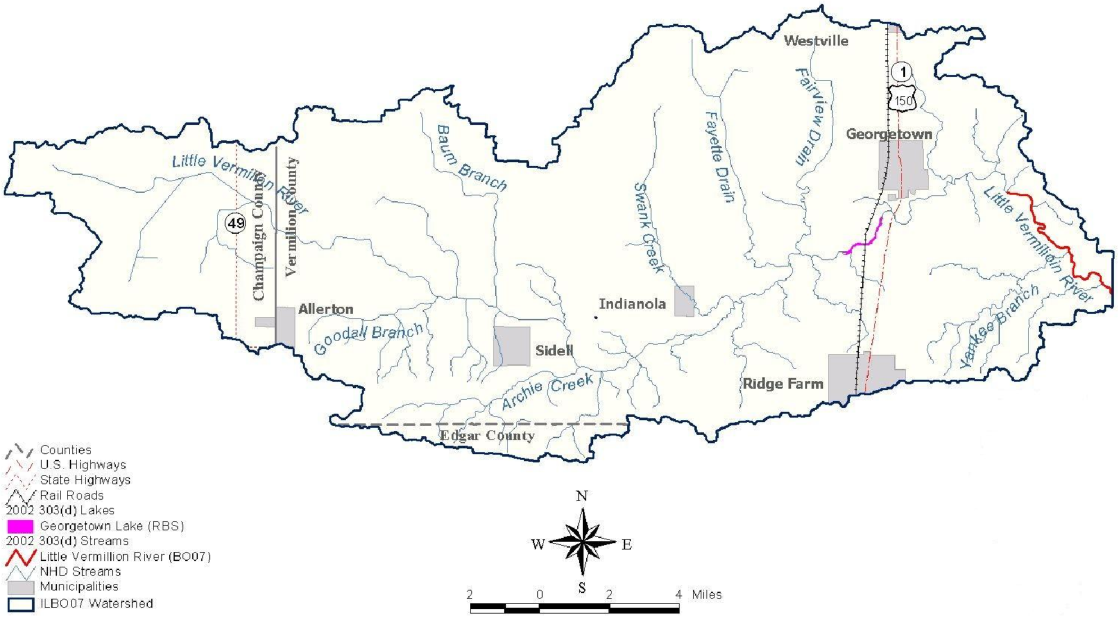
Illinois
Environmental
Protection Agency

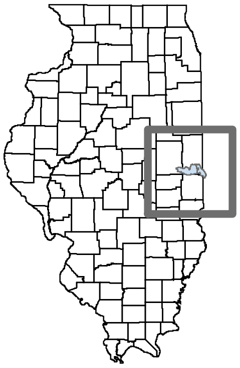
Bureau of Water
P.O. Box 19276
Springfield, IL 62794-9276

June 2008

IEPA/BOW/08-015

LITTLE VERMILION RIVER/ LAKE GEORGETOWN WATERSHED TMDL REPORT





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TMDL Development for the Little Vermilion River/Lake Georgetown Watershed, Illinois

This file contains the following documents:

1) U.S. EPA Approval letters for Stage Three TMDL Report
2) Stage One Report: Watershed Characterization and Water Quality Analysis
3) Stage Three Report: Georgetown Lake TMDL Development
4) Stage Three Report: Little Vermillion River TMDL Development
5) Georgetown Lake Implementation Plan
6) Little Vermilion River Implementation Plan

T Sample

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

REPLY TO THE ATTENTION OF:
WW-16J

SEP 30 2005

RECEIVED
OCT 11 2005
Watershed Management Section
BUREAU OF WATER

Ms. Marcia Willhite
Bureau of Water
IEPA
1021 North Grand Avenue East
Springfield, IL 62794-9276

Dear Ms. Willhite:

The United States Environmental Protection Agency (U.S. EPA) has reviewed the final Total Maximum Daily Load (TMDL) from the Illinois Environmental Protection Agency (IEPA) for the Little Vermilion/Georgetown Lake Watershed in Illinois. The TMDL is for Georgetown Lake (RBS) for phosphorus and addresses phosphorus, habitat, excessive algal growth, and Total Suspended Solids (TSS) that impair multiple uses.

Based on this review, U.S. EPA has determined that Illinois' TMDL for phosphorus meet the requirements of Section 303(d) of the Clean Water Act and U.S. EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, U.S. EPA hereby approves the TMDL addressing four impairments for Little Vermilion River/Georgetown Lake Watersheds. The statutory and regulatory requirements, and U.S. EPA's review of Illinois' compliance with each requirement, are described in the enclosed decision document.

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

Sincerely yours,

for Jo Lynn Traub
Director, Water Division

Enclosure

cc: Bruce Yurdin, IEPA

DS

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

OCT 13 2006

REPLY TO THE ATTENTION OF:
WW-16J

RECEIVED
OCT 18 2006
Watershed Management Section
BUREAU OF WATER

Ms. Marcia T. Willhite, Chief
Bureau of Water
IEPA
P.O. Box 19276
Springfield, IL 62794-9276

Dear Ms. Willhite:

The United States Environmental Protection Agency (U.S. EPA) has reviewed the final Total Maximum Daily Load (TMDL) from the Illinois Environmental Protection Agency (IEPA) for the Little Vermilion River in Illinois. The TMDL is for the Little Vermilion River (BO-07) for fecal coliform and addresses the impaired primary contact use. Based on this review, U.S. EPA has determined that Illinois' TMDL for fecal coliform meets the requirements of Section 303(d) of the Clean Water Act and U.S. EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, U.S. EPA hereby approves the TMDL addressing one impairment for the Little Vermilion River. The statutory and regulatory requirements, and U.S. EPA's review of Illinois' compliance with each requirement, are described in the enclosed decision document.

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

Sincerely yours,

for Jo Lynn Traub
Director, Water Division

Enclosure

cc: Bruce Yurdin, IEPA

TMDL Development for the Little Vermilion River Watershed

Stage One Report:
Watershed Characterization and Water Quality Analysis

FINAL REPORT

April 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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Key Findings

As part of the Section 303(d) listing process, the Illinois Environmental Protection Agency (IEPA) has identified two waterbodies in the Little Vermilion River watershed as impaired:

- Georgetown Lake (segment RBS)
- Little Vermilion River (segment BO07)

The purpose of this report is to describe the watershed in which these waters are located and review the available water quality data to confirm the impairments. This report also identifies several potential options for proceeding with developing total maximum daily loads (TMDLs) for these waters.

A review of the available water quality data confirms most of these impairments. However, insufficient data have been collected with which to make a direct comparison of the fecal coliform criteria as it applies to Little Vermilion River segment BO07.

Other key findings described in this report include:

- Mean total phosphorus concentrations exceed IEPA water quality criteria for several months in Georgetown Lake. Furthermore, dissolved phosphorus appears to comprise a significant proportion of the total phosphorus loading. On a monthly average basis, dissolved phosphorus comprises approximately 20 to 50 percent of total phosphorus in Georgetown Lake.

- There does not appear to be any significant improving or degrading trend over time for the assessed water quality parameters. Nutrient levels in Georgetown Lake, particularly total phosphorus, have remained relatively constant over the period of record. Similarly, fecal coliform counts collected in the Little Vermilion River have remained at nearly the same levels over the period of record.

- A lack of continuous streamflow data for Little Vermilion River poses a challenge for developing the TMDLs, as does the significant area of the watershed that is tile drained.

- Fecal coliform sampling is recommended for Little Vermilion River segment BMO07 to gather five samples within 30 days to allow for a direct comparison with the state’s water quality standard.

- The University of Illinois has conducted an extensive amount of research in the Little Vermilion River watershed as part of the Little Vermilion River Agricultural Nonpoint Source Hydrologic Unit Area Project. Water quality and flow data are available, as are various tools that have been developed to better understand hydrology and water quality in the watershed. This research provides a strong foundation for moving forward with TMDL development.

1 Introduction

The Little Vermilion River watershed (ILBO07) is located in east-central Illinois and drains approximately 200 square miles. Approximately 85 percent of the total watershed area is in eastern Vermilion County and smaller portions of the watershed are in Champaign (13 percent) and Edgar (2 percent) counties.

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

- Georgetown Lake (RBS)
- Little Vermilion River (BO07)

The Clean Water Act and USEPA regulations require that states develop TMDLs for waters on the Section 303(d) lists. IEPA is currently developing TMDLs for pollutants that have numeric water quality standards. Of the pollutants impairing Georgetown Lake, total phosphorus is the only parameter with a numeric water quality standard for lakes. There are also numeric water quality standards for the Little Vermilion River fecal coliform listing. IEPA believes that addressing the phosphorus impairment for Georgetown Lake should lead to an overall improvement in water quality due to the interrelated nature of the other listed pollutants. For example, reducing loads of phosphorus should result in less algal growth and some of the management measures taken to reduce phosphorus loads (e.g., reducing shoreline erosion) should also reduce loads of suspended solids.

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 Georgetown Lake and Little Vermilion River TMDLs include:

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

- Use the best available science and available data to determine the maximum load the waterbodies can receive and fully support all of their designated uses.

- Use the best available science and available data to determine current loads of pollutants to the impaired waterbodies.

- If current loads exceed the maximum allowable load, determine the load reduction that is needed.

- Identify feasible and cost-effective actions that can be taken to reduce loads.

