices, and the installation of an aeration system. Several of these recommendations were later implemented.

A Phase II Implementation study (Illinois EPA, 1998) examined the differences between pre-implementation and post-implementation periods. The study found that shoreline protection and stabilization measures suggested in the Phase I report proved to be successful in reducing shoreline erosion, and that dredging operations increased overall storage capacity by over 200 percent. Additionally, the study found that dredging operations resulted in an estimated 26.5 percent reduction in sediment load. However, a majority of the chemical parameters remained approximately the same between the pre- and post-implementation periods. In particular, mean phosphorus levels were found to remain above 0.05 mg/L and were sufficient to increase algal biomass and subsequently contribute to low dissolved oxygen levels during summer months.

2.2 Sugar Creek Watershed

Agricultural land dominates the land use/land cover upstream of the Paris Twin Lakes (Figure 2-2). Corn and soybeans are the primary crops, representing 41 percent and 34 percent, respectively, of all subwatershed land use and land cover types. Approximately 11 percent of the subwatershed consists of urban land uses/land cover and 8 percent consists of rural grassland with all other land use/land cover types comprising less than 7 percent of the area.

Most soils upstream of Paris Twin West Lake are categorized as Class B soils (moderately well drained) with moderate erosion potential (e.g. K-factors that range in value from 0.20 to 0.37). Only a small area contains soils where K-factor values exceed 0.37, suggesting that inherent erodibility does not exceed the moderate classification in the majority of the basin. These low erosion susceptibility areas occur throughout the watershed and are typically associated with sandy soils with high infiltration rates. Figure 2-2 shows that most of the highly erodible soils are near or adjacent to the lakes or lake tributaries.

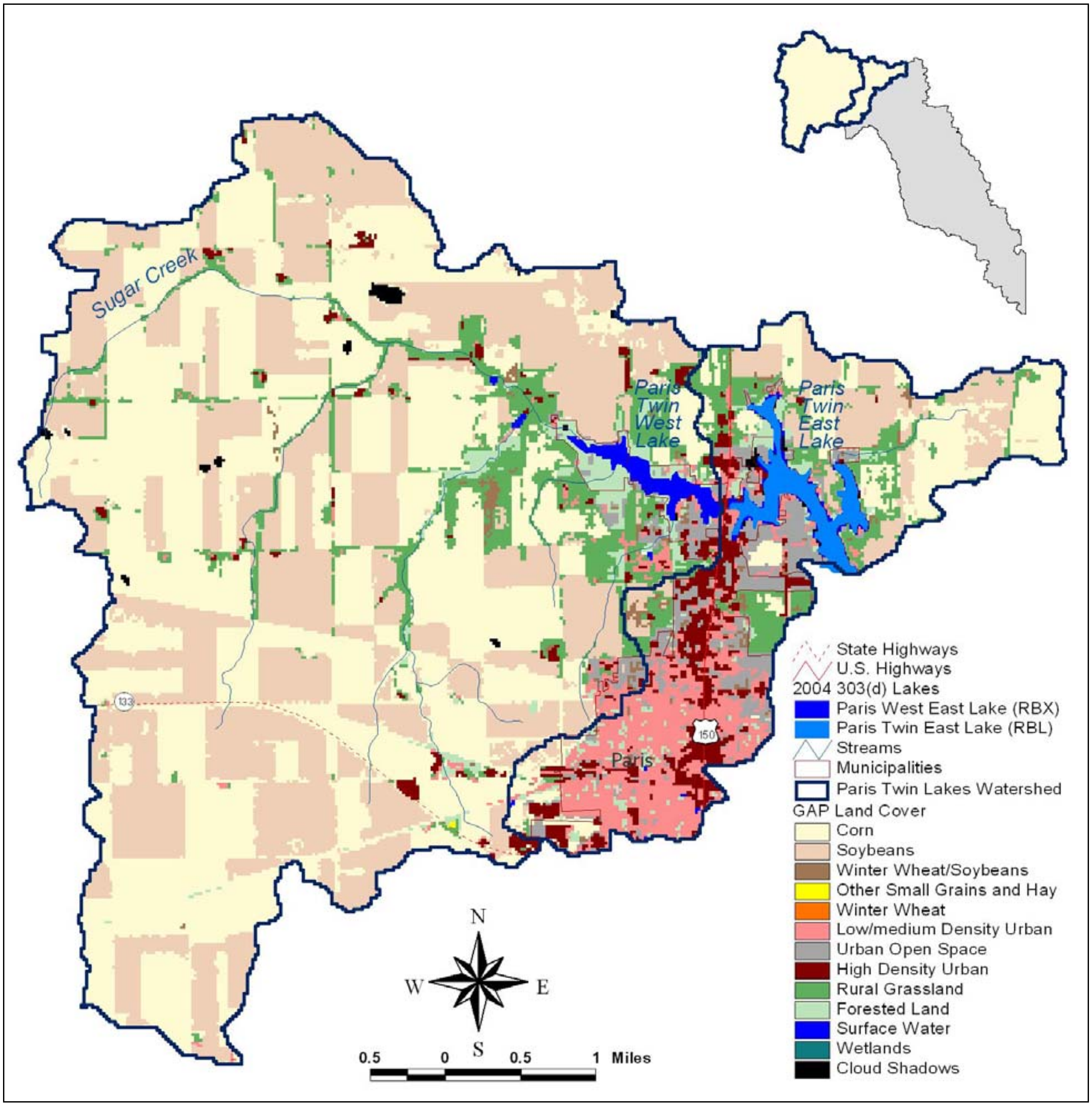

Figure 2-1. Land use/land cover in the Paris Twin Lakes Watershed.

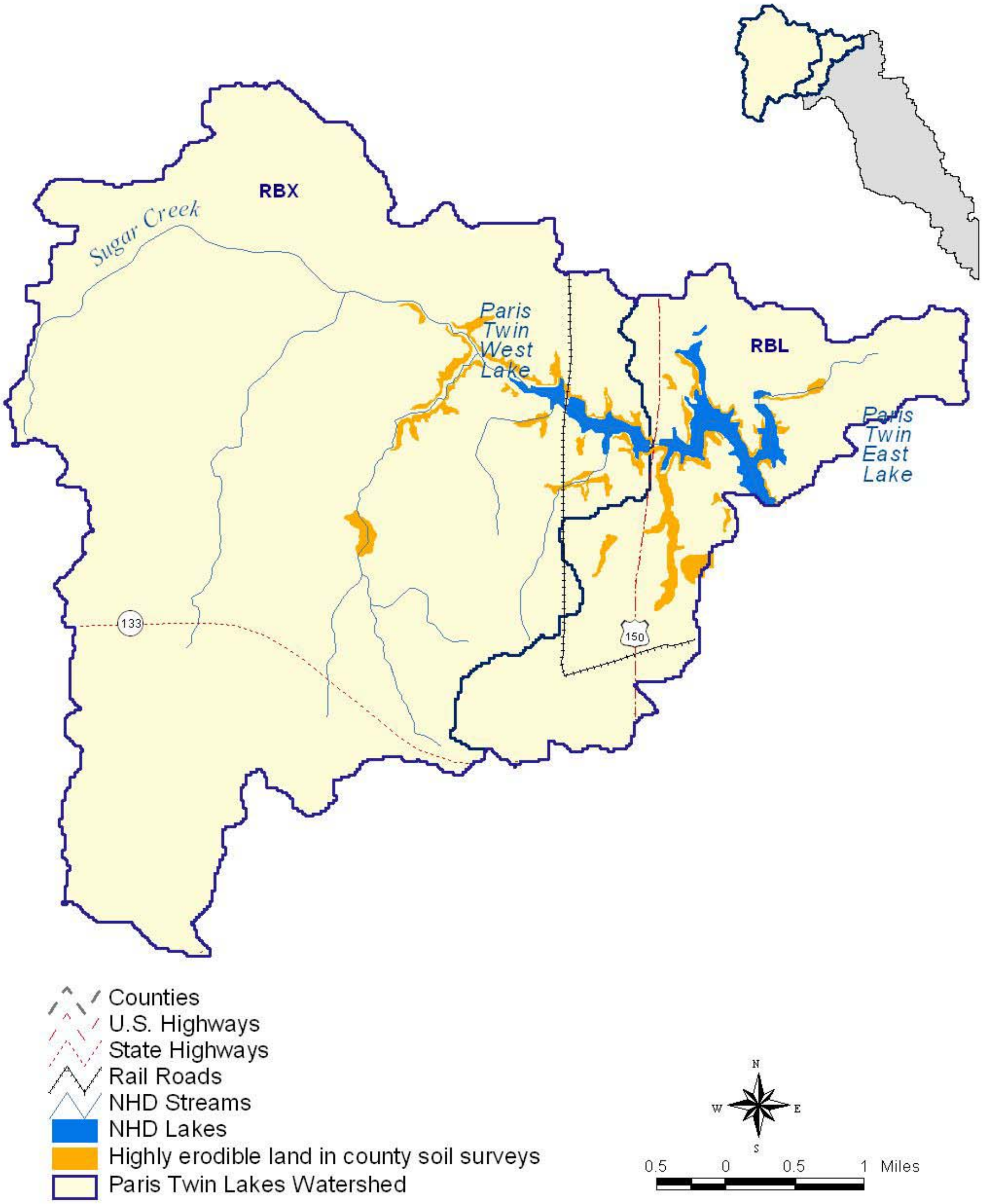

Figure 2-2. Highly Erodible Soils in the Paris Twin Lake Watershed.

3.0 WATER QUALITY STANDARDS AND ASSESSMENT OF WATER QUALITY DATA

This section presents the applicable water quality standards and a brief summary of the historic water quality data for the Paris Twin Lakes. Additional information on the historic water quality conditions within the lakes can be found in the Stage 1 Report.

3.1 Applicable Water Quality Standards

To assess the designated use support for Illinois waterbodies, the IEPA uses rules and regulations adopted by the Illinois Pollution Control Board (IPCB). The following are the use support designations provided by the IPCB for the Paris Twin Lakes:

General Use Standards - These standards protect for aquatic life, wildlife, agricultural use, primary contact recreation (where physical configuration of the waterbody permits it), secondary contact recreation, and most industrial uses. Primary contact recreation includes any recreational or other water use in which there is prolonged and intimate contact with the water involving considerable risk of ingesting water in quantities sufficient to pose a significant health hazard, such as swimming and water skiing. Secondary contact recreation includes any recreational or other water use in which contact with the water is either incidental or accidental and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, commercial and recreational boating, and any limited contact incident to shoreline activity. These standards are also designed to ensure the aesthetic quality of the state's aquatic environment.

Numeric water quality standards have been adopted to correspond to these designated uses. The water quality standards require that total phosphorus concentrations remain at or below 0.05 mg/L.

3.2 Water Quality Assessment

As discussed in the Stage 1 Report, water quality data collected in the Paris Twin Lakes show that approximately 83 percent of total phosphorus samples exceeded the water quality standard, including 98 percent of samples taken after 1998. Total phosphorus concentrations at the surface (one foot depth) are typically similar to total phosphorus concentrations for deeper samples. Although there is a great deal of variability, total nitrogen to total phosphorus ratios are usually greater than 10, suggesting that phosphorus is the limiting nutrient for algal growth in Paris Twin Lake (Chapra, 1997).

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4.0 POLLUTION SOURCES AND MANAGEMENT ACTIVITIES

As discussed in Section 2.0, the majority of land in the Paris Twin Lakes watershed (70 percent) is used for agricultural production. Other land uses include grasslands, forest, urban areas, and wetlands. This section describes typical pollutant loading rates from each source category in the watershed along with appropriate best management practices (BMPs) to achieve a reduction in phosphorus loading. The TMDL allocation for Paris Twin Lakes indicates that a reduction in phosphorus load of 75 percent is required to meet the Illinois water quality standard.

4.1 WWTP/NPDES Permittees

There are no point sources upstream of Paris Twin Lakes and so this report will not focus on the control of this source category. .

4.2 Agricultural Land Uses

Because the majority of land in the watershed is used for agricultural production, and no permitted discharges of phosphorus exist upstream of the two lakes, agriculture is likely the primary source of phosphorus loading to Paris Twin Lake. This section of the implementation plan describes the mechanisms of phosphorus loading from farmland and management practices that have been employed in other watersheds to reduce loading. This report does not contain an exhaustive list of agricultural best management practices (BMPs). Only cost-effective practices with demonstrated phosphorus removal capabilities are included. No animal confinements are located in the watershed and the majority of livestock are cattle on pasture (Edgar County Soil and Water Conservation District, personal communications).

4.2.1 Source Description and Approximate Loading

Accumulation of phosphorus on farmland occurs from decomposition of residual crop material, fertilization with chemical and manure fertilizers, atmospheric deposition, wildlife excreta, irrigation water, and application of waste products from municipal and industrial wastewater treatment facilities. Phosphorus is transported from agricultural land in both dissolved and particulate form. Losses occur through soil erosion, infiltration to groundwater and subsurface flow systems, and surface runoff. Crop harvesting also results in a phosphorus loss which should be accounted for when performing a field scale phosphorus balance. The USDA (2003) reports that crops utilize 30 percent of the phosphorus applied, and that, on average, 30 lb/ac/yr of phosphorus is lost via adsorption to soil particles or transport in runoff.

Adsorption refers to the processes that bind phosphorus to soil particles.

4.2.1.1 Fertilizer Inputs

The majority of nutrient loading from farmland occurs from fertilization with commercial and manure fertilizers (USEPA, 2003). In heavily fertilized areas, soil phosphorus content has increased significantly over natural levels.

Soil phosphorus tests are used to measure the phosphorus available for crop growth. Test results reported in parts per million (ppm) can be converted to lb/ac by multiplying by 2 (USDA, 2003). Based on a survey of state soil testing laboratories in 1997, 64 percent of soils in Illinois had high soil phosphorus test concentrations (> 50 ppm). By 2000, the percentage of soils testing high decreased to 58 percent (USDA, 2003). Guidelines in the Illinois Agronomy Handbook (IAH) recommend maintaining soil test phosphorus content in east-central Illinois at 22.5 ppm (45 lb/ac). Soils that test at or above 32.5

The majority of nutrient loading from farmland occurs from fertilization with commercial and manure fertilizers.

ppm (65 lb/ac) should not be fertilized until subsequent crop uptake decreases the test to 22.5 ppm (45 lb/ac) (IAH, 2002). Soil phosphorus tests should be conducted once every three or four years to monitor accumulation or depletion of phosphorus (USDA, 2003).

Phosphorus level as high as100 ppm has been seen in this watershed. The minimum phosphorus levels observed is 15 ppm. However, this is not typical throughout the whole watershed (Coombes, 2007). Figure 4-11 shows the range of values typically observed in the Paris Twin Lake watershed along with the target maintenance level and level at which no additional phosphorus should be applied according to the IAH. The variability in measurements across the watershed illustrates the need for soil testing prior to fertilizer application.

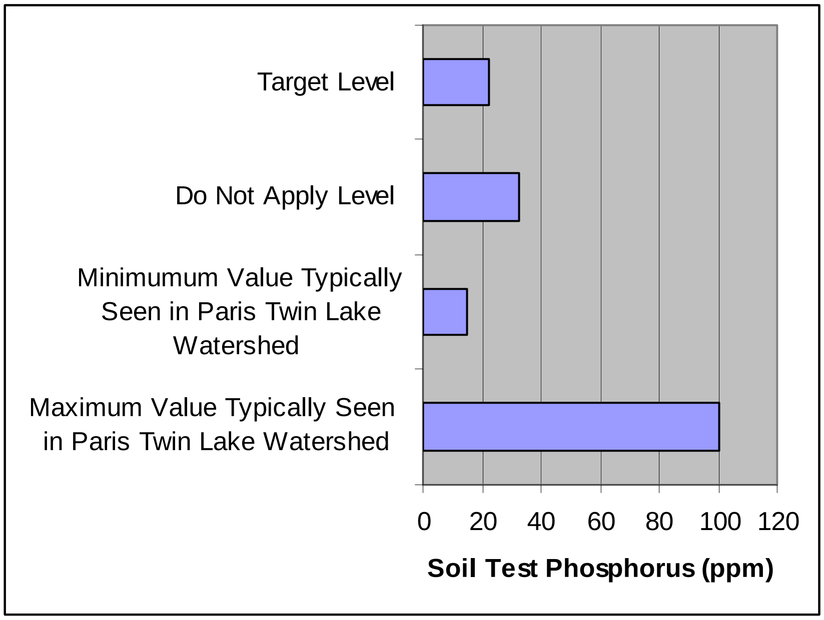


Figure 4-1. Soil Test Phosphorus Levels Measured in the Paris Twin Lake Watershed.

4.2.1.2 Tile Drain Systems

Tile drainage systems are used to lower the water table below the root zone to maximize crop yields on fields that otherwise would not be suitable for crop production. The systems allow for greater rates of infiltration by draining the soil profile more quickly. Runoff is reduced since more water is infiltrated to the groundwater zone, and as a result, rates of erosion and particulate pollutant transport are reduced. However, the concentrations of dissolved pollutants in the tile water tend to be higher relative to typical surface runoff. Because nitrate is a public health hazard at concentrations greater than 10 mg/L, most of the work concerning water quality impacts and appropriate BMPs for tile drain systems has focused on this parameter. Concerns with eutrophication and the role of phosphorus have prompted more recent studies for controlling this nutrient as well.

Tile drainage systems are used extensively in Illinois to lower the water table and increase the area of land available for agricultural production. Flows discharged from tile drainage systems located under high phosphorus content soils have significantly higher phosphorus concentrations than those under low to medium content soils. The majority of phosphorus transported through tile systems is in the dissolved form. However, particulate phosphorus is also transported as water passes through the soil profile and dislodges particles. Concentrations of both dissolved and particulate phosphorus increase significantly in tile systems following large rain events (Gentry et al., 2007).

The USDA (2003) reports that dissolved phosphorus concentrations in tile drainage increased dramatically above a soil test phosphorus breakpoint. One study showed a linear increase in tile drain phosphorus concentrations when the soil test concentration exceeded 60 ppm by the Olsen test or 100 ppm by the Bray-1 test (USDA, 2003; HWRCI, 2005). The maximum concentration occurred on soils testing at 110 ppm (Olsen test) with a tile drain dissolved phosphorus concentration of 2.75 mg/L. Researchers in Iowa found the breakpoint for increased tile drain phosphorus concentrations to be 80 ppm (Mallarino, 2004).

Research conducted in other watersheds in east-central Illinois estimated that tile drains contribute 45 to 90 percent of the annual total phosphorus load from agricultural fields, depending on climate conditions (Gentry et al., 2007). It is recommended that sampling of tile drains be performed in the watershed when the tile lines are running to determine the total and dissolved phosphorus concentrations.

Tile drains may contribute 45 to 90 percent of the total phosphorus load from agricultural fields in east-central Illinois.

4.2.1.3 Phosphorus Loading Rates

Phosphorus loading rates from agricultural lands vary widely based on climate, topography, soil characteristics, and farm management practices. IEPA (2004) estimated an average loading rate from row crop agriculture in the Altamont Reservoir watershed in Effingham County to be 1.7 lb/ac/yr based on GWLF modeling results. Loading rates from row crop agriculture to the Charleston Side Channel Reservoir are estimated to range from 2.1 to 3.5 lb/ac/yr based on SWAT modeling of the Upper Embarras River Watershed (IEPA, 2003). Neither of these models is capable of directly simulating tile drainage systems, though model parameters may be altered during calibration to approximate conditions.

Gentry et al. (2007) studied three heavily tiled watersheds in east-central Illinois with extensive row crop production. The average annual total phosphorus transport to streams from agricultural fields was estimated to be 0.41 to 0.67 lb/ac/yr based on instream measurements, with loads in high precipitation years ranging from 0.9 to 1.9 lb/ac/yr. Loads were estimated based on measurements taken near the mouth of each monitored stream; no discussion of instream phosphorus kinetics (plant uptake, soil adsorption, etc.) was included. Loads from one tile system were measured directly over a 2-year period. The tile system transported 0.1 to 1.2 lb/ac/yr of total phosphorus. Both dissolved reactive phosphorus and particulate bound phosphorus are transported through tile systems (Gentry et al., 2007).

To summarize Section 4.2.1:

- Agricultural lands are a primary source of phosphorus loading in the Paris Twin Lake watershed.
- A large fraction of the phosphorus load is directly or indirectly related to the application of fertilizer.
- Tile drain systems in the Paris Twin Lake watershed may transport a significant fraction of the total phosphorus load.
- Based on data collected in other heavily tiled, east-central Illinois watersheds, the phosphorus loading rate during a normal to dry year is approximately 0.5 lb/ac/yr, and during extremely wet years is approximately 1.5 lb/ac/yr. The BATHTUB modeling for Paris Twin West Lake indicates that current average loading rates are approximately 0.61 lb/ac/yr (daily load times 365 days per year) and that an average load of 0.15 lb/ac/yr would be required to meet the water quality standard in the lake. For Paris Twin East Lake, the current average load is estimated to be 0.38 lb/ac/yr with an average load of 0.09 lb/ac/yr needed to achieve the phosphorus standard of 0.05 mg/L.

4.2.2 Appropriate BMPs

Phosphorus is typically exported from agricultural fields by overland flow or subsurface pathways. The contribution to each pathway depends on field topography, soil compaction, surface roughness, and use of artificial subsurface drainage systems. While tile drain systems are used extensively throughout east-central Illinois, the exact location and extent of these systems in the Paris Twin Lakes watershed is not known. Information on existing BMPs in the watershed as well as areas that could potentially support riparian buffers or filter strips are included in Figure 4-2 and Table 4-1.

Several structural and non-structural BMPs have been developed and studied for use in agricultural areas. The following sections describe these BMPs in terms of removal mechanisms, effectiveness, and cost. Though the BMPs are presented individually, they typically must be used in combinations to mitigate hydrologic and water quality impacts. Some BMPs will be effective on all farms, regardless of drainage patterns. Others are only applicable to artificially drained fields. It will be up to the individual operator to determine the BMPs best suited for his or her operation.

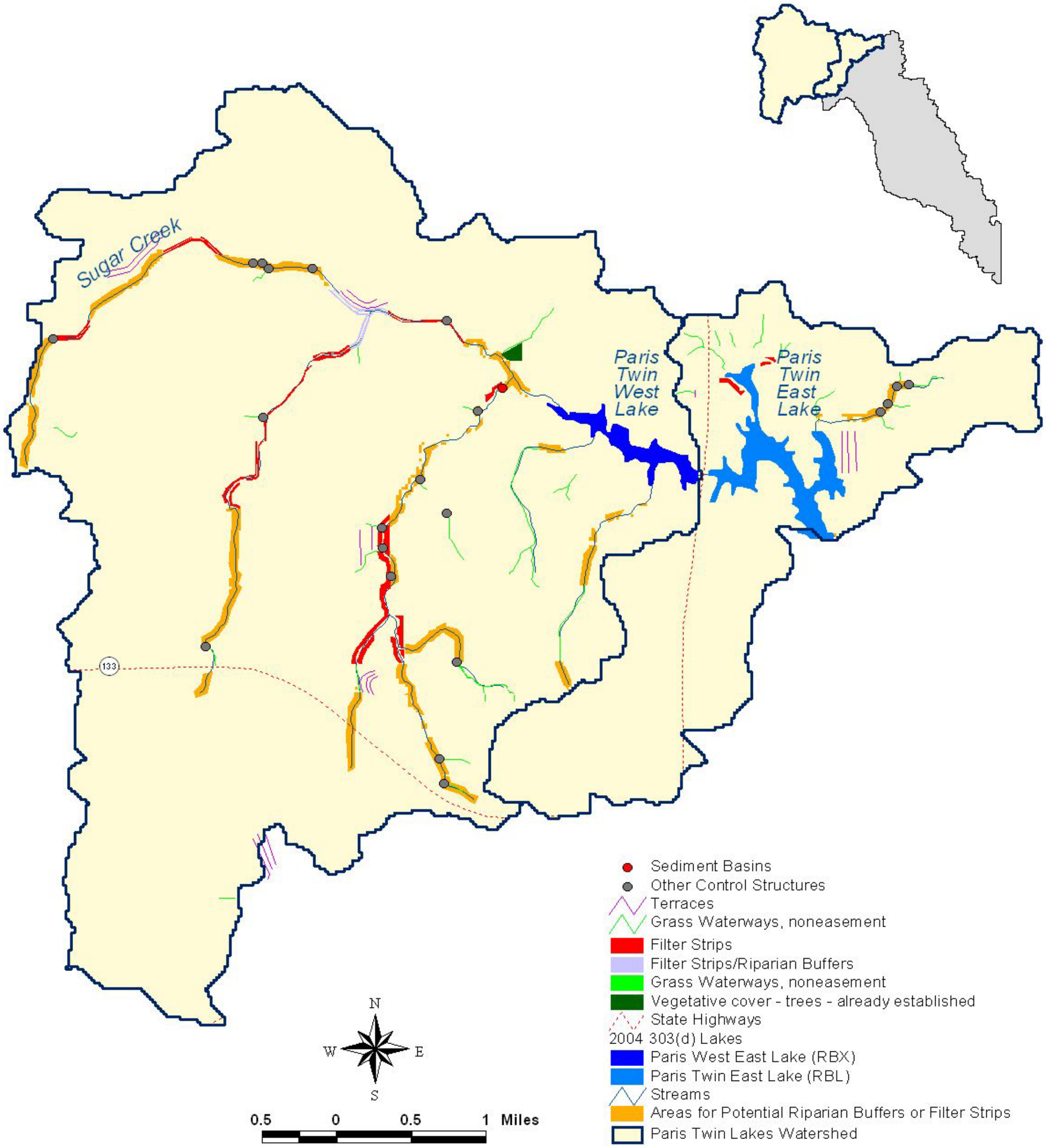


Figure 4-2. Existing and Potential BMPs in the Paris Twin Lakes Watershed.