- Inform and involve the public throughout the project to ensure that key concerns are addressed and the best available information is used.

- Submit a final TMDL report to USEPA for review and approval.

Table 1-1. 2004 303(d) List Information for the Little Vermilion River Watershed (ILBO07)

Segment (Area)	Name	Designated Uses and Support Status	Causes of Impairment	Potential Sources of Impairment
RBS (46.10 ac)	Georgetown Lake	Overall Use (Not Assessed); Fish Consumption (Full); Drinking Water Supply (Not Assessed); Aquatic Life Support (Full); Primary Contact (Not Supporting); Secondary Contact (Partial)	Habitat Assessment, Total Suspended Solids, Excessive Algal Growth, Total Phosphorus	Agriculture (non-irrigated crop production, grazing related sources/pasture land), Urban Runoff/Storm Sewers, Contaminated Sediments, Herbicide/ Algicide Application
BO07 (5.11 mi)	Little Vermilion River	Aquatic Life Support (Full), Primary Contact/swimming (Not Supporting)	Fecal Coliform	Source Unknown

Source: IEPA, 2004.

The project is being initiated in three stages. Stage One involves the characterization of the watershed, an assessment of the available water quality data, and identification of potential technical approaches. Stage Two will involve additional data collection, if necessary. Stage Three will involve model development and calibration, TMDL scenarios, and implementation planning. This report documents the results of Stage One.

2 Watershed Characteristics

The physical characteristics of the Little Vermilion River watershed are described in the following sections. For the purposes of this characterization, the watershed was subdivided into two subwatersheds according to their respective Illinois water body segment identification. These subwatersheds correspond to the upstream contributing areas of Georgetown Lake (RBS) and the Little Vermilion River (segment BO07). 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 Little Vermilion River watershed (Figure 2-3) is in east-central Illinois, trends in an eastern direction and drains approximately 128,548 acres in the State of Illinois. Approximately 108,837 acres, 84.67 percent of the total watershed area, lie in eastern Vermilion County. Smaller portions of the watershed are located in Champaign County (17,057 acres or 13.27 percent) and Edgar County (2,654 acres or 2.06 percent).

Georgetown Lake is located in the eastern portion of the Little Vermilion River watershed. The lake was created in 1948 by damming and flooding a portion of the Little Vermilion River. The lake surface area is 64 acres (IEPA, 2003) and the average depth is approximately six feet. Georgetown Lake used to serve as a drinking water source for the City of Georgetown. However, the City began obtaining groundwater from Indiana in May 2003 and therefore no longer uses Georgetown Lake as a public water supply. Typical views of Georgetown Lake are presented in Figure 2-1 and Figure 2-2.

The segment of the Little Vermilion River that is listed as impaired is located downstream of Georgetown Lake.

Figure 2-1. Georgetown Lake (view from old water treatment plant).

Figure 2-2. Georgetown Lake spillway.

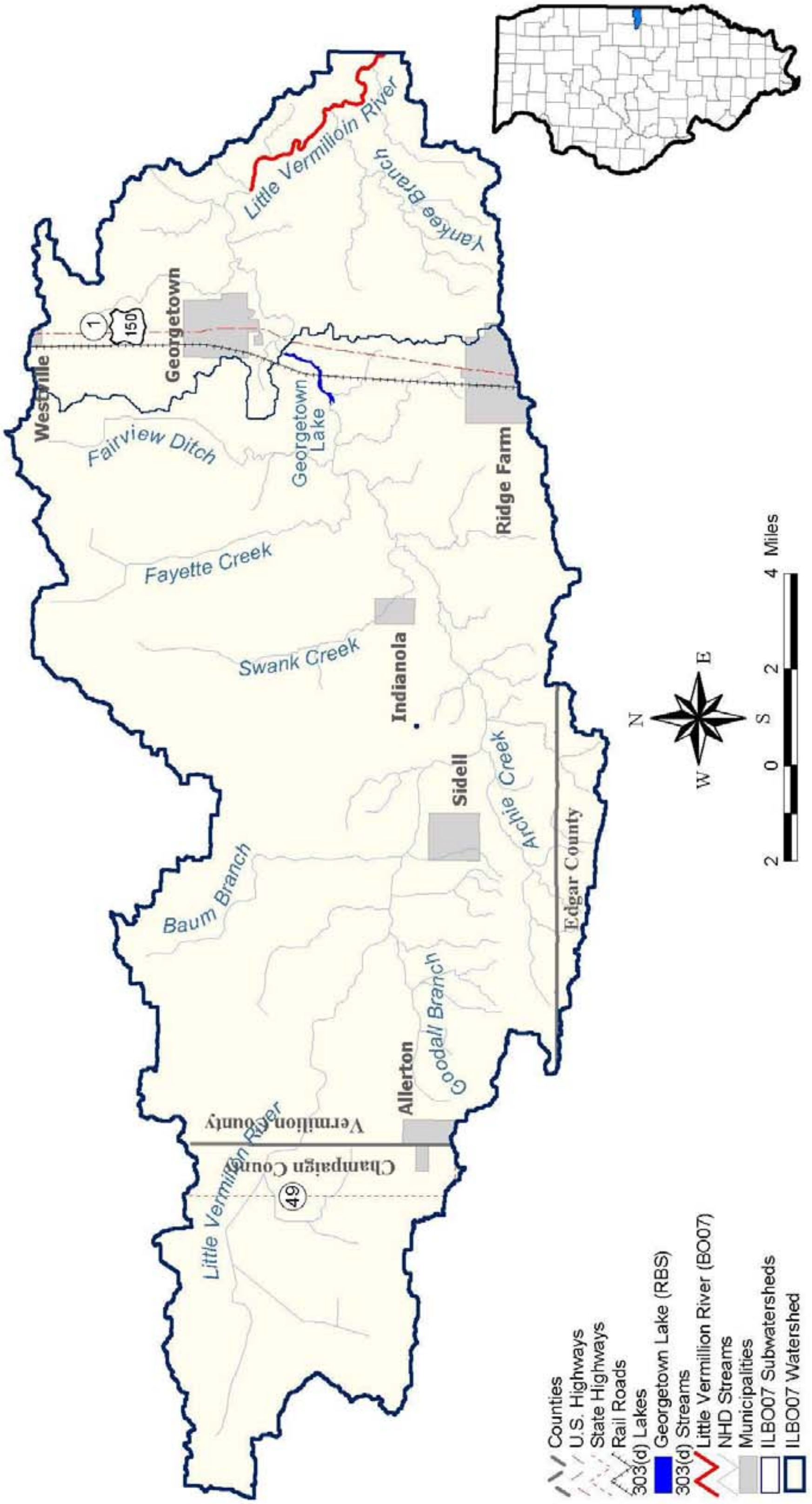

Figure 2-3. Location of the Little Vermilion River watershed

2.2 Topography

The Little Vermilion River watershed consists of very flat topography. Elevation in the Little Vermilion River watershed ranges from approximately 772 feet in the headwaters to 572 feet at the outlet of the watershed. Stream gradient for the entire Little Vermilion River is 2.8 feet per mile (slope < 1 percent) with an absolute elevation change of 107 feet along the 38.6-mile segment. Stream gradient for the listed segment BO07 is 14 feet per mile with an absolute elevation change of 72 feet along the 5.11-mile segment.

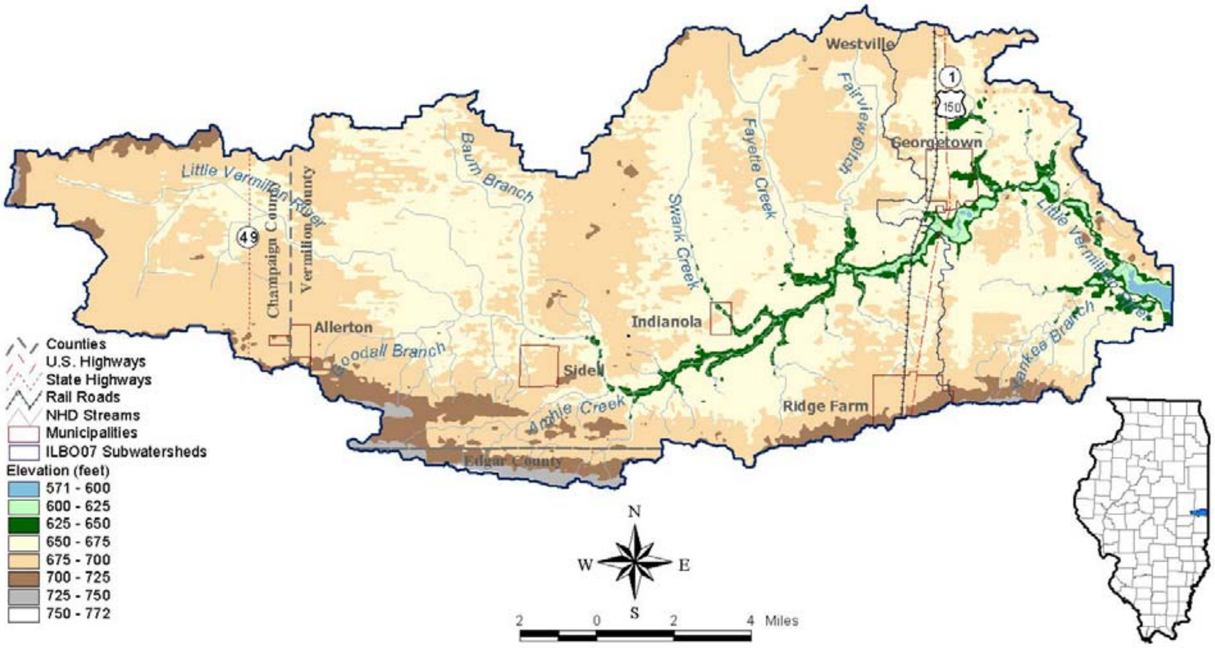

Figure 2-4. Elevation in the Little Vermilion River watershed.