Table 4-1. SWCD BMP practices and acreages in the watershed.

Practice	Area
Sediment Basins	Unknown (1 Basin in Watershed)
Other Control Structures	Unknown (21 Structures in Watershed)
Terraces	Unknown (15 Terraces in Watershed)
Grass Waterways, noneasement	Greater than 3 Acres (36 Waterways in Watershed, 34 waterways acreage not accounted for)
Filter Strips	Approximately 77 Acres (no acreage reported for 2 filter strips)
Filter Strips/Riparian Buffers	11.45 Acres
Vegetative cover - trees - already established	6.9 Acres

4.2.2.1 Nutrient Management Plans

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

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

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

The IAH lists guidelines for fertilizer application rates based on the inherent properties of the soil (typical regional soil phosphorus concentrations, root penetration, pH, etc.), the starting soil test phosphorus concentration for the field, and the crop type and expected yield (IAH, 2002). If the starting soil test phosphorus concentration is less than 22.5 ppm, the IAH suggests building up the phosphorus levels over a four year period to achieve a soil test phosphorus concentration of 22.5 ppm (45 lb/ac). If the starting point is at or above 22.5 ppm (45 lb/ac), then the IAH suggests maintenance-only application rates based on crop type and expected yields. At starting concentrations greater than 32.5 ppm (65 lb/ac), the IAH recommends that no phosphorus be applied until subsequent crop uptake reduces the starting value to 22.5 ppm (45 lb/ac). Table 4-2 and Table 4-3 summarize the buildup, maintenance, and total application rates for various starting soil test concentrations for sample corn and soybean yields, respectively. For a complete listing of buildup and maintenance rates for the three availability zones and varying yields of corn, soybeans, oats, wheat, and grasses, see Chapter 11 of the IAH.

Starting Soil Test Phosphorus	*Fertilization Guidelines*
Less than 22.5 ppm:	*Buildup plus maintenance*
Between 22.5 and 32.5 ppm:	*Maintenance only*
Greater than 32.5 ppm:	*None*

Table 4-2. Suggested Buildup and Maintenance Application Rates of P_2O_5 for Corn Production in the Medium Inherent Phosphorus Availability Zone (IAH, 2002).

Starting Soil Test P ppm (lb/ac)	Buildup P_2O_5 (lb/ac)[1]	Maintenance P_2O_5 (lb/ac)[2]	Total P_2O_5 (lb/ac)
10 (20)	56	71	127
15 (30)	34	71	105
20 (40)	11	71	82
22.5 (45)	0	71	71
25 (50)	0	71	71
30 (60)	0	71	71
32.2 (65) or higher	0	0	0

[1] Rates based on buildup for four years to achieve target soil test phosphorus of 22.5 ppm (45 lb/ac).

[2] Maintenance rates assume a corn yield of 165 bushels per acre. The IAH lists maintenance rates discretely for yields of 90 to 200 bushels per acre.

Table 4-3. Suggested Buildup and Maintenance Application Rates of P_2O_5 for Soybean Production in the Medium Inherent Phosphorus Availability Zone (IAH, 2002).

Starting Soil Test P ppm (lb/ac)	Buildup P_2O_5 (lb/ac)[1]	Maintenance P_2O_5 (lb/ac)[2]	Total P_2O_5 (lb/ac)
10 (20)	56	51	107
15 (30)	34	51	85
20 (40)	11	51	62
22.5 (45)	0	51	51
25 (50)	0	51	51
30 (60)	0	51	51
32.2 (65) or higher	0	0	0

[1] Rates based on buildup for four years to achieve target soil test phosphorus of 22.5 ppm (45 lb/ac).

[2] Maintenance rates assume a soybean yield of 60 bushels per acre. The IAH lists maintenance rates discretely for yields of 30 to 100 bushels per acre.

Nutrient management plans also address methods of application. Fertilizer may be applied directly to the surface, placed in bands below and to the side of seeds, or incorporated in the top several inches of the soil profile through drilled holes, injection, or tillage. Surface applications that are not followed by incorporation may result in accumulation of phosphorus at the soil surface and increased dissolved phosphorus concentrations in surface runoff (Mallarino, 2004). Incorporation of fertilizer to a minimum depth of two inches prior to planting has shown a decrease in dissolved phosphorus runoff concentrations of 60 to 70 percent and reductions in total phosphorus runoff concentrations of 20 percent (HWRCI, 2005). Subsurface application, such as deep placement, has similar impacts on dissolved phosphorus in runoff with reductions in total phosphorus of 20 to 50 percent (HWRCI, 2005).

Methods of phosphorus application have shown no impact on crop yield (Mallarino, 2004). The Champaign County Soil and Water Conservation District (CCSWCD) reports that deep placement of phosphorus in bands next to the seed zone requires only one-third to one-half the amount of phosphorus fertilizer to achieve the same yields and that on average, fertilizer application rates were decreased by 13 lb/ac (Stikkers, 2007). Thus, deep placement will not only reduce the amount of phosphorus available for transport, but will also result in lower fertilizer costs. Figure 4-3 shows the deep placement attachment used by the CCSWCD.

Phosphorus application rates may be reduced by one-third to one-half with deep placement.

(Photo Courtesy of CCSWCD)

Figure 4-3. Deep Placement Phosphorus Attachment Unit for Strip-till Toolbar.

For corn-soybean rotations, it is recommended that phosphorus fertilizer be applied once every two years, following harvest of the corn crop if application consists of broadcast followed by incorporation (UME, 1996). Band placement should occur prior to or during corn planting, depending on the type of field equipment available. In this part of Illinois, most fertilizer is applied after bean harvest and before corn planting (Sample, 2007). Fertilizer should be applied when the chance of a large precipitation event is low. Researchers in Iowa found that runoff concentrations of phosphorus were 60 percent lower when the following precipitation event occurred 10 days after fertilizer application, as opposed to 24 hours after

Check the weather forecast before applying fertilizer. Apply fertilizer only when the chance of heavy rain is low.

application. Application to frozen ground or snow cover should be strongly discouraged. Researchers studying loads from agricultural fields in east-central Illinois found that fertilizer application to frozen ground or snow followed by a rain event could transport 40 percent of the total annual phosphorus load (Gentry et al., 2007).

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

The effectiveness of nutrient management plans (application rates, methods, and timing) in reducing phosphorus loading from agricultural land will be site specific. Average reductions of total phosphorus load in Pennsylvania are reported at 35 percent (USEPA, 2003). Total phosphorus load reductions with subsurface application at agronomic rates are reported at 20 to 50 percent (HWRCI, 2005).

4.2.2.2 Tillage Practices

Conservation tillage practices and residue management are commonly used to control erosion and surface transport of pollutants from fields used for crop production. The IAH (2002) defines conservation tillage as any tillage practice that results in at least 30 percent coverage of the soil surface by crop residuals after planting. Tillage practices leaving 20 to 30 percent residual cover after planting reduce erosion by approximately 50 percent compared to bare soil. Practices that result in 70 percent residual cover reduce erosion by approximately 90 percent (IAH, 2002). The residuals not only provide erosion control, but also provide a nutrient source to growing plants, and continued use of conservation tillage results in a more productive soil with higher organic and nutrient content. Increasing the organic content of soil has the added benefit of reducing the amount of carbon in the atmosphere by storing it in the soil. Researchers estimate that croplands and pasturelands could be managed to trap 5 to 17 percent of the greenhouse gases produced in the United States (Lewandrowski et al., 2004).

Several practices are commonly used to maintain the suggested 30 percent cover:

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

The NRCS provides additional information on these conservation tillage practices:

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

Tillage system practices are not available specifically for Paris Twin Lake watershed; however, county-wide tillage system surveys have been undertaken by the Illinois Department of Agriculture (2006). It is assumed that the general tillage practice trends evidenced throughout the county are applicable to the Paris Twin Lake watershed. The results of the 2006 survey for Edgar County is presented in Table 4-4. The table shows that approximately half of the corn fields used conventional tillage practices whereas most of the soybean and small grain fields used either reduced-till, mulch-till, or no-till.

Table 4-4. Percentage of Agricultural Fields Surveyed with Indicated Tillage System in Edgar County, Illinois, in 2006.

Crop Field Type	Tillage Practice			
	Conventional	Reduced-till	Mulch-till	No-till
Corn	48	21	4	27
Soybean	7	21	10	63
Small Grain	0	67	33	0

Source: Illinois Department of Agriculture, 2006.

Corn residues are more durable and capable of sustaining the required 30 percent cover required for conservation tillage. Soybeans generate less residue, the residue degrades more quickly, and supplemental measures or special care may be necessary to meet the 30 percent cover requirement (UME, 1996). Figure 4-4 shows a comparison of ground cover under conventional and conservation tillage practices.

Figure 4-4. Comparison of conventional (left) and conservation (right) tillage practices.

No-till systems typically concentrate phosphorus in the upper two inches of the soil profile due to surface application of fertilizer and decomposition of plant material (IAH, 2002; UME, 1996). This pool of phosphorus readily mixes with precipitation and can lead to increased concentrations of dissolved phosphorus in surface runoff. Chisel plowing may be required once every several years to reduce stratification of phosphorus in the soil profile.

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

4.2.2.3 Cover Crop

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

Cover crops alone may reduce soil and runoff losses by 50 percent, and when used with no-till systems may reduce soil loss by more than 90 percent (IAH, 2002). On naturally drained fields where surface runoff is the primary transport mechanism of phosphorus, reduction in phosphorus loading would be substantial as well. In Oklahoma, use of cover crops resulted in 70 to 85 percent reductions in total phosphorus loading (HRWCI, 2005) (cropping rotation was not described). Cover crops have the added benefit of reducing the need for pesticides and fertilizers (OSUE, 1999), and are also used in conservation tillage systems following low residue crops such as soybeans (USDA, 1999). Use of cover crops is illustrated in Figure 4-5.

(Photo Courtesy of CCSWCD)

Figure 4-5. Use of Cover Crops.

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

4.2.2.4 Vegetative Controls

Other phosphorus control measures for agricultural land use include vegetated filter strips, grassed waterways, and riparian buffers. The USDA (2003) does not advocate using these practices solely to control phosphorus loading, but rather as supplemental management measures following operational strategies. USEPA (2003) lists the percent effectiveness of vegetative controls on phosphorus removal at 75 percent.

Vegetated Filter Strips

Filter strips are used in agricultural and urban areas to intercept and treat runoff before it leaves the site. If topography allows, filter strips may also be used to treat effluent from tile drain outlets. Filter strips will require maintenance, including grading and seeding, to ensure distributed flow across the filter and protection from erosion. Periodic removal of vegetation will encourage plant growth and uptake and remove nutrients stored in the plant material. Filter strips are most effective on sites with mild slopes of generally less than 5 percent, and to prevent concentrated flow, the upstream edge of a filter strip should follow one elevation contour (NCDENR, 2005). A grass filter strip is shown in Figure 4-6.

(Photo Courtesy of CCSWCD)

Figure 4-6. Grass Filter Strip Protecting Stream from Adjacent Agriculture.

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

Filter strips also serve to reduce the quantity and velocity of runoff. Filter strip sizing is dependent on site specific features such as climate and topography, but at a minimum, the area of a filter strip should be no less than 2 percent of the drainage area for agricultural land (OSUE, 1994). The minimum filter strip width suggested by NRCS (2002) is 30 ft. The strips are assumed to function properly with annual maintenance for 30 years before requiring replacement of soil and vegetation. Filter strips have been found to effectively remove pollutants from agricultural runoff. Reductions in phosphorus loading of 65 percent are reported (USEPA, 2003; Kalita, 2000).

Grassed Waterways

Grassed waterways are stormwater conveyances lined with grass that prevent erosion of the transport channel. In addition, the grassed channel reduces runoff velocities, allows for some infiltration, and filters out some particulate pollutants. Phosphorus reductions for grassed waterways are reported at 30 percent (Winer, 2000). A grassed waterway providing surface drainage for a corn field is shown in Figure 4-7.

(Photo Courtesy of CCSWCD)

Figure 4-7. Grassed Waterway.

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

Creation of Riparian Buffers

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

Preserving natural vegetation along stream corridors can effectively reduce water quality degradation associated with development. The root structure of the vegetation in a buffer enhances infiltration of runoff and subsequent trapping of nonpoint source pollutants. However, the buffers are only effective in this manner when the runoff enters the buffer as a slow moving, shallow "sheet"; concentrated flow in a ditch or gully will quickly pass through the buffer offering minimal opportunity for retention and uptake of pollutants.

Even more important than the filtering capacity of the buffers is the protection they provide to streambanks. The rooting systems of the vegetation serve as reinforcements in streambank soils, which helps to hold streambank material in place and minimize erosion. Due to the increase in stormwater runoff volume and peak rates of runoff associated with agriculture and development, stream channels are subject to greater erosional forces during stormflow events. Thus, preserving natural vegetation along stream channels minimizes the potential for water quality and habitat degradation due to streambank erosion and enhances the pollutant removal of sheet flow runoff from developed areas that passes through the buffer.

Converting land adjacent to streams for the creation of riparian buffers will provide stream bank stabilization, stream shading, and nutrient uptake and trapping from adjacent treated areas**.** A GIS analysis of land use within 25 feet of the streams in this watershed indicates that 42 percent of the land is currently farmed, 42 percent is forested, 7 percent is wetland and the rest is urban or surface water.

Riparian buffers should consist of native species and may include grasses, grass-like plants, forbs, shrubs, and trees. Minimum buffer widths of 25 feet are required for water quality benefits. Higher removal rates are provided with greater buffer widths. NCSU (2002) reports phosphorus removal rates of approximately 25 to 30 percent for 30 ft wide buffers and 70 to 80 percent for 60 to 90 ft wide buffers. Riparian corridors typically treat a maximum of 300 ft of adjacent land before runoff forms small channels that short circuit treatment. In addition to the treated area, the land converted from agricultural land to buffer will generate 90 percent less phosphorus based on data presented in Haith et al. (1992). Buffer widths based on slope measurements and recommended plant species should conform to NRCS Field Office Technical Guidelines. A riparian buffer protecting the stream corridor from adjacent agricultural areas is shown in Figure 4-8.

(Photo Courtesy of CCSWCD)

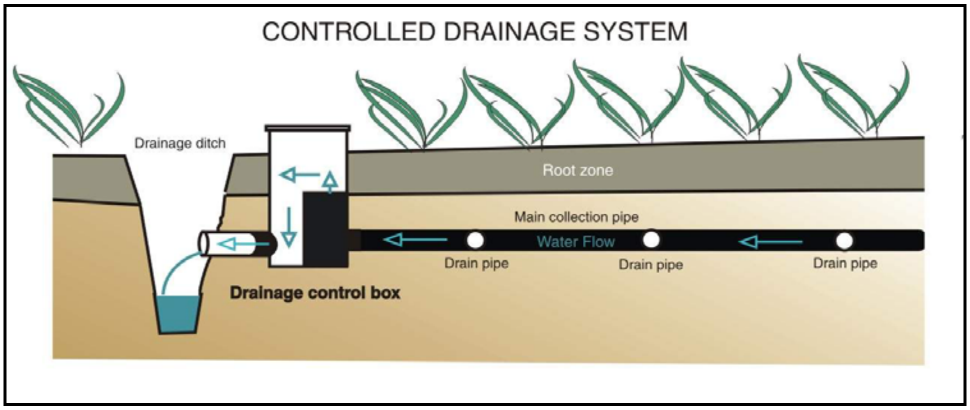
Figure 4-8. Riparian Buffer Between Stream Channel and Agricultural Areas.

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

4.2.2.5 Drainage Control Structures for Tile Drain Outlets

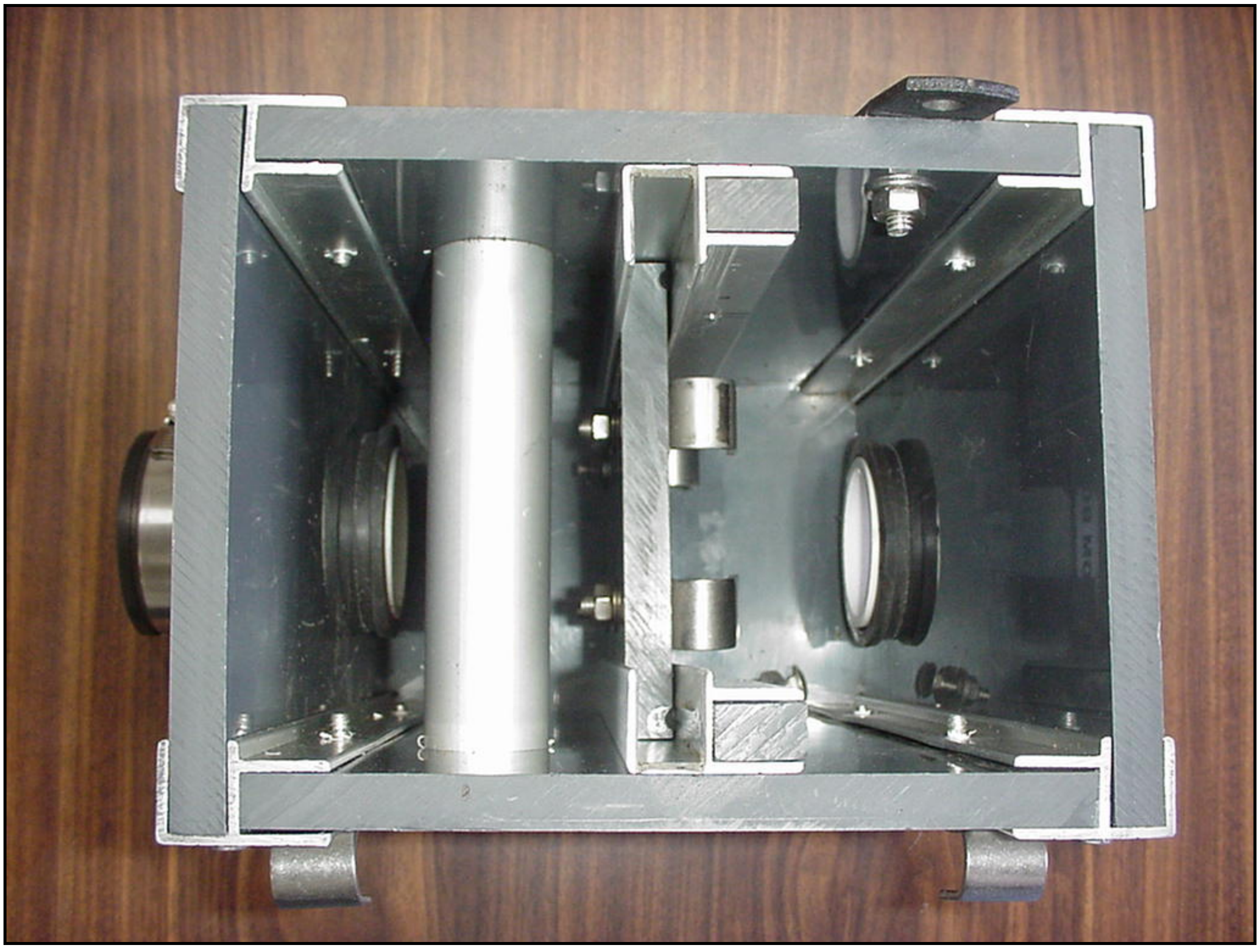
A conventional tile drain system collects infiltrated water below the root zone and transports the water quickly to a down-gradient surface outlet. Placement of a water-level control structure at the outlet (Figure 4-9 and Figure 4-10) allows for storage of the collected water to a predefined elevation. The stored water becomes a source of moisture for plants during dry conditions and undergoes biological, chemical, and physical processes that result in lower nutrient concentrations in the final effluent. Use of control structures on conventional tile drain systems in the coastal plains has resulted in reductions of total phosphorus loading of 35 percent (Gilliam et al., 1997). Researchers at the University of Illinois also report reductions in phosphorus loading with tile drainage control structures. Concentrations of phosphate were reduced by 82 percent, although total phosphorus reductions were not quantified in this study (Cooke, 2005). Going from a surface draining system to a tile drain system with outlet control reduces phosphorus loading by 65 percent (Gilliam et al., 1997).

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



(Illustration Courtesy of the Agricultural Research Service Information Division)

Figure 4-9. Controlled Drainage Structure for a Tile Drain System.



(Photo Courtesy of CCSWCD)

Figure 4-10. Interior View of a Drainage Control Structure with Adjustable Baffle Height.
The NRCS provides additional information on drainage management at: http://efotg.nrcs.usda.gov/references/public/IL/554.pdf.

The main points discussed in Section 4.2.2 are summarized in the following list. In addition, Table 4-5 gives a brief description of each BMP as well as the reported reductions in phosphorus loading.

Section 4.2.2.1:

- Phosphorus fertilizer should be applied at rates suggested in the Illinois Agronomy Handbook depending on crop type, expected yield, and Bray P-1 soil test phosphorus level.
- Deep placement of phosphorus adjacent to the seed bed may reduce fertilizer application rates by one-third to one-half. Total phosphorus loading may be reduced by 20 to 50 percent.
- Fertilizer should be applied when the chance of precipitation is low (predicted by local weather forecasting). Fertilizer should never be applied to frozen ground or snow.

Section 4.2.2.2:

- Conservation tillage practices reduce erosion and add nutrients and organic material to the soil profile.

- No-till systems tend to concentrate phosphorus in the upper two inches of the soil and may result in increased concentrations of dissolved phosphorus in runoff.
- Strip till practices may reduce phosphorus loading from agricultural fields by 68 percent and no-till may reduce loads by 76 percent.

Section 4.2.2.3:

- Cover crops reduce erosion during winter months and contribute nitrogen to the following cash crop.
- Reductions in phosphorus loading range from 70 to 85 percent.

Section 4.2.2.4:

- Filter strips intercept and treat agricultural water before it leaves the field. Reductions in phosphorus are approximately 65 percent.
- Grassed waterways are vegetated channels designed to convey stormwater. Phosphorus load reductions are approximately 30 percent.
- Riparian buffers effectively remove phosphorus from a small area of adjacent land, and are essential for maintaining streambank stability, appropriate water temperatures, and adequate habitat. Phosphorus reductions from the area converted from agriculture to buffer are approximately 90 percent; the buffer should remove approximately 80 percent of the phosphorus from the adjacent 300 ft of agricultural area.

Section 4.2.2.5:

- Use of drain-control structures on tile drain outlets reserves water for crop use during dry periods.
- Reductions in dissolved phosphorus of 82 percent and total phosphorus of 35 percent have been documented.

Table 4-5. Phosphorus Removal BMPs for Agricultural Land Uses.

BMP	Description and Removal Mechanism	Estimated Phosphorus Reduction
Nutrient Management Plan	Site specific guidance on appropriate fertilization rates, methods of application, and timing. Appropriate application rates for optimized crop yield reduce loading from excessive nutrient application.	Depends on current application rates and methods compared to site specific guidance. Total phosphorus reductions of **20 to 50 percent** are reported (USEPA, 2003; HRWCI, 2005).
Conservation Tillage	Tillage practices that maintain a minimum of 30 percent ground cover with crop residuals. Reduces erosion rates and phosphorus losses. Increases soil quality by providing organic material and nutrient supplementation.	Strip till and no-till can reduce total phosphorus loads by **68 and 76 percent**, respectively (Czapar, 2006).
Cover Crop	Use of ground cover plants on fallow fields. Reduces erosion, provides organic materials and nutrients to soil matrix, reduces nutrient losses, suppresses weeds, and controls insects.	Total phosphorus reductions of **70 to 85 percent** are reported (HRWCI, 2005).
Filter Strips	Placement of vegetated strips in the path of field drainage to treat sediment and nutrients.	Total phosphorus reductions of **65 percent** are reported (USEPA, 2003; Kalita, 2000).
Grassed Waterway	A stormwater conveyance planted with grass to reduce erosion of the transport channel. Provides filtering of particulate pollutants and reduces runoff volume and velocity.	Total phosphorus reductions of **30 percent** are reported (Winer, 2000).
Restoration of Riparian Buffers	Conversion of land adjacent to stream channels to vegetated buffer zones. Removes phosphorus by sedimentation and plant uptake. Provides stream bank stability, stream shading, and aesthetic enhancement.	Riparian buffers may achieve an **80 percent** reduction in total phosphorus from treated areas, assuming a 90 ft buffer width (NCSU, 2002). Lands converted from agricultural use are estimated to have a **90 percent** reduction in total phosphorus loading (Haith et al, 1992).
Controlled Drainage, Retrofit	Use of outlet control structure to store tile drain water for crop use during dry periods.	Reductions in total phosphorus loading of **35 percent** are reported (Gilliam et al., 1997).
Controlled Drainage, New Tile System	Converting from a surface drained system to a tile drained system with outlet control structures.	Reductions in total phosphorus loading of **65 percent** are reported (Gilliam et al., 1997).