2.3 Land Use and Land Cover

General land cover data for the Little Vermilion River 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 for the watershed. Each 98-foot by 98-foot pixel contained within the satellite image is classified according to its reflective characteristics. Figure 2-5 displays land use and land cover in the Little Vermilion River watershed. A complete listing of the Illinois GAP land cover categories is given in Table A-1 in Appendix A.

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.

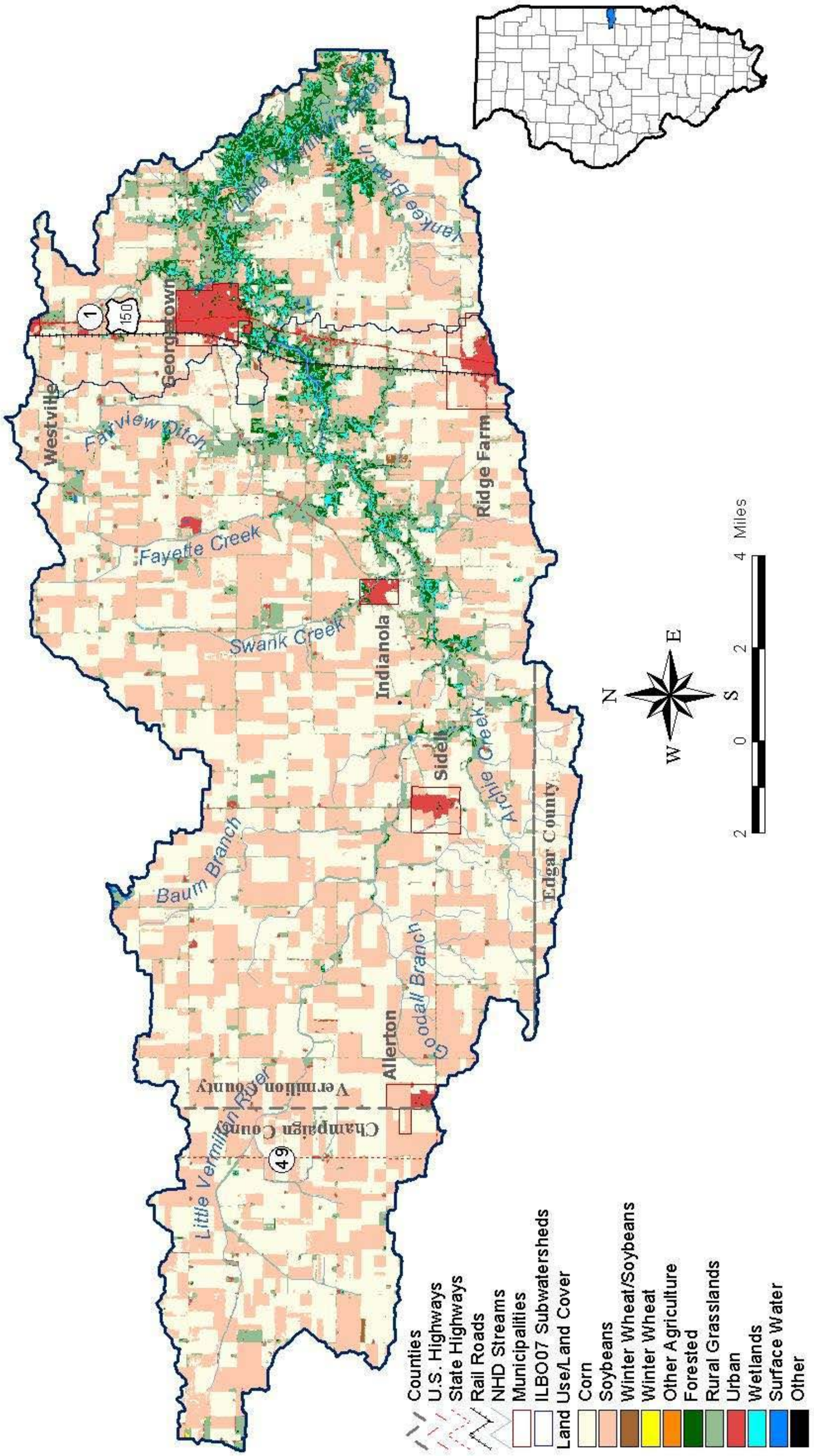

Figure 2-5. GAP land cover in the Little Vermilion River watershed.

2.3.1 Georgetown Lake (Water Body Segment RBS)

Agricultural land use is the dominant land use type in the Georgetown Lake subwatershed, accounting for 96 percent of the total subwatershed area. As shown in Table 2-1, corn and soybeans are the dominant crops, representing 46 percent and 41 percent of all subwatershed land use and land cover types, respectively. Approximately 1,669 acres and 1,663 acres are devoted to forestlands and urban land uses, each representing approximately 2 percent of the subwatershed area. Approximately one percent of land use/land cover is classified as wetlands. Other land cover types represent less than one percent of the subwatershed area.

Table 2-1. Land Use and Land Cover in the Georgetown Lake Subwatershed

Land Use / Land Cover Description	Area		Percent of Watershed Area
	Acres	Square Miles	
Corn	47,915.2	74.9	46.40
Soybeans	42,343.6	66.2	41.00
Rural Grasslands	8,784.1	13.7	8.51
Forested	1,669.3	2.6	1.62
Urban	1,663.3	2.6	1.61
Wetlands	622.9	1.0	0.60
Surface Water	152.1	0.2	0.15
Winter Wheat/Soybeans	109.9	0.2	0.11
Winter Wheat	7.1	<0.1	0.01
Other	4.2	<0.1	<0.01
Other Agriculture	2.7	<0.1	<0.01
Total	**103,274.4**	**161.4**	**100.00**

2.3.2 Lower Little Vermilion River (Illinois Waterbody Segment BO07)

The listed segment BO07 drains the entire Little Vermilion River watershed and corn and soybean are the dominant crop types, accounting for 44 percent and 39 percent of total watershed area, respectively. Rural grasslands account for slightly more than ten percent of the watershed area, while forested and urban land uses account for approximately 3.2 percent and 2.2 percent of the watershed area (Table 2-2).

Table 2-2. Land Use and Land Cover in the Upper Little Vermilion River Subwatershed

Land Use / Land Cover Description	Watershed Area		Percent of Watershed Area
	Acres	Square Miles	
Corn	56,528.1	88.3	43.97
Soybeans	49,966.4	78.1	38.87
Rural Grasslands	13,143.9	20.5	10.22
Forested	4,073.1	6.4	3.17
Urban	2,852.2	4.5	2.22
Wetlands	1,420.7	2.2	1.11
Surface Water	325.1	0.5	0.25
Winter Wheat/Soybeans	218.6	0.3	0.17
Other Agriculture	7.6	<0.1	0.01
Winter Wheat	7.1	<0.1	0.01
Other	4.2	<0.1	<0.01
Total	**128,547.0**	**200.9**	**100.00**

2.3.3 Tillage Practices

Tillage system practices are not available specifically for the Little Vermilion River watershed; however, county-wide tillage system surveys have been undertaken by the Illinois Department of Agriculture (2002; 2004). It is assumed that the general tillage practice trends evidenced throughout the county are applicable to the Little Vermilion River watershed. The results of these surveys for Vermilion County, in which most of the watershed is located, are presented in Table 2-3. The table shows that the percentage of fields employing conventional tillage for corn and soybeans decreased from 2002 to 2004, whereas the percentage of small grain fields using conventional tillage increased.

Table 2-3. Percentage of Agricultural Fields Surveyed with Indicated Tillage System in Vermilion County, Illinois, in 2002 and 2004.

2002 Transect Survey				
Crop Field Type	Tillage Practice			
	Conventional	**Reduced-till**	**Mulch-till**	**No-till**
Corn	92	6	1	2
Soybean	31	24	9	36
Small Grain	50	0	0	50
2004 Transect Survey				
Crop Field Type	Tillage Practice			
	Conventional	**Reduced-till**	**Mulch-till**	**No-till**
Corn	89	8	2	0
Soybean	21	24	14	41
Small Grain	100	0	0	0

Source: Illinois Dept. of Agriculture, 2002; 2004.

2.3 Soils

Soils data and geographic information service (GIS) coverages from the Natural Resources Conservation Service (NRCS) were used to characterize soils in the Little Vermilion River 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. Figure 2-6 displays the STATSGO soil map units in the Little Vermilion River watershed. It should be noted that map units can be highly variable and the following information is meant as a general representation of soil characteristics within the 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 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 subwatersheds, in the Little Vermilion River watershed.