4.2.3 Estimated Cost of Implementation

The net costs associated with the agricultural BMPs described in Section 4.2.2 depend on the cost of construction (for structural BMPs), maintenance costs (seeding, grading, etc.), and operating costs (electricity, fuel, labor, etc). In addition, some practices require that land be taken out of farm production and converted to treatment areas, which results in a loss of income from the cash crop. On the other hand, taking land out of production does save money on future seed, fertilizer, labor, etc., and this must be accounted for as well. This section describes how the various costs apply to each BMP, and presents an estimate of the annualized cost spread out over the service life of the BMP. Incentive plans, carbon trading, and cost share programs are discussed separately in Section 7.0.

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

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

4.2.3.1 Nutrient Management Plans

A good nutrient management plan should address the rates, methods, and timing of fertilizer application. To determine the appropriate fertilizer rates, consultants in Illinois typically charge $6 to $18 per acre, which includes soil testing, manure analysis, scaled maps, and site specific recommendations for fertilizer management (USEPA, 2003). Actual savings (or costs) depend on the reduction (or increase) in fertilizer application rates required by the nutrient management plan as well as other farm management recommendations.

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

Table 4-6 summarizes the assumptions used to develop the annualized cost for this BMP.

Table 4-6. Costs Calculations for Nutrient Management Plans.

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

4.2.3.2 Tillage Practices

Conservation tillage practices generally require fewer trips to the field, saving on labor, fuel, and equipment repair costs, though increased weed production may result in higher pesticide costs relative to conventional till (USDA, 1999). In general, conservation tillage results in increased profits relative to conventional tillage (Olson and Senjem, 2002; Buman et al., 2004; Czapar, 2006). The HRWCI (2005) lists the cost for conservation tillage at $0/ac.

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

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

Table 4-7 summarizes the available information for determining average annual cost for this BMP.

Table 4-7. Costs Calculations for Conservation Tillage.

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

4.2.3.3 Cover Crop

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

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

Accounting for the seed cost, herbicide cost, and fertilizer offset results in an average net cost of approximately $19.25/ac assuming that cover crop planting recommendations for a typical 2 year corn/soybean rotation are followed (Mannering et al., 1998). These costs do not account for yield increases which may offset the costs completely. Table 4-8 summarizes the costs and savings associated with ryegrass and hairy vetch.

Table 4-8. Costs Calculations for Cover Crops.

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

4.2.3.4 Vegetative Controls

The BMPs discussed above are farm management strategies that are applied over large areas; costs are estimated for each acre of agricultural land operating with the BMP. The vegetated controls are structural BMPs that collect runoff from agricultural fields and treat it in small zone using infiltration, sedimentation, and plant uptake to remove phosphorus. To compare costs with the farm management BMPs, the cost analyses for these structural BMPs are listed as the cost to treat one acre of agricultural drainage.

Filter Strips

Filter strips can either be seeded with grass or sodded for immediate function. The seeded filter strips cost approximately $0.30 per sq ft to construct, and sodded filter strips cost approximately $0.70 per sq ft to construct. Assuming that the required filter strip area is 2 percent of the area drained (Section 4.2.2.4) means that 870 square feet of filter strip are required for each acre of agricultural land treated. The construction cost to treat one acre of land is therefore $261/ac for a seeded filter strip and $609/ac for a sodded strip. At an assumed system life of 20 years (Weiss et al., 2007), the annualized construction costs are $13/ac/yr for seeded and $30.50/ac/yr for sodded strips. Annual maintenance of filter strips is estimated at $0.01 per sq ft (USEPA, 2002b) for an additional cost of $8.70/ac/yr of agricultural land treated. In addition, the area converted from agricultural production to filter strip will result in a net annual income loss of $3.50. Table 4-9 summarizes the costs assumptions used to estimate the annualized cost to treat one acre of agricultural drainage using either a seeded or sodded filter strip.

Table 4-9. Costs Calculations for Seeded and Sodded Filter Strips.

Item	Costs of Seeded Filter Strip Required to Treat One Acre of Agricultural Land	Costs of Sodded Filter Strip Required to Treat One Acre of Agricultural Land
Costs per Square Foot		
Construction Costs	$0.30	$0.70
Annual Maintenance Costs	$0.01	$0.01
Costs to Treat One Acre of Agricultural Land (assuming 870 sq ft of filter strip)		
Construction Costs	$261	$609
System Life (years)	20	20
Annualized Construction Costs	$13	$30.50
Annual Maintenance Costs	$8.70	$8.70
Annual Income Loss	$3.50	$3.50
Average Annual Costs	**$25/ac treated**	**$43/ac treated**

Grassed Waterways

Grassed waterways costs approximately $0.50 per sq ft to construct (USEPA, 2002b). These stormwater conveyances are best constructed where existing bare ditches transport stormwater, so no income loss from land conversion is expected with this practice. It is assumed that the average area required for a grassed waterway is approximately 0.1 to 0.3 percent of the drainage area, or between 44 and 131 sq ft per acre. The range is based on examples in the Illinois Drainage Guide, information from the NRCS Engineering Field Handbook, and a range of waterway lengths (100 to 300 feet). Waterways are assumed to remove phosphorus effectively for 20 years before soil, vegetation, and drainage material need to be replaced (Weiss et al., 2007). The construction costs spread out over the life of the waterway is thus $2.25/yr for each acre of agriculture draining to a grassed waterway. Annual maintenance of grassed waterways is estimated at $0.02 per sq ft (Rouge River, 2001) for an additional cost of $1.75/ac/yr of agricultural land treated. Table 4-10 summarizes the annual costs assumptions for grassed waterways.

Table 4-10. Costs Calculations for Grassed Waterways.

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

Riparian Buffers

Restoration of riparian areas costs approximately $100/ac to construct and $475/ac to maintain over the life of the buffer (Wossink and Osmond, 2001; NCEEP, 2004). Maintenance of a riparian buffer should be minimal, but may include items such as period inspection of the buffer, minor grading to prevent short circuiting, and replanting/reseeding dead vegetation following premature death or heavy storms. Assuming a buffer width of 90 ft on either side of the stream channel and an adjacent treated width of 300 ft of agricultural land, one acre of buffer will treat approximately 3.3 acres of adjacent agricultural land. The cost per treated area is thus $30/ac to construct and $142.50/ac to maintain over the life of the buffer. Assuming a system life of 30 years results in an annualized cost of $59.25/yr for each acre of agriculture land treated (Table 4-11).

Table 4-11. Costs Calculations for Riparian Buffers.

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

4.2.3.5 Drainage Control Structures for Tile Drain Outlets

Cooke (2005) estimates that the cost of retrofitting tile drain systems with outlet control structures ranges from $20 to $40 per acre. Construction of new tile drain systems with outlet control is approximately $75/ac. The yield increases associated with installation of tile drain systems are expected to offset the cost of installation (Cooke, 2005). It is assumed that outlet control structures have a system life of 30 years. Cost assumptions for retrofitting and installation of new tile drain systems with outlet control devices are summarized in Table 4-12.

Table 4-12. Costs Calculations for Outlet Control Devices on Tile Drain Systems.

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

Estimated net costs per acre of land managed or treated are summarized in Table 4-13 for each of the agricultural BMPs discussed in this plan. Costs were adjusted to reflect year 2004 prices for the Paris, Illinois area and represent total annualized costs to maintain and construct. The total costs were derived without accounting for the difference in value between costs incurred in the first year of the project versus costs incurred over the lifetime of the project (this process is typically termed “discounting”). If discounting had been used, the comparison would change between projects with relatively high upfront costs and projects with relatively high annual costs. When selecting the BMPs, farmers should consider how the timing of costs affects their operation as well as the total relative differences.

Table 4-13. Estimated 2004 Costs of Agricultural BMPs for Paris, Illinois.

BMP	Annualize Cost per Acre Treated per Year
Nutrient Management Plan	$0.75/ac to $3.75/ac
Conservation Tillage	$1.25/ac to $2.25/ac
Cover Crops	$19.25/ac
Filter Strips, Seeded	$25/ac
Filter Strips, Sodded	$43/ac
Grassed Waterways	$2/ac to $6/ac
Restoration of Riparian Buffers	$59.25/ac
Controlled Drainage, Retrofit	$0.75/ac to $1.50/ac
Controlled Drainage, New	$2.50/ac

4.2.4 BMP Effectiveness and Estimated Load Reductions

Several BMPs are available for use in the Paris Twin Lake watershed to reduce phosphorus loading from agricultural areas. Selecting a BMP will depend on estimated removal efficiencies, construction and maintenance costs, and individual preferences. Table 4-14 summarizes the annualized costs (construction, maintenance, and operation) for each BMP to treat one acre of agricultural runoff. The removal efficiencies reported in the literature are included as well.

Table 4-14. Cost and Removal Efficiencies for Agricultural BMPs.

BMP	Total Phosphorus Percent Reduction	Annualize Cost per Acre Treated per Year
Nutrient Management Plan	20 to 50	$0.75/ac to $3.75/ac
Conservation Tillage	68 to 76	$1.25/ac to $2.25/ac
Cover Crops	70 to 85	$19.25/ac
Filter Strips, Seeded	65	$25/ac
Filter Strips, Sodded	65	$43/ac
Grassed Waterways	30	$2/ac to $6/ac
Restoration of Riparian Buffers	90, 80[1]	$59.25/ac
Controlled Drainage, Retrofit	35	$0.75 to $1.50/ac
Controlled Drainage, New	65	$2.50/ac

[1] Land converted to a buffer from agricultural production will have a 90 percent lower phosphorus loading rate (Haith et al., 1992). Loads from adjacent treated areas will have an 80 percent reduction in phosphorus loading (NCSU, 2002).

4.3 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems are not typically a significant source of phosphorus loading if they are operating as designed. However, if the failure rates of systems in this watershed are high, then the loading from this source may be significant. At this time, no database of onsite wastewater treatment systems is available for the Paris Twin Lake watershed, so it is difficult to estimate levels of performance.

4.3.1 Source Description and Approximate Loading

Phosphorus loading rates from properly functioning onsite wastewater systems are typically insignificant. However, if systems are placed on unsuitable soils, not maintained properly, or are connected to subsurface drainage systems, loading rates to receiving waterbodies may be relatively high. It is suggested that each system in the watershed be inspected to accurately quantify the loading from this source. Systems older than 20 years and those located close to the lake should be prioritized for inspection.

To approximate the phosphorus loading rate from onsite wastewater systems, a rough calculation based on the population density, the area of the watershed, and net loading rates reported in the Generalized Watershed Loading Function (GWLF) User's manual were assumed. Year 2000 US Census data for Edgar County indicates that the total population in the watershed is approximately 8,563, and that 8,336 people reside in the City of Paris which treats wastewater at the Paris Sewage Treatment Plant. The number of people likely served by onsite wastewater treatment systems is therefore 227. Edgar County has an average household size of 2.4, so the number of systems in the watershed is approximately 94.

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

In a properly functioning septic system, wastewater effluent leaves the septic tank and percolates through the system drainfield. Phosphorus is removed from the wastewater by adsorption to soil particles. Plant uptake by vegetation growing over the drainfield is assumed negligible since all of the phosphorus is removed in the soil treatment zone. Failing systems that either short circuit the soil adsorption field or cause effluent to pool at the ground surface are assumed to retain phosphorus through plant uptake only (average annual uptake rate of 0.2 g/capita/day). Direct discharge systems intentionally bypass the drainfield by connecting the septic tank effluent directly to a waterbody or other transport line (such as an agricultural tile drain) so that no soil zone treatment or plant uptake occurs.

The USEPA Onsite Wastewater Treatment Systems Manual (2002b) estimates that septic systems fail (do not perform as designed) at an average rate of 7 percent across the nation. Based on comments made by local residents during the TMDL public meeting, failure rates in the Paris Twin Lakes watershed are likely higher. Phosphorus loading rates under four scenarios were calculated to show the range of loading from this source. System failures were distributed evenly over the three failure types: short circuiting, ponding, and directly discharging. Table 4-15 shows the phosphorus load if 7, 15, 30, and 60 percent of systems in the watershed are failing.

Table 4-15. Failure Rate Scenarios and Resulting Phosphorus Loads to Paris Twin Lakes Watershed.

Failure Rate[1] (%)	Average Annual Phosphorus Load (lb/yr)
7[2]	30
15	65
30	130
60	260

[1] Failures are assumed distributed evenly over short-circuiting, ponded, and directly discharging systems.
[2] This is the average annual failure rate across the nation and is likely not representative of failure rates in the Paris Twin Lakes watershed.

4.3.2 Appropriate BMPs

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

- Inspect system annually and pump system every 3 to 5 years, depending on the tank size and number of residents per household.
- Refrain from trampling the ground or using heavy equipment above a septic system (to prevent collapse of pipes).

- Prevent septic system overflow by conserving water, not diverting storm drains or basement pumps into septic systems, and not disposing of trash through drains or toilets.

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

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

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

4.3.3 Estimated Cost of Implementation

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

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

The cost of developing and maintaining a watershed-wide database of the onsite wastewater treatment systems in the Paris Twin Lakes watershed depends on the number of systems that need to be inspected. Based on Census data collected in 2000, there are approximately 94 households in the watershed. After the initial inspection of each system and creation of the database, only systems with no subsequent maintenance records would need to be inspected. A recent inspection program in South Carolina found that inspections cost approximately $160 per system (Hajjar, 2000).

Education of home and business owners that use onsite wastewater treatment systems should occur periodically. Public meetings; mass mailings; and radio, newspaper, and TV announcements can all be used to remind and inform owners of their responsibility to maintain their systems (Table 4-16).

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

The Edgar County Department of Public Health is responsible for administering septic tank programs in the watershed. The Department is responsible for the issuance of installation permits and the inspection of newly constructed and/or renovated/repaired septic systems and will inspect septic system compliance when a complaint is filed.

The Illinois EPA has proposed a new Clean Water Act general permit for private sewage disposal systems that discharge wastewater to the ground surface, storm sewers, streets, curbs, gutters, swales, ditches, streams, rivers, lakes or ponds. The proposed permit applies only to private surface discharging sewage disposal systems; conventional septic systems that discharge to a below-ground septic field are not required to be covered by this permit. The permit would limit how much fecal bacteria and other pollution the surface-discharging systems can emit. The permit would put in place a continuing system of maintenance and monitoring to reduce the chances that systems will fail and to catch them early if they do. The permit establishes one set of conditions rather than trying to re-write the parameters for every case.

Table 4-16. Costs Associated with Maintaining and Replacing an Onsite Wastewater Treatment System.

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

4.3.4 Effectiveness and Estimated Load Reductions

It is difficult to estimate the phosphorus loading rate from septic systems in the Paris Twin Lakes watershed because local estimates of failure rates are not available. Depending on the level of failure, septic systems in the Paris Twin Lakes watershed could contribute between 30 lb-P/yr and 260 lb-P/yr. The total annual cost for an initial inspection and periodic maintenance (pumping every three to five years) is approximately $100 to $120 per system per year.

4.4 Lake Bottom Sediments

Internal recycling of phosphorus could be a significant factor affecting TP concentrations, especially for East Lake because of the known low dissolved oxygen concentrations. It is possible that existing aerators in the Paris Twin Lakes may improve dissolved oxygen concentrations at the lake bottoms while running, although the data indicates that dissolved oxygen concentrations in these lakes are still low.

4.4.1 Source Description and Approximate Loading

Phosphorus release from sediments occurs during lake stratification when the soil water interface becomes anoxic (depleted of oxygen). It is very difficult to estimate the magnitude of this source without sufficient data on actual sediment release from the sediment or tributary loads. However, it is considered a potentially significant source within East Lake.

4.4.2 Appropriate BMPs

For lakes experiencing high rates of phosphorus inputs from bottom sediments, several management measures are available to control internal loading. This section presents three options that precipitate and bind phosphorus to the sediment. This discussion allows for a comparison of removal costs for the agricultural BMPs. The BMP costs for the next highest source of phosphorus loading (septic systems) could not be quantified for comparison with agricultural BMPs due to the uncertainties with failure rates and cost of implementing an inspection program. Thus, the discussion of three inlake phosphorus BMPs is presented to put the loading rates and cost for phosphorus removal from agricultural sources in perspective.

Hypolimnetic (bottom water) aeration involves an aerator air-release that can be positioned at a selected depth or at multiple depths to increase oxygen transfer efficiencies in the water column and reduce internal loading by establishing aerobic conditions at the sediment-water interface. Hypolimnetic aeration effectiveness in reducing phosphorus concentration depends in part on the presence of sufficient iron to bind phosphorus in the oxygenated waters. A mean hypolimnetic iron:phosphorus ratio greater than 3.0 is optimal to promote iron phosphate precipitation (Stauffer, 1981). The iron:phosphorus ratio in the sediments should be greater than 15 to bind phosphorus (Welch, 1992).

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

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

4.4.3 Estimated Cost of Implementation

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

The number and size of hypolimnetic aerators used in a waterbody depend on lake morphology, bathymetry, and hypolimnetic oxygen demand. Total cost for successful systems has ranged from $170,000 to $1.7 million (Tetra Tech, 2002). USEPA (1993) reports initial costs ranging from $340,000 to $830,000 plus annual operating costs of $60,000. System life is assumed to be 20 years. Paris Twin Lakes currently have 6 aerators which were installed approximately 15 years ago: two within West Lake and four within East Lake (Personal communications with Rick Craig, City of Paris Water Treatment Plant, February 1, 2008).

Alum treatments are effective on average for approximately 8 years per application and can reduce internal loading by 80 percent. Treatment cost ranges from $290/ac to $720/ac (WIDNR, 2003). The combined surface area of Paris Twin Lake is 220 ac, so total application costs for the lake would likely range from $63,800 to $154,800.

Dierberg and Williams (1989) cite mean initial and annual costs for 13 artificial circulation projects in Florida of $440/ac and $190/ac/yr, respectively. For Paris Twin Lake, which has a surface area of 220 ac, the construction cost would be $96,800 and the annual maintenance costs $41,800. The system life is assumed 20 years.

Table 4-17 summarizes the cost analyses for the three inlake management measures. The final column lists the annualized cost per lake surface area (220 ac) treated.

Table 4-17. Cost Comparison of Inlake Phosphorus Controls.

Control	Construction or Application Cost	Annual Maintenance Cost	Annualized Costs $/ac/yr
Hypolimnetic Aeration	$170,000 to $830,000	$60,000	$850 to $1,260
Alum Treatment	$63,800 to $154,800	$0	$36 to $90
Artificial Circulation	$96,800	$41,800	$210

4.4.4 Effectiveness and Estimated Load Reductions

Little information is available concerning the effectiveness of the aerators currently installed in the Paris Twin Lakes on reducing internal loading of phosphorus. However, sampling of the lake that has occurred since they were installed indicates that phosphorus concentrations continue to exceed water quality standards.

For the purposes of this Implementation Plan, it is assumed that aerators, alum treatment, and artificial circulation devices all reduce internal loading by 80 percent. Based on this assumption, alum treatment is the most cost-effective.

4.5 Precipitation and Atmospheric Deposition

Phosphorus loading from atmospheric deposition is not considered a significant fraction of the loading to Paris Twin Lakes. Wind erosion is usually the primary loading mechanism for phosphorus, but is not a concern in east-central Illinois (Franke, 2006). USGS reports atmospheric deposition rates of phosphorus from agricultural areas near Lake Michigan at 0.18 lb/ac/yr (Robertson, 1996). With a lake surface area of 25.1 ac and 65.9, the phosphorus load due to atmospheric deposition to West and East Lakes are estimated to be 4.5 lb-P/yr and 11.9 15 lb-P/yr respectively. This is small fraction of the load estimated from watershed sources.

4.6 Shoreline Erosion

No information is currently available to assess the impacts of shoreline erosion to the water quality of Paris Twin Lakes. However, the Phase II Implementation study (Illinois EPA, 1998) found that shoreline protection and stabilization measures suggested in the Phase I report proved to be successful in reducing shoreline erosion and it is therefore not considered a significant current source.

4.7 Stream Channel Erosion

The extent of stream channel erosion in the Paris Twin Lake watershed is not known. Inspection of the streambanks is needed to quantify the loading from this source.

4.7.1 Source Description and Approximate Loading

Without field inspections of the streambanks in the Paris Twin Lake watershed, it is not possible to quantify the amount of phosphorus loading from this source. The most cost-effective way to assess streambank erosion is to visually inspect representative reaches of each channel and rank the channel stability using a bank erosion index. Banks ranked moderately to severely eroding should be targeted for stabilization efforts. A more time and resource intensive method is to determine the rate of erosion by inserting bank pins and measuring the rate of recession. Once soil loss estimates are obtained, phosphorus loading can be calculated from soil phosphorus contents.

4.7.2 Appropriate BMPs

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

4.7.3 Estimated Cost of Implementation

Because the extent of streambank erosion in the watershed is not known, specialized BMPs, such as engineering controls, are not suggested. Rather, the agricultural BMPs discussed in Section 4.2 that also address streambank stability are recommended (Table 4-18).

Table 4-18. Agricultural Phosphorus BMPs with Secondary Benefits for Streambank Stability.

BMP	Description	Annualized Cost Estimates
Filter Strips	Placement of vegetated strips in the path of field drainage to remove sediment and nutrients and reduce runoff velocities.	Seeded filter strips cost $25/ac treated Sodded strips cost $43/ac treated
Grassed Waterways	A runoff conveyance that removes phosphorus by sedimentation and plant uptake. Reduces peak flow velocities and subsequent erosion.	$2/ac to $6/ac
Restoration of Riparian Buffers	Conversion of land adjacent to stream channels to vegetated buffer zones. Removes phosphorus by sedimentation and plant uptake. Provides stream bank stability, stream shading, and aesthetic enhancement.	$59.25/ac treated

4.7.4 Effectiveness and Estimated Load Reductions

Because the phosphorus loading from streambank erosion has not been quantified, it is not possible to estimate the additional phosphorus removed by these BMPs (over that assumed for agricultural load reductions). The benefits of filter strips, grassed waterways, and riparian buffers are therefore underestimated in this report.

4.8 Lawn Fertilizer Application

Another potential source of nutrients is lawn fertilizer application from residential properties surrounding the lakes. According to the GAP landuse database, there are 32 acres of residential land within a half-mile of Paris Twin East and 15 acres within a half-mile of Paris Twin West. Nutrients in lawn fertilizers from residential areas can be carried to the lake during precipitation events and can be a major seasonal source of phosphorus and nitrogen. Loading rates from lawn fertilizers (residential landuse) are estimated to range from 0.68 lb/ac/yr to 1.96 lb/ac/yr for total phosphorus (Loehr, et.al., 1989). Therefore, the estimated total phosphorus load from this source could range from 32 to 92 lb/yr.

The most effective BMP for managing loads from lawn fertilizes is a public outreach program that educates the homeowner about lawn care and the importance of minimizing fertilizer applications. A public outreach program can be accomplished through public meetings; mass mailings; radio, newspaper, and TV announcements to educate individual homeowners. The costs associated with outreach programs will vary depending on the level of effort. Assuming education will be given through annual public reminders, the annual cost is estimated at $1 per household. The average cost to implement an outreach program for lawn fertilizer management is therefore approximately $47/yr yr assuming an average lot size of 1 acre.

Homeowners and businesses with property near the lakes can also reduce lawn fertilizer applications by using native vegetation in streamside buffer strips and near lake areas which also reduces maintenance costs.

5.0 PRIORITIZATION OF IMPLEMENTATION

The phosphorus TMDL for Paris Twin Lake requires a 75 percent reduction in annual loading. Section 4.0 provides loading estimates by source category and describes management options in terms of cost and load reduction capability. This section condenses the information presented in Section 4.0 so that the management strategies can be prioritized to cost effectively reduce phosphorus loading.