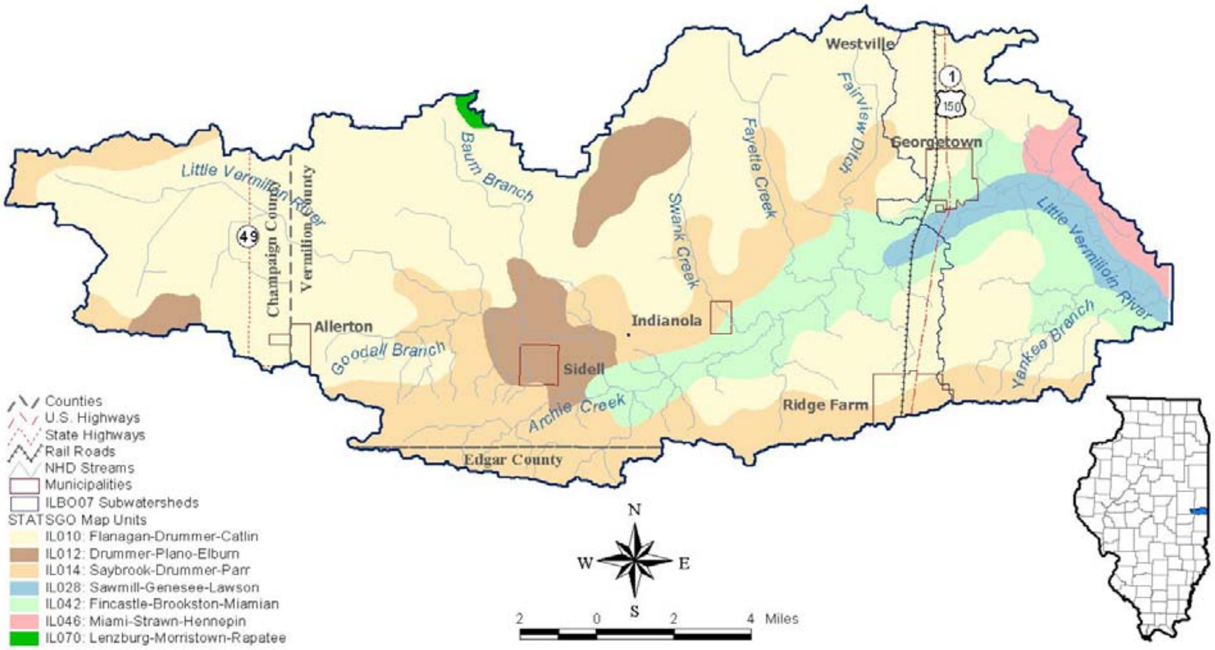

Figure 2-6. Distribution of STATSGO Map Units in the Little Vermilion River watershed.

2.3.1 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 2-4. 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 2-7 presents the general distribution of hydrologic soil groups in the Little Vermilion River watershed. The figure shows the dominant hydrologic groups in the basin are B and C. Hydrologic soil group B composes soils throughout the majority of the basin, including soils adjacent to segments RBS and BO07. Hydrologic group C composes soils along the Little Vermilion River from Sidell downstream to Georgetown Lake.

Table 2-4. 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.

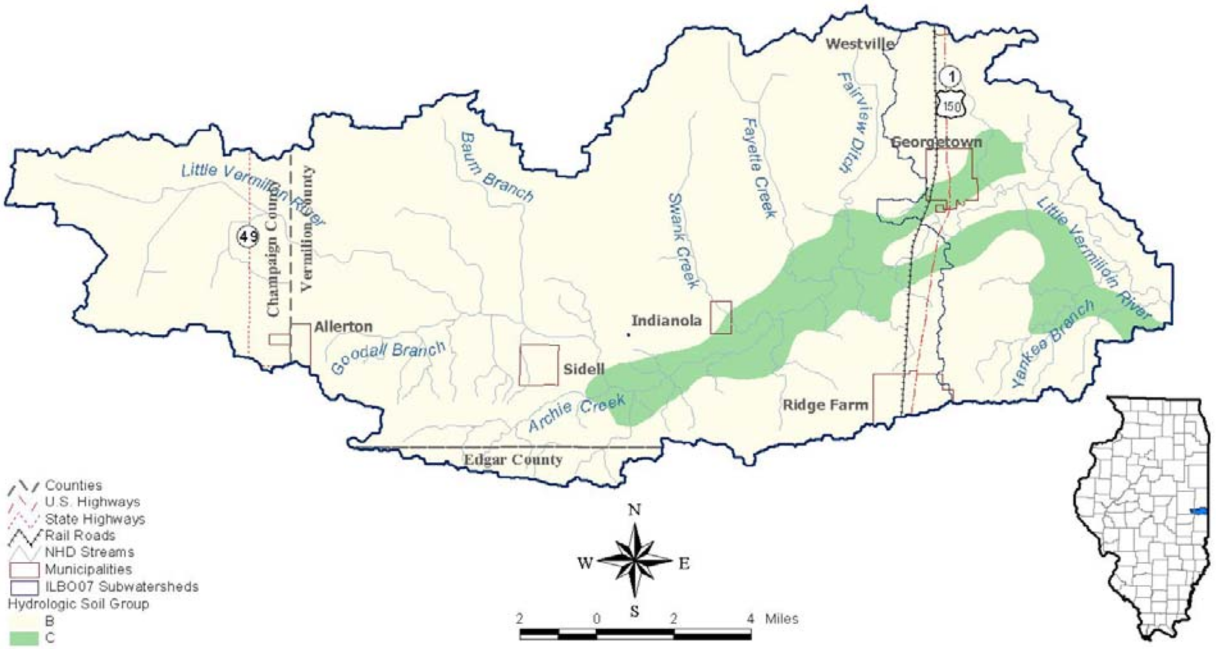

Figure 2-7. Hydrologic soil group distribution in the Little Vermilion River watershed.

2.3.2 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 Little Vermilion River watershed is shown in Figure 2-8. The figure indicates that soils with moderate erosion potential (i.e., K-factors ranging from 0.28 to 0.37) compose most of the watershed. Moderate erosion susceptibility areas occur throughout the watershed and are typically associated with sandy soils with moderate infiltration rates. K-factor values in segments RBS and BO07 are approximately 0.311. The largest K-factors are recorded in a small area in the headwaters of Baum Branch.

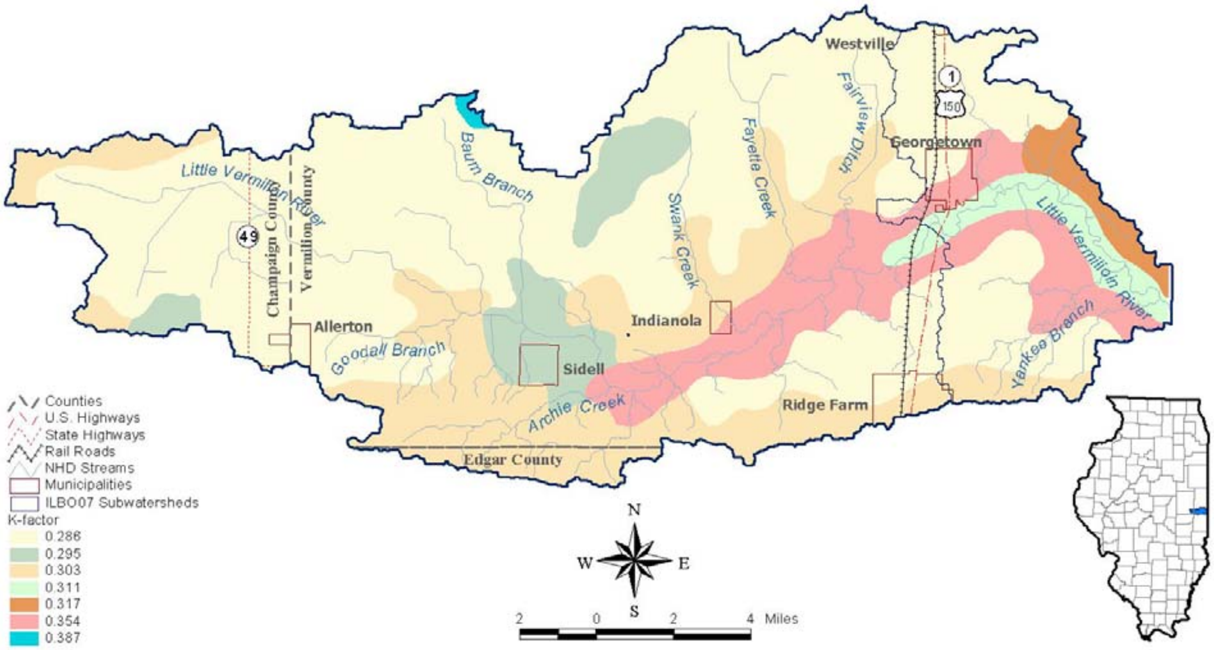

Figure 2-8. USLE K-Factor distribution in the Little Vermilion River watershed.

2.3.3 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 2-9 displays the distribution of depth to water table for the basin and shows that minimum depths range from 2.45 feet to 6 feet. Minimum depths occur along the northern margin of the watershed with maximum depths in the headwaters of Baum Branch.

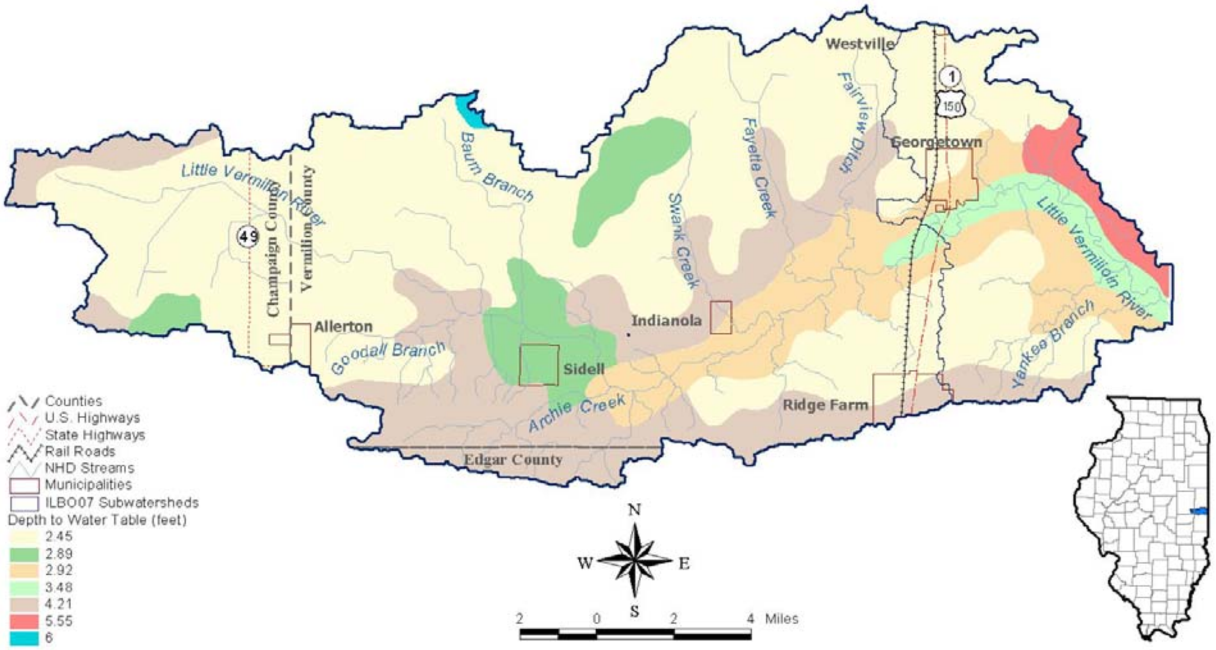

Figure 2-9. Depth to water table in the Little Vermilion River watershed

2.4 Population

The population of the Little Vermilion River watershed 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. Nonurban population for each county was determined by first subtracting the total county urban population from the total county population. 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. It is assumed that the nonurban population for each county is uniformly distributed throughout the nonurban portion of the county.

The methodology described resulted in a watershed population estimate of approximately 11,000 people. The population is evenly distributed between areas classified as urban and nonurban (Table 2-5). Figure 2-3 displays the locations of the counties, cities, and towns.

Table 2-5. Watershed Population Summarized by County

County	Watershed Population	Percent Watershed Population [a]	Nonurban Population	Percent Nonurban Population [a]	Urban Population	Percent Urban Population [a]
Champaign	1,009	9.17	947	8.61	62	0.56
Vermilion	9,948	90.40	4,567	41.50	5,381	48.90
Edgar	48	0.44	48	0.44	0	0.00
Total	**11,005**	**100.00**	**5,562**	**50.54**	**5,443**	**49.46**

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

Urban population centers in the Little Vermilion River watershed are listed Table 2-6. Georgetown is the largest urban area in the watershed and has a population of 3,628 people. Other municipalities include Allerton, Indianola, Ridge Farm, and Westville.

Table 2-6. Urban Population Centers in the Little Vermilion River Watershed

Waterbody Segment/ County	Municipality	Total Urban Population
Champaign County	Allerton	62
Vermilion County	Allerton	218
	Georgetown	3,628
	Indianola	207
	Ridge Farm	550
	Sidell	626
	Westville	152
	Total	**5,443**

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

Table 2-7 demonstrates population change, calculated for the ten-year period between 1990 and 2000, and indicates a seven percent decline for the watershed.

Table 2-7. Population Change in the Little Vermilion River Watershed

County	Municipality	1990 Population	2000 Population	Absolute Change	Percent Change
Champaign County	Nonurban	897	947	50	5.53
Vermilion County	Allerton	58	62	4	6.75
	Nonurban	5,316	4,567	-749	-14.08
	Allerton	204	218	14	7.09
	Georgetown	3,678	3,628	-50	-1.36
	Indianola	336	207	-129	-38.39
	Ridge Farm	566	550	-16	-2.91
	Sidell	584	626	42	7.19
	Westville	162	152	-10	-6.22
Edgar County	Nonurban	48	48	0	0.00
	Total	**11,849**	**11,005**	**-894**	**-7.13**

3 Climate and Hydrology

This section presents information on climate and hydrology within the Little Vermilion River watershed. Both of these topics have important implications for water quality within the watershed.

3.1 Climate

East central Illinois has a temperate climate with hot summers and cold, snowy winters. Average annual precipitation in Sidell (Station 117952) is 38.76 inches. On average there are 124 days with at least 0.01 inches of precipitation. Annual average snowfall is 21.6 inches. Monthly variation of total precipitation, snowfall, and temperature is presented 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.

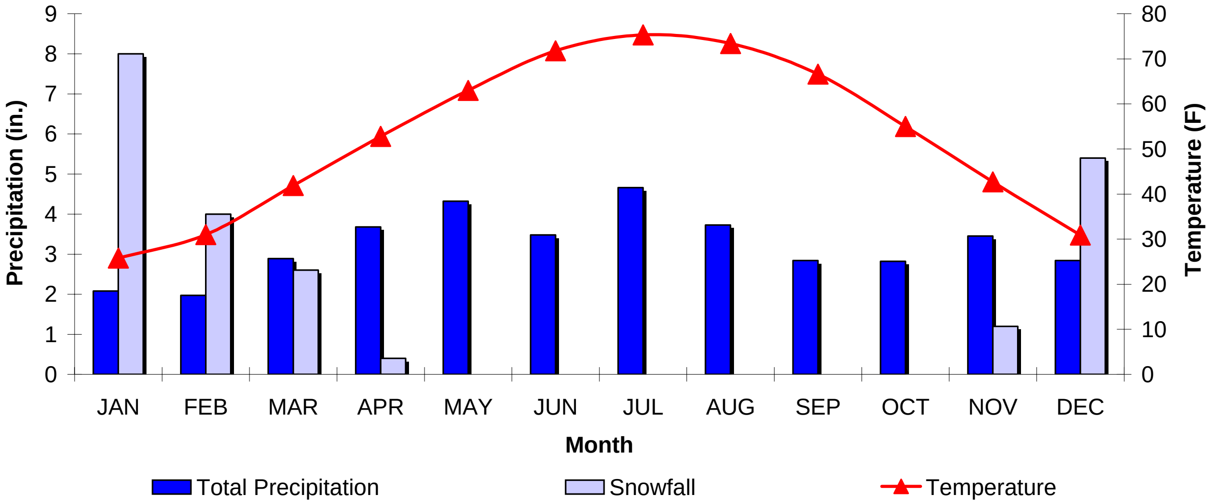

Figure 3-1. Climate summary for the Sidell 5 NW station.

3.2 Hydrology

This section presents information related to the general hydrology, streams types, and subbasins found within the Little Vermilion River watershed.

3.2.1 Reservoir Hydrology

Georgetown Lake, built in 1948, has a surface area of 64 acres and an average depth of approximately six feet. The lake used to serve as a source of drinking water for the city of Georgetown but now primarily provides recreation opportunities such as fishing and small boating.

IEPA studied groundwater flows into Georgetown Lake in the early 1990s (IEPA, 1992) and determined that groundwater exchange between the lake and underlying materials is difficult to calculate. Groundwater inflows and outflow were estimated and the average difference between the two was found to be 3.8 percent of total outflows. This relatively low percentage might be due to the low-impermeable soils and very flat topography. 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 5 stream types in the Little Vermilion River Basin (Figure 3-2). Most streams were classified as perennial streams (Table 3-1). Intermittent streams make up the second most abundant stream type in the basin and have flow only for short periods during the course of a year. Numerous ditches are located within the watershed to provide drainage. Due to the flat nature of the watershed, nearly all of the flow from agricultural fields in the watershed to the river is from subsurface flow (Northcott et al., 2002).