5.1 Current Phosphorus Loading to Paris Twin Lake

Phosphorus loads to Paris Twin Lake vary yearly due to the frequency and intensity of rainfall events and the timing of fertilizer application. Phosphorus loads from the 20,488 ac of heavily tiled row crop agriculture likely range from 5,390 lb/yr to 16,169 lb/yr based on data presented by Gentry et al. (2007). In addition to agricultural sources of phosphorus, onsite wastewater treatment systems also contribute phosphorus loading. It is difficult to quantify the loading from septic systems, but the load likely falls somewhere between 30 lb/yr and 260 lb/yr, depending on the failure rate of systems in the watershed. The phosphorus loading from internal lake recycling could not be calculated and the loading from atmospheric deposition is considered negligible. For comparison, the average observed loads into West Lake are 8,642 lb/yr (Table 1-3) and the observed East Lake loads are 5,556 lb/yr (Table 1-4).

Managing phosphorus loads to the lake will primarily involve the use of agricultural BMPs and maintenance of septic systems. Significant work has already begun in the watershed as a result of an IEPA 319 grant and Federal Clean Lakes Studies. A map of existing SWCD BMP projects in the watershed is presented in Figure 4-2. Watershed management measures currently in place in the Paris Twin Lake watershed include the following (Edgar County Soil and Water Conservation, 1998):

- 8 grassed waterways
- 4,800 feet of terraces
- 500 ft of waterway diversions
- 1 rock chute
- 2 concrete block chutes
- 1 concrete crossing
- Rip rap stream stabilization
- 5.2 ac of buffer zones
- 1 sediment retention basin

It is difficult to estimate the load reductions achieved by these BMPs because little information on the design practices and contributing drainage area is available. If phosphorus concentrations are reduced relative to data collected over the past decade, then the cumulative effectiveness of these practices in achieving load reductions can be assessed.

5.2 Use of Phosphorus BMPs to Meet Water Quality Goals

Table 5-1 summarizes the potential loading from each source (without considering BMPs) along with reported reductions and the total cost to implement the measures over all applicable areas. The information in the table is not to suggest that each BMP will be implemented watershed wide, nor does it account for BMPs already in place. The purpose is to compare the potential load reduction from each BMP as well as the cost associated with achieving that reduction.

Note that the source area, and therefore the loading rate, for riparian buffers is much less than for the other agricultural controls because riparian buffers are only applicable along stream channels and only treat the adjacent 300 ft of land on either side of the buffer, not the entire watershed. In addition to the treated area adjacent to the buffer, the land converted to a buffer also recognizes a reduction in phosphorus loading. To achieve a reduction of 80 percent, we are assuming a buffer width on both sides of the stream channel of 90 ft. The estimated stream length in the watershed where riparian buffers could be constructed is 17.21 miles. Thus, the area that could be converted to a buffer is approximately 371 acres and the area treated by this amount of buffer is 1100 acres. Given phosphorus loading rates from tiled agricultural land ranging from 0.5 lb/ac/yr to 1.5 lb/ac/yr, the loading from the source area (1471 ac) is approximately 735.5 to 2206.5 lb/yr. The other agricultural BMPs are applicable to all 10,779 ac of farmland in the watershed and are not restricted by the presence of a stream channel.

Table 5-1. Comparison of Phosphorus BMPs for Agricultural Production, and Onsite Wastewater Treatment Systems

BMP	Reported Phosphorus Removal Rate (%)	Estimated Loading from Source (lb/yr)	Potential Reduction in Phosphorus Loading (lb/yr)	Annualized Costs for Full Management
Agricultural BMPs for 10,779 Acres of Farmland in the Watershed				
Nutrient Management Plan with Deep Phosphorus Placement	20 to 50	5,390 to 16,169	1,078 to 8,084	$ 8,099to $40,496
Conservation Tillage	68 to 76	5,390 to 16,169	3,665 to 12,288	$13,498to $24,297
Cover Crops	70 to 85	5,390 to 16,169	3,773 to 13,743	$207,880
Seeded Filter Strips	65	5,390 to 16,169	3,503 to 10,509	$26,997
Sodded Filter Strips	65	5,390 to 16,169	3,503 to 10,509	$46,437
Grassed Waterways	30	5,390 to 16,169	1,617 to 4,850	$21,558 to 64,794
Restoration of Riparian Buffers	80 for treated area and 90 for converted area	735 to 2206	588 to 1,985	$846,327
Retrofit Controlled Drainage	35	5,390 to 16,169	1,886 to 5,700	$8,099 to $16,198
Onsite Wastewater Treatment BMPs Assuming 94 Systems in the Watershed				
Pumping/ Maintenance	100 percent reduction if all systems are maintained properly and functioning as designed with replacement likely occurring once every 30 years	30 to 260	30 to 260	$6,580 to $7,990 to pump all 94 systems once every three to five years
Inspection				Up to $3000 if each system has to be inspected once every five years.
Replacement				$6,300 to $31,300 assuming each system is replaced once every 30 years
Education				$94

Extending agricultural BMPs to additional areas in the watershed will likely result in significant reductions in phosphorus loading above those already achieved with current management measures. Nutrient management plans with deep phosphorus placement, conservation tillage, grassed waterways, and retrofitting tile drain systems with outlet control devices are all relatively inexpensive BMPs with potential phosphorus reductions ranging from 1,078 to 12,288 lb/yr. These load reductions are comparable to the more expensive BMPs at less than one-fourth of the cost.

Achieving a zero percent failure rate of septic systems in the Paris Twin Lake watershed would likely reduce loads by 30 to 260 lb/yr, assuming that the current failure rate is somewhere between 7 and 60 percent. In terms of phosphorus load reduction, this management measure would be relatively expensive compared to the agricultural BMPs.

Given the relatively low contribution of atmospheric deposition to the total phosphorus balance, control of this sources is not cost-effective. Similarly, the magnitude of internal lake recycling is unknown and addressing this source will be expensive. Therefore, for the Paris Twin Lake watershed, load reductions should be focused on agricultural BMPs and repair of failing septic systems.

5.2.1 Implementation Strategy for Agricultural BMPs

Focusing on the low cost-high reduction options first will likely result in greater participation in the community. The use of grassed waterways along drainage pathways is applicable watershed-wide and is capable of reducing phosphorus loads by approximately 30 percent. Another relatively low cost option is retrofitting the tile drain systems in the watershed with outlet control devices that store water for crop use during dry periods and have been shown to reduce phosphorus loading by 35 percent.

Conservation tillage practices, particularly on corn fields should also be encouraged. The majority of soybean fields (55 percent) and corn fields (32 percent) in Edgar County use some form of conservation tillage. Extending conservation tillage to the remaining 45 percent of soybean fields and 68 percent of corn fields may reduce phosphorus loading by 68 to 76 percent, assuming that half of the fields are planted in soybean or corn during any given year.

Nutrient management planning, conservation tillage practices, grassed waterways, and controlled drainage structures are all relatively low cost BMPs, with approximate net costs ranging from $1 to $6/ac/yr.

Once these practices have been adopted on as many fields as possible through voluntary participation of growers in the watershed, future water quality sampling will determine whether or not the higher cost BMPs may be necessary. Use of cover crops, filter strips, and restoration of riparian buffers would be supplemental strategies for the lower cost, source reduction practices; expected costs of these practices range from $19 to $60 per acre treated.

6.0 MEASURING AND DOCUMENTING PROGRESS

The Volunteer Lake Monitoring Program (VLMP) is currently operating under the Tier 1 sampling program for Paris Twin Lakes. Expansion of this program to Tier 2 is a possibility for this lake. If needed, the program may even be expanded to Tier 3. The three levels of monitoring are summarized below:

- Tier 1 – In this tier, volunteers perform Secchi disk transparency monitoring and field observations only. Monitoring is conducted twice per month from May through October typically at three in-lake sites.
- Tier 2 – In addition to the tasks of Tier 1, Tier 2 volunteers collect water samples for nutrient and suspended solid analysis at the representative lake site: Site 1. Water quality samples are taken only once per month in May-August and October in conjunction with one Secchi transparency monitoring trip.
- Tier 3 – This is the most intensive tier. In addition to the tasks of Tier 1, Tier 3 volunteers collect water samples at up to three sites on their lake (depending on lake size and shape). Their samples are analyzed for nutrients and suspended solids. They also collect and filter their own chlorophyll samples. This component may also include DO/Temp. profiles as equipment is available. As in Tier 2, water quality samples are taken only once per month in May-August and October in conjunction with one Secchi transparency monitoring trip.

Data collected in either Tier 1 or Tier 2 is considered educational. It is used to make general water quality assessments. Data collected in Tier 3 is used in the Integrated Report and is subject to the impaired waters listing. It would also be useful to determine why concentrations in the lake are higher during dry summers compared to wet summers. The following tests and measurements would be helpful in this effort.

- Measuring dissolved and total phosphorus concentrations in tile drain effluent.
- Leak testing and inspecting the centralized wastewater system including the sewer pipes, lagoon liner, and effluent pipeline.
- Inspection of onsite wastewater treatment systems in the watershed to determine rates of failure and approximate contribution to the lake.

Continuing to monitor total phosphorus and other water quality parameters in Paris Twin Lakes will determine how effective these management practices are. If the concentrations are still observed above the water quality standard, encouragement of the use of BMPs across the watershed through education and incentives will be a priority. It may also be necessary to begin funding efforts for structural BMPs such as filter strips and riparian buffer restoration.

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7.0 REASONABLE ASSURANCE

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

7.1 Environmental Quality Incentives Program (EQIP)

Several cost share programs are available to farmers and landowners who voluntarily implement resource conservation practices in the Paris Twin Lakes watershed. The most comprehensive is the NRCS Environmental Quality Incentives Program (EQIP) which offers cost sharing and incentives to farmers statewide who utilize approved conservation practices to reduce pollutant loading from agricultural lands.

- The program will pay $10 for one year for each acre of farmland that is managed under a nutrient management plan (up to 400 acres per farmer).
- Use of vegetated filter strips will earn the farmer $100/ac/yr for three years (up to 50 acres per farmer).
- The program will also pay 60 percent of the cost to construct grassed waterways, riparian buffers, and windbreaks.
- Use of residue management will earn the farmer $15/ac for three years (up to 400 acres per farmer).
- Installation of drainage control structures on tile outlets will earn the farmer $5/ac/yr for three years for the effected drainage area as well as 60 percent of the cost of each structure.

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

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

7.2 Conservation 2000

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

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

7.2.1 Conservation Practices Program (CPP)

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

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

7.2.2 Streambank Stabilization Restoration Program

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

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

7.2.3 Sustainable Agriculture Grant Program (SARE)

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

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

7.3 Conservation Reserve Program (CRP)

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

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

7.4 Nonpoint Source Management Program (NSMP)

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

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

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

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

7.5 Agricultural Loan Program

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

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

7.6 Illinois Conservation and Climate Initiative (ICCI)

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

Current exchange rates are available online at http://chicagoclimatex.com. Administrative fees of $0.14/mt plus 8 percent are subtracted from the sale price.

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

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

Table 7-1 and Table 7-2 summarize the cost share programs available for phosphorus reduction BMPs in the Paris Twin Lakes watershed.

Table 7-1. Summary of Assistance Programs Available for Farmers in the Paris Twin Lakes Watershed.

Assistance Program	Program Description	Contact Information
NRCS EQIP	Offers cost sharing and rental incentives to farmers statewide who utilize approved conservation practices to reduce pollutant loading from agricultural lands. Applies to nutrient management plans, filter strips, grassed waterways, riparian buffers, and conservation tillage.	USDA Local Service Centers Natural Resources Conservation Service (NRCS) U.S. Department of Agriculture 11759 Il Highway 1 Paris, IL 61944 Phone: (217) 465-5325
Conservation 2000 CPP	Provides up to 60 percent cost share for several agricultural phosphorus BMPs: cover crops, filter strips, grassed waterways.	Edgar County SWCD 11759 Il Highway 1 Paris, IL 61944 Phone: (217) 465-5325, Ext. 3 Fax: (217) 466-1130
Conservation 2000 Streambank Stabilization Restoration Program	Provides 75 percent cost share for establishment of riparian corridors along severely eroding stream banks. Also provides technical assistance and educational information for interested parties.	Edgar County SWCD 11759 Il Highway 1 Paris, IL 61944 Phone: (217) 465-5325, Ext. 3 Fax: (217) 466-1130
SARE	Funds educational programs for farmers concerning sustainable agricultural practices.	Edgar County SWCD 11759 Il Highway 1 Paris, IL 61944 Phone: (217) 465-5325, Ext. 3 Fax: (217) 466-1130
FSA CRP	Offsets income losses due to land conversion by rental agreements. Targets highly erodible land or land near sensitive waters. Provides up to 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years for converted land.	Farm Service Agency (FSA) Local Office 11759 Il Highway 1 Paris, IL 61944 Phone: (217) 465-5325, Ext. 3 Fax: (217) 466-1130
NSMP (319)	Provides grant funding for educational programs and implementation of nonpoint source pollution controls.	Illinois Environmental Protection Agency Bureau of Water Watershed Management Section, Nonpoint Source Unit P.O. Box 19276 Springfield, IL 62794-9276 Phone: (217) 782-3362
Agricultural Loan Program	Provides low-interest loans for the construction and implementation of agricultural BMPs. Loans apply to equipment purchase as well.	Office of State Treasurer Agricultural Loan Program 300 West Jefferson Springfield, Illinois 62702 Phone: (217) 782-2072 Fax: (217) 522-1217
ICCI	Allows farmers to earn carbon trading credits for use of conservation tillage, grass, and tree plantings.	Edgar County SWCD 11759 Il Highway 1 Paris, IL 61944 Phone: (217) 465-5325, Ext. 3 Fax: (217) 466-1130

Table 7-2. Assistance Programs Available for Agricultural Phosphorus BMPs.