Table 3-1. Summary of Stream Type in the Little Vermilion River Basin

Stream Type	Stream Length (miles)	Percent
Perennial Stream	300.7	51.21
Intermittent Stream	262.4	44.68
Canal/Ditch	17.7	3.01
Artificial Path	6.0	1.02
Connector	0.5	0.08
Total	587.1	**100.00**

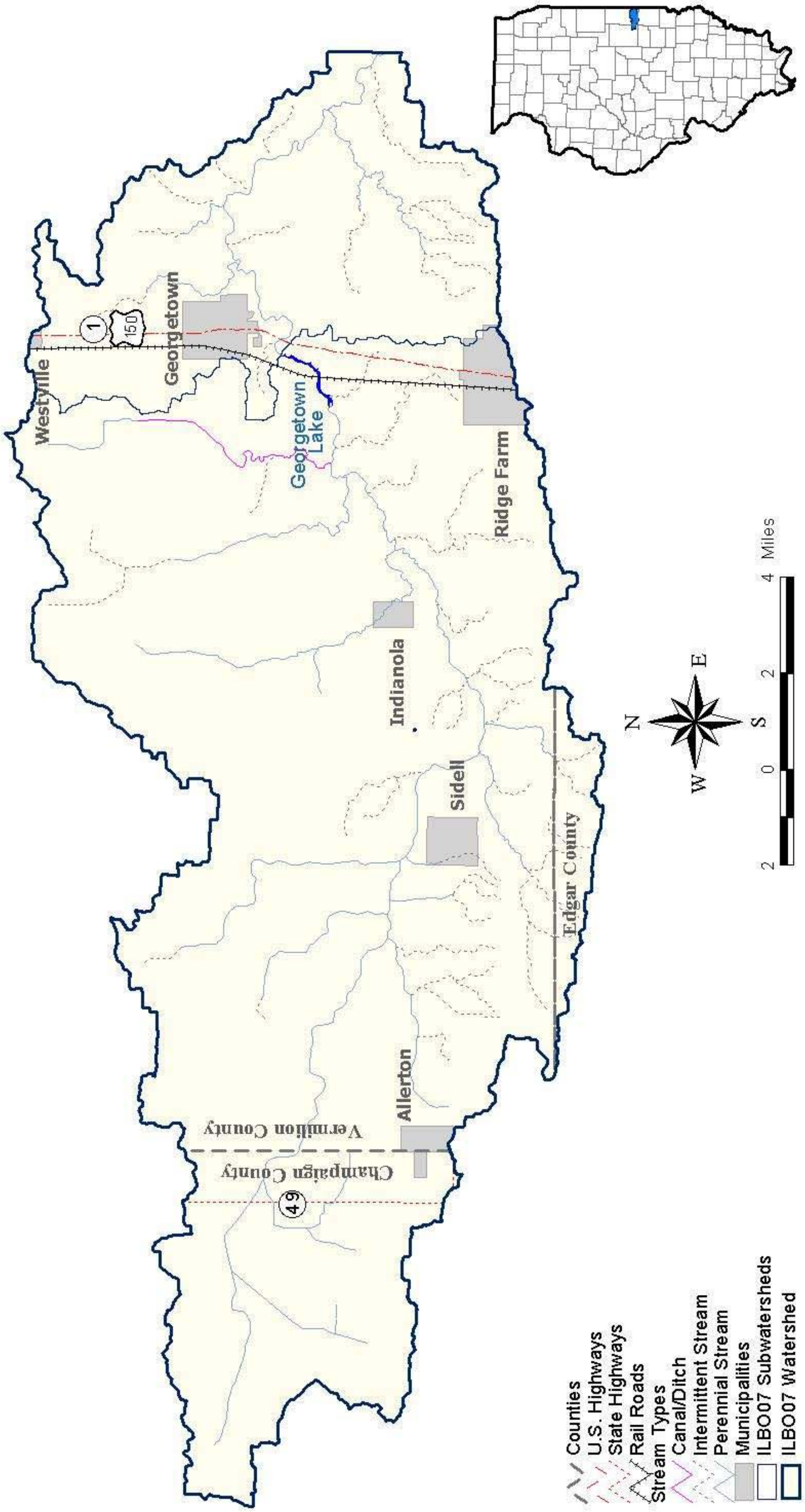

Figure 3-2. Stream types in the Little Vermillion River watershed.

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 Little Vermilion River 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 2-3 and later watershed figures, conform very well to the drainage divides given by the Illinois 12-digit Hydrologic Unit Codes.

3.2.4 Tile Drainage

The Little Vermilion River watershed, as with many other watersheds in Illinois, is extensively underlain by drain tile designed to remove standing water from the soil surface for agricultural purposes. 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. However, the University of Illinois has collected extensive flow data since 1992 at the Champaign/Vermilion county line as part of the Little Vermilion River Agricultural Nonpoint Source Hydrologic Unit Area Project. Flow has been measured downstream of the county line and at Georgetown Lake since 1998 (Mitchell et al., 2000a). These flow data sets have been requested from the University of Illinois but not yet received by Tetra Tech, Inc.

4 Inventory and Assessment of Water Quality Data

This section presents the 2004 303(d) list information for all listed waterbodies in the Little Vermilion River 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 2004 303(d) list for the watershed is given in Table 1-1. The table shows that Georgetown Lake is listed for impairments related to nutrients. The Little Vermilion River (segment BO07) is listed for impairments related to fecal coliform.

4.2 Previous Studies

Numerous water quality studies have been completed in the Little Vermilion River watershed in conjunction with the Little Vermilion River Agricultural Nonpoint Source Hydrologic Unit Area Project. These studies have focused on a variety of topics, including model evaluations (Northcott et al., 2001; Yu et al., 2001; Yuan et al., 2001; Walker et al., 2000); nitrate transport (Mitchell et al., 2000a); sediment transport (Mitchell et al., 2000b); atrazine transport (Yuan et al., 2000); and the performance of best management practices (Cooke et al., 2001). The data from these studies have been requested from the University of Illinois but have not yet been received.

IEPA's Ambient Lake Monitoring Program also assessed water quality in the Georgetown Reservoir in 2001 (IEPA, 2003). The study found concentrations of atrazine ranging from 0.5 mg/L to 2.4 mg/L and metolachlore and acetachlore concentrations less than 1 mg/L.

IEPA also conducted a Facility-Related Stream Survey (FRSS) in the Little Vermilion River watershed in preparation for discharges from the Black Beauty coal mine. Water quality, habitat, sediment, and macroinvertebrate data were collected in the Little Vermilion River upstream of Georgetown Lake and in an unnamed tributary to the Little Vermilion River.

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 Little Vermilion River 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 (mg/L).

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 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 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.

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 Little Vermilion River watershed. 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. Other potential 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 and geese, 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 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 Little Vermilion River watershed:

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.

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
Chlorophyll-a	µg/L	None	None
Habitat Alterations			
Habitat Alterations		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 Georgetown Lake and the Little Vermilion River were downloaded from the STORET and USGS NWIS databases. Additionally, sampling data from the Georgetown Sewage Treatment Plant, Georgetown Water Treatment Plant, Sidell Water Treatment Plant, Allerton Water Treatment Plant, and Dynachem, Inc. 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 Georgetown 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.

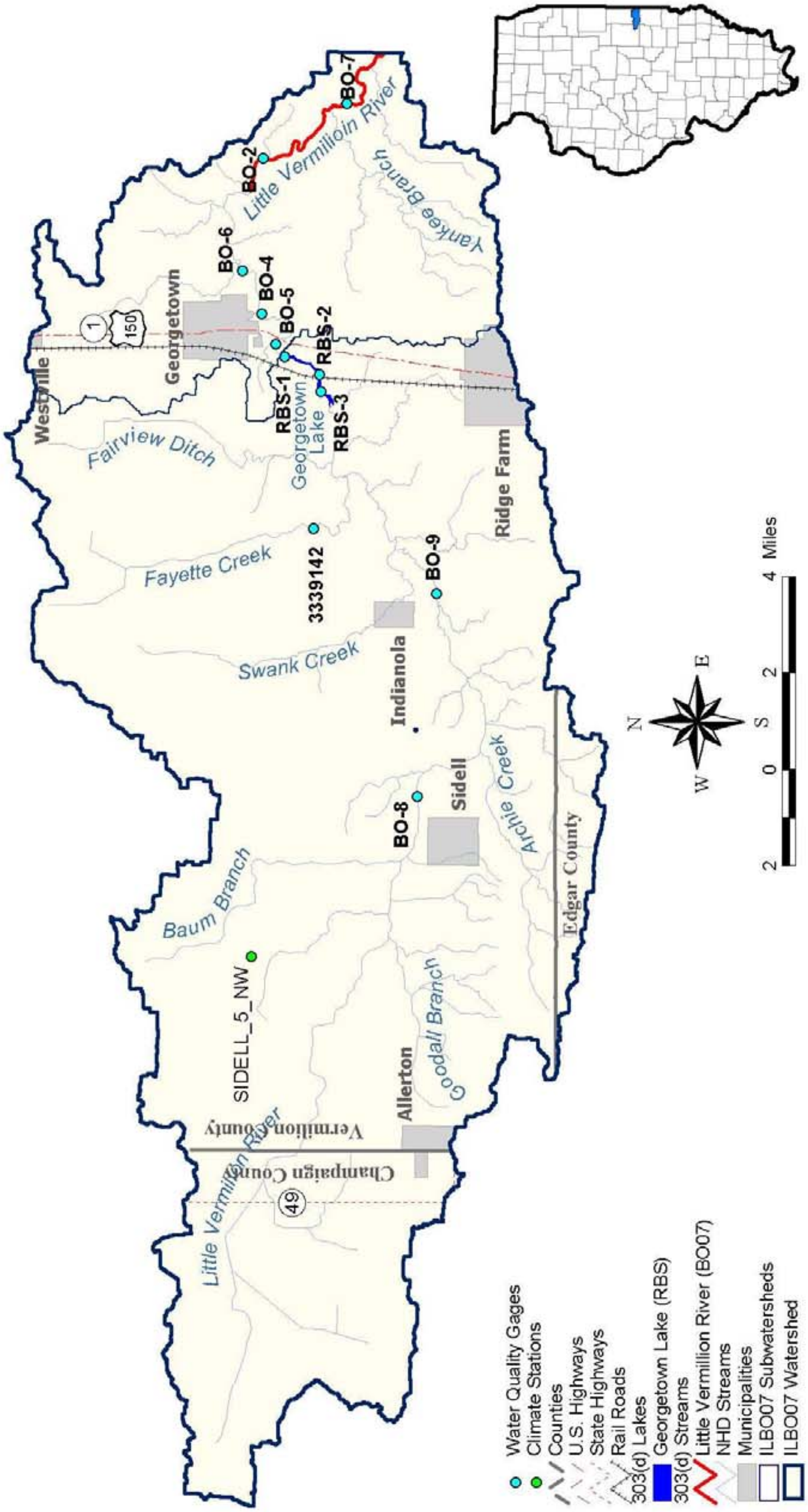

Figure 4-1. Water quality sampling stations in the Little Vermilion River watershed.