BMP	Cost Share Programs and Incentives
Education and Outreach	Conservation 2000 Streambank Stabilization Restoration Program SARE NSMP ECSWCD
Nutrient Management Plan	EQIP: $10/ac for one year, 400 ac. max. ECSWCD: up to $30/ac for one year
Conservation Tillage	EQIP: $15/ac for three years, 400 ac. max. ICCI: earns 0.5 mt/ac/yr of carbon trading credit
Cover Crops	CPP: cost share of 60 percent
Filter Strips	EQIP: $100/ac for three years, 50 ac. max. CPP: 60 percent of construction costs CRP: 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years ICCI: earns 0.75 mt/ac/yr of carbon trading credit for each acre planted
Grassed Waterways	EQIP: 60 percent of construction of costs CPP: 60 percent of construction costs CRP: 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years ICCI: earns 0.75 mt/ac/yr of carbon trading credit for each acre planted
Land Retirement of Highly Erodible Land or Land Near Sensitive Waters	CRP: 50 percent of the costs of establishing vegetative cover and cash incentive of $185/ac/yr for 15 years ICCI: earn between 0.75 and 5.4 mt/ac/yr of carbon trading credit depending on species planted
Restoration of Riparian Buffers	EQIP: 60 percent of construction of costs CRP: 50 percent of the costs of establishing vegetative cover and cash incentive of $185/ac/yr for 15 years CPP: up to 75 percent of construction costs ECSWCD: $250 contract incentive ICCI: earn between 0.75 and 5.4 mt/ac/yr of carbon trading credit depending on species planted

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

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8.0 IMPLEMENTATION TIME LINE

This implementation plan for the Paris Twin Lakes TMDL defines a phased approach for achieving the phosphorus standard in the lakes (Figure 8-1). Ideally, implementing phosphorus control measures in the Paris Twin Lake watershed will be based on voluntary participation which will depend on 1) the effectiveness of the educational programs for farmers and landowners, and 2) the level of participation in the programs. This section outlines a schedule for implementing the control measures and determining whether or not they are sufficient to meet the water quality standard.

Phase I of this implementation plan should focus on education of farm owners concerning the benefits of agricultural BMPs on crop yield, soil quality, and water quality as well as cost share programs available in the watershed. It is expected that initial education through public meetings, mass mailings, TV and radio announcements, and newspaper articles could be achieved in less than 6 months. As described in Section 7.0, assistance with educational programs is available through the following agencies: the Illinois Department of Agriculture Conservation 2000 Streambank Stabilization Restoration Program, the Illinois Department of Agriculture Sustainable Agriculture Grant Program (SARE), the Illinois Environmental Protection Agency Nonpoint Source Management Program (NSMP), and the Edgar County Soil and Water Conservation District .

Phase II of the implementation schedule will involve voluntary participation of farmers and landowners in adopting BMPs such as nutrient management planning, conservation tillage, grassed waterways, and tile drain outlet control. The local Natural Resources Conservation Service office will be able to provide technical assistance and cost share information for these BMPs. Continued monitoring of water quality in Paris Twin Lake could occur at the three Illinois EPA monitoring stations located on each lake. This phase of the plan will likely take three years.

If phosphorus concentrations measured during Phase II monitoring remain above the water quality standard, Phase III of the implementation plan will be necessary. The load reduction achieved during Phase II should be estimated by 1) summarizing the areas where BMPs are in use, 2) calculating the reductions in loading from BMPs, and 3) determining the impacts on total phosphorus concentrations measured before and after Phase II implementation. If BMPs are resulting in decreased phosphorus concentrations, and additional areas could be incorporating these practices, further efforts to include more stakeholders in the voluntary program will be needed. If the Phase II BMPs are not having the desired impacts on phosphorus concentrations, or additional areas of incorporation are not available, supplemental agricultural BMPs will be needed: cover crops, filter strips, restoration of riparian areas, etc. Strategic placement of these more expensive BMPs near stream channels and the lake shore will provide maximized benefits. If required, this phase may last five to ten years.

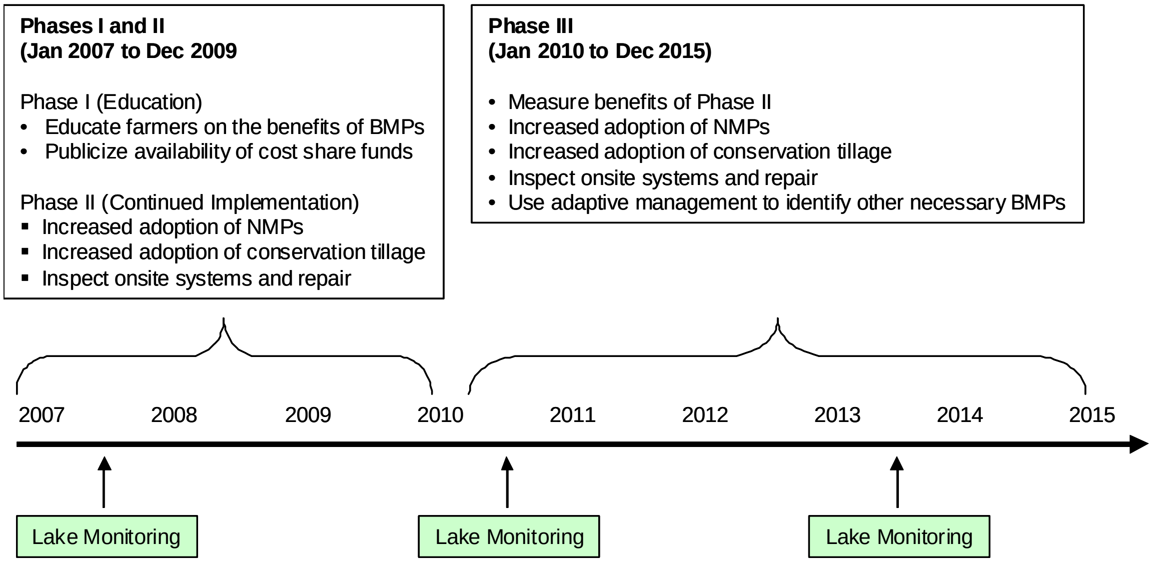

Figure 8-1. Timeline for the Paris Twin Lakes Phosphorus TMDL Implementation Plan.

9.0 CONCLUSIONS

Total phosphorus concentrations collected in Paris Twin Lakes frequently exceed the Illinois water quality standard of 0.05 mg/L. IEPA has included Paris Twin Lake on the Illinois 303(d) list of impaired waters, and the phosphorus TMDL was approved in September 2006. The total phosphorus TMDL for Paris Twin Lakes indicate that a reduction in loading of 75 percent is required to maintain the total phosphorus standard. This implementation plan has identified the major sources of phosphorus loading to the lake and suggests a phased approach to achieve the water quality standard.

The major sources of phosphorus to Paris Twin Lakes are agriculture and failing septic systems. Four cost-effective agricultural BMPs have been identified to reduce phosphorus loading to the lake: nutrient management planning with deep phosphorus placement, conservation tillage, grassed waterways, and use of outlet control structures on tile drain systems. These BMPs can each be implemented at a cost ranging from $1 to $6/ac/yr (not considering cost share programs) and may be sufficient to meet the water quality standard in the lake if they are used widely across the watershed.

Phase I of this implementation plan will provide education and incentives to farmers in the watershed to encourage the use of these BMPs. Phase II will occur during and following Phase I and will involve voluntary participation of farmers and landowners in the watershed. Future water quality monitoring will determine whether or not the voluntary BMPs are capable of reaching the water quality goals in the watershed.

Whether or not Phase III will be required depends on the results of future water quality sampling. If the water quality standard is not being met after implementation of the voluntary BMPs on as many acres as possible, then the more expensive BMPs (ranging from $19 to $60 per acre treated, not accounting for cost share programs) will need to be considered. These include cover crops, filter strips, and restoration of riparian buffers. Due to the expense of these BMPs, it will be necessary to strategize their placement to maximize the benefits to water quality.

In addition to the agricultural sources, septic systems likely contribute 30 to 260 lb-P/yr to Paris Twin Lakes Though controlling phosphorus loads from agricultural areas will likely achieve the required phosphorus reduction, failing wastewater treatment systems are a public health hazard and potential source of other pollutants. Ensuring proper onsite treatment will require a comprehensive inspection, maintenance, and education program. Reduction in phosphorus loading to the lakes will be a secondary benefit of the program.

As agricultural BMPs are implemented and failing septic systems are corrected, water quality in Paris Twin Lakes should improve accordingly. Measuring the effectiveness of these BMPs will require continued sampling of water quality in both lakes over the next several years. Measurements should continue for a minimum of two monitoring cycles to document progress and direct future management strategies.

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REFERENCES

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

Bird, Garry. 2006. Personal communication via email to Alix Matos dated July 20, 2006. Garry Bird, Director of Environmental Health, Champaign-Urbana Public Health District.

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

Chapra, S. C., 1997. Surface Water Quality Modeling. McGraw Hill. Boston, Massachusetts.

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

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

Coombes, R. 2007. Personal Communications dated October 12, 2007. USDA Natural Resources Conservation Service, Paris Service Office, Illinois NRCS.

Craig, Rick. 2008. Personal communication via phone to Elizabeth Hansen dated February 1, 2008. Rick Craig, Paris Water Plant Superintendent

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

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

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

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

Franke, G. 2006. Personal communication via email to Alix Matos dated July 25, 2006. Glen Franke, District Conservationist, Danville Field Office, Illinois NRCS.

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

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

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

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

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

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

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

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

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

IEPA. 2003. Charleston Side Channel Reservoir Total Maximum Daily Load Report, Coles County, Illinois. Illinois Environmental Protection Agency, IEPA/BOW/03-013, August 2003.

IEPA. 2004. Altamont New Reservoir TMDL Report. Illinois Environmental Protection Agency, IEPA/BOW/03-011, October 2004.

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

Illinois Department of Agriculture, 2006. 2006 Illinois Soil Conservation Transect Survey Summary, Springfield, Illinois.

INHS. 2003. Illinois Natural History Survey's 1999-2000 1:100 000 Scale Illinois Gap Analysis Land Cover Classification, Raster Digital Data, Version 2.0, September 2003.

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

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

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

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

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

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

NCSU. 2002. Riparian Buffers and Controlled Drainage to Reduce Agricultural Nonpoint Source Pollution. Departments of Soil Science and Biological and Agricultural Engineering, North Carolina Agricultural Research Service, North Carolina State University, Raleigh, North Carolina. Technical Bulletin 318, September 2002.

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

Nürnberg, G. K. 1984. The prediction of internal phosphorus load in lakes with anoxic hypolimnia. *Limnol. Oceanogr*. 29: lll-124.

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

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

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

OSUE. 1999. Cover Crop Fundamentals. Ohio State University Extension Food, Agricultural and Biological Engineering. Fact Sheet AGF-142-99.

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

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

Rast, W. and G.F. Lee. 1983. “Nutrient Loading Estimates for Lakes,” *Journal of Environmental Engineering*, 109:502-517.

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

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

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

Southwest Farm Press. 2001. Drought underscores value of con-till, Sep 20, 2001.

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

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

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

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

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

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

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

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

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

USEPA. 1993. Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters. EPA 840-B-92-002 January 1993.

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

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

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

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

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

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

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

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

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