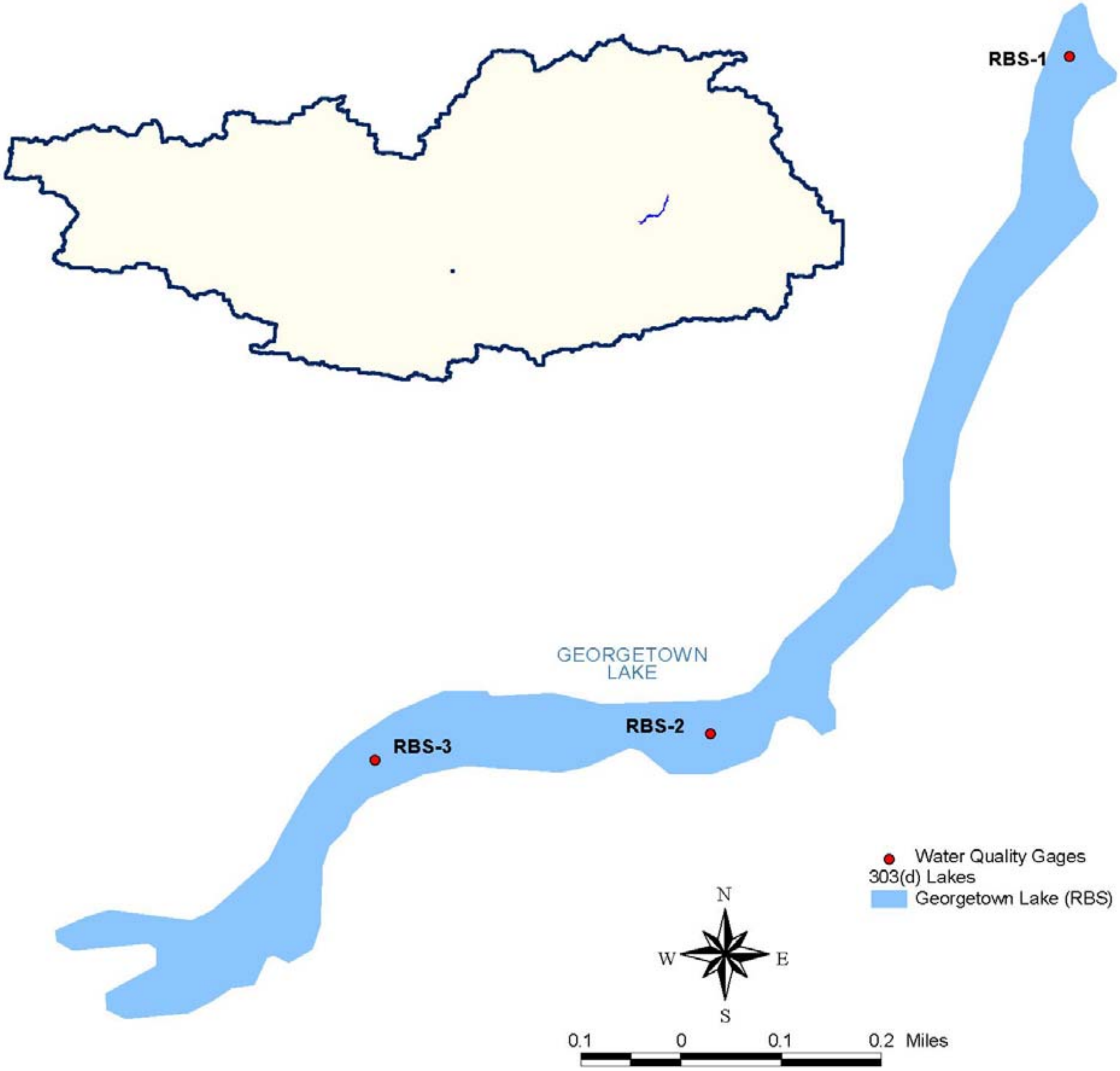

Figure 4-2. Water quality sampling stations in Georgetown Lake.

4.5.1 Georgetown Lake (RBS)

Water quality data collected in Georgetown Lake at IEPA monitoring stations RBS-1, RBS-2, and RBS-3 are available from 1982 to 2002. A summary of these data is presented in the selections below.

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 dissolved phosphorus data. Additionally, Figure 4-3 presents the TP data over the period-of-record. A review of the data reveals that 82 percent of TP samples violated the water quality standard, including 100 percent of recent samples

(Table 4-4). Violations of the TP standard at surface samples (one foot depth) are similar to violations observed at deeper depths.

Table 4-3. Summary of total phosphorus and other nutrient-related parameters for Georgetown Lake.

Parameter	Samples (Count)	Start	End	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	CV*
Total Phosphorus	66	5/18/1983	10/21/2002	0.02	0.09	0.42	0.60
Dissolved Phosphorus	61	5/18/1983	10/21/2002	0.01	0.03	0.07	0.46

*CV = standard deviation/average

Table 4-4. Violations of the total phosphorus standard in Georgetown 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)	66	54	82%	21	21	100%
Total Phosphorus (1-foot Depth)	52	42	81%	15	15	100%

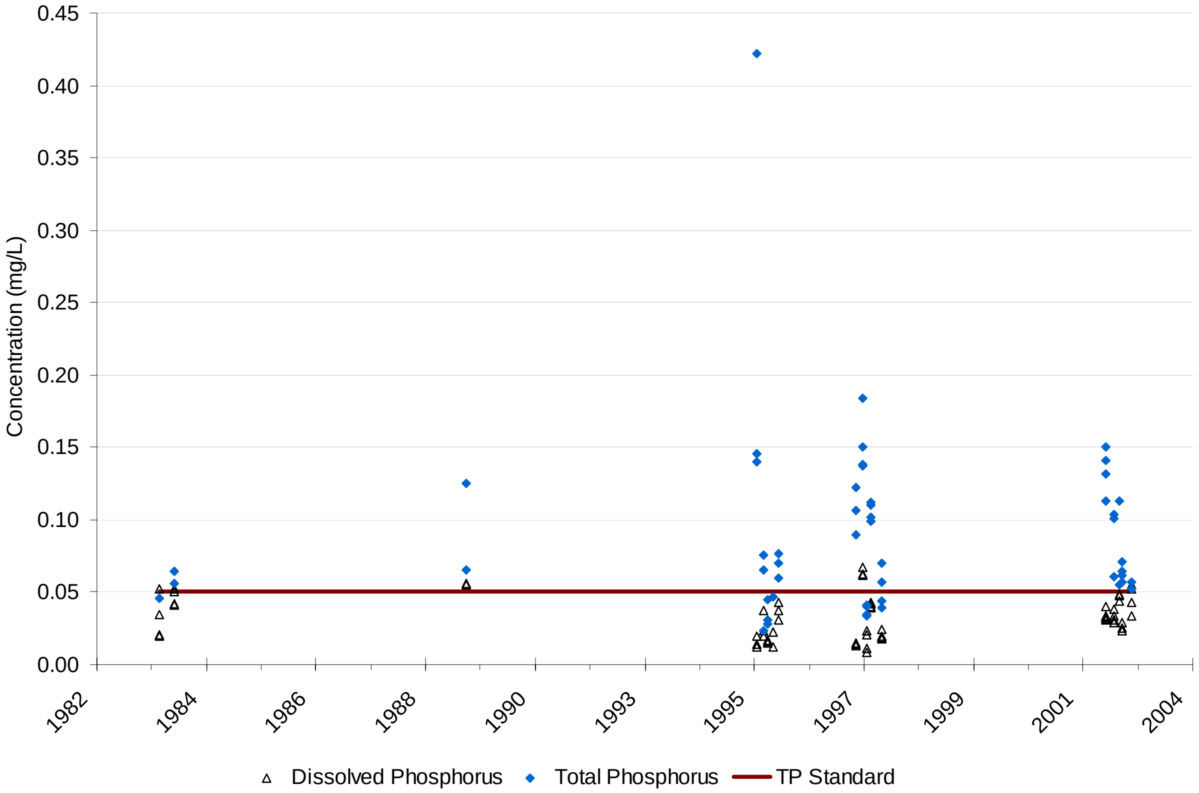

Figure 4-3. Total phosphorus and dissolved phosphorus sampling observations in the Georgetown Lake.

Monthly median and mean TP concentrations for the period of record are presented in Figure 4-4. Data are not available for the months of January, February, March, November, and December. The figure shows that the water quality standard of 0.05 mg/L has been exceeded in all sampled months. Additionally, median and mean monthly TP concentrations display seasonal variability. TP concentrations are lowest in April, increase in the summer months of June through September, and decrease in the month of October.

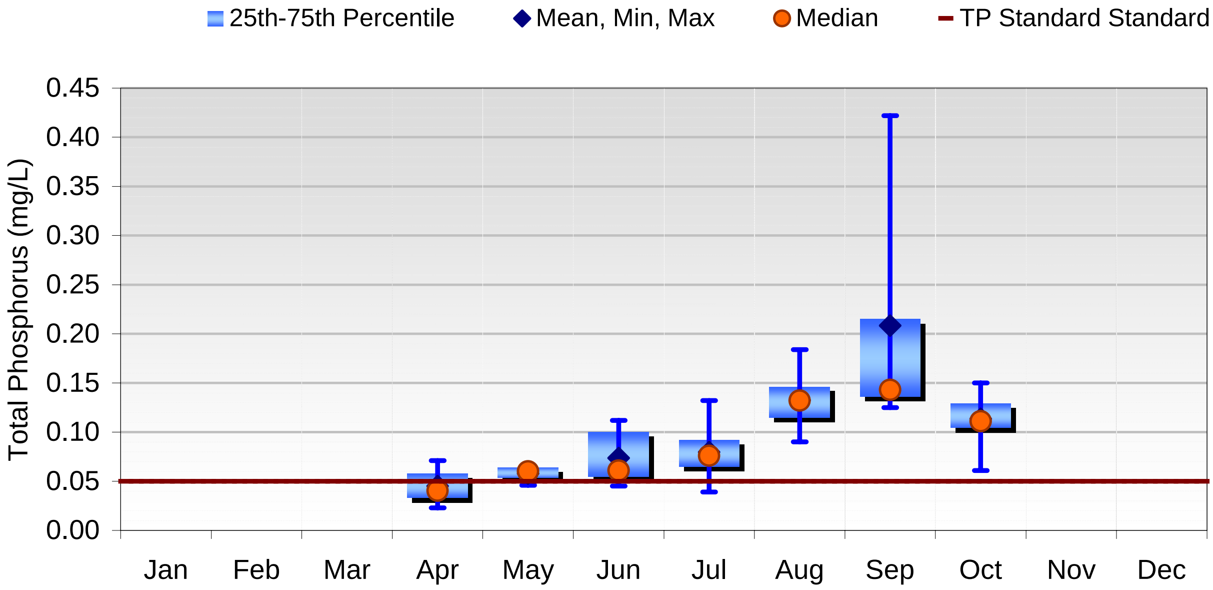

Figure 4-4. Monthly statistics for total phosphorus in Georgetown Lake, 1983–2002.

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 in Georgetown Lake are shown in Figure 4-5. DP data are available from April through October. The figure shows that mean and median DP concentrations are lowest in April and reach their maximum in September (although there are limited data for this month). DP concentrations increase from April through June, decrease in July, and increase again though September.

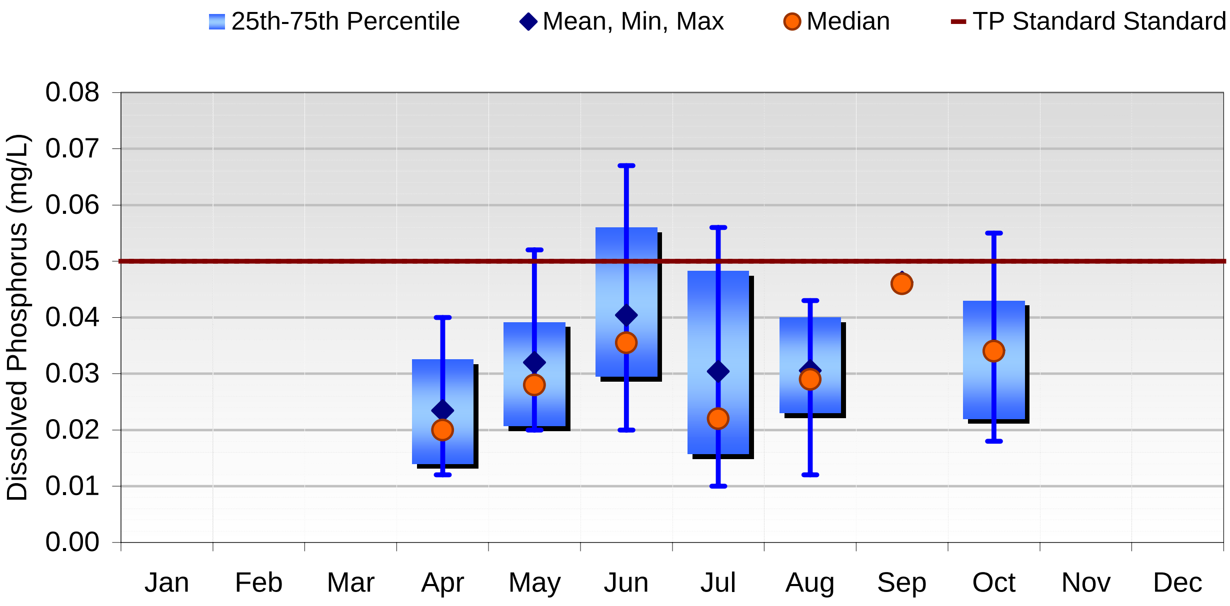

Figure 4-5. Dissolved phosphorus monthly statistics in Georgetown Lake, 1983–2002.

The proportion of DP to TP is quite variable over the period of record as shown in Figure 4-6, ranging from 12 percent to nearly 85 percent. However, most observations are greater than 30, indicating that sources of dissolved phosphorus are significant within the watershed. The monthly percent contribution of DP to TP is quite variable, with the highest proportions observed in April, May, and June (Figure 4-7).

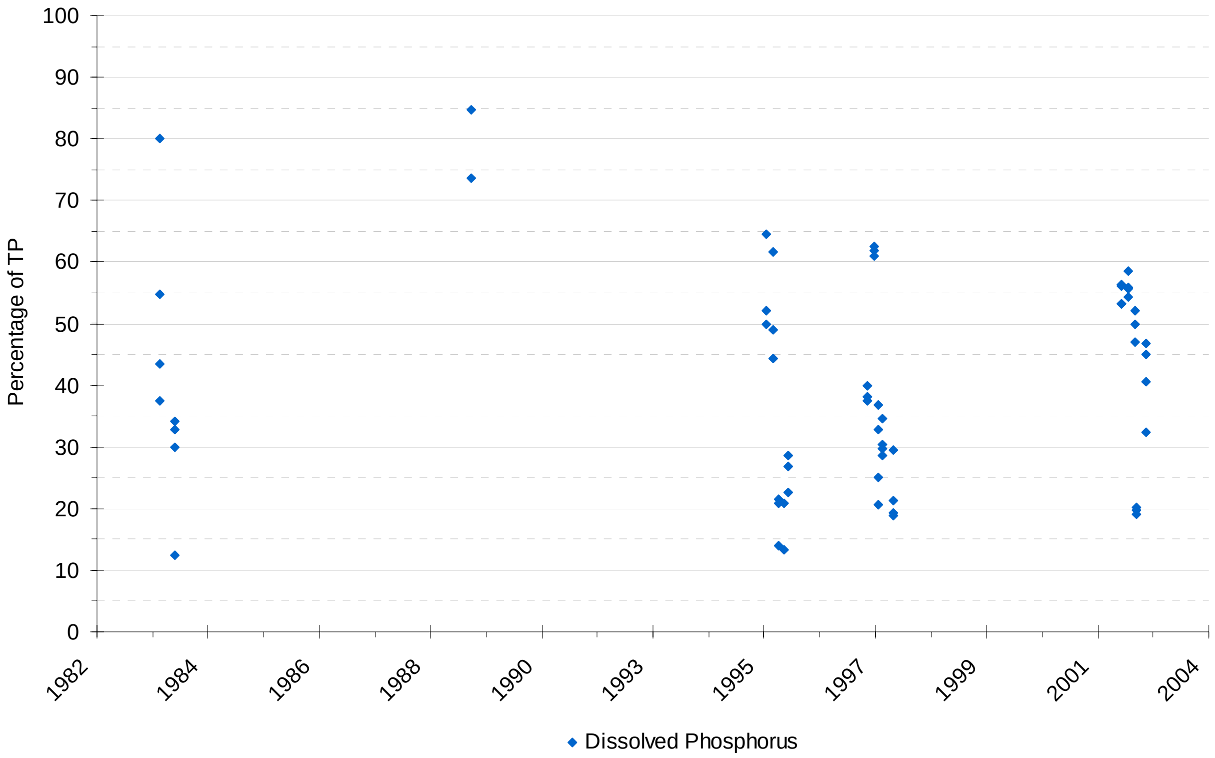

Figure 4-6. Proportion of dissolved phosphorus in total phosphorus for Georgetown Lake.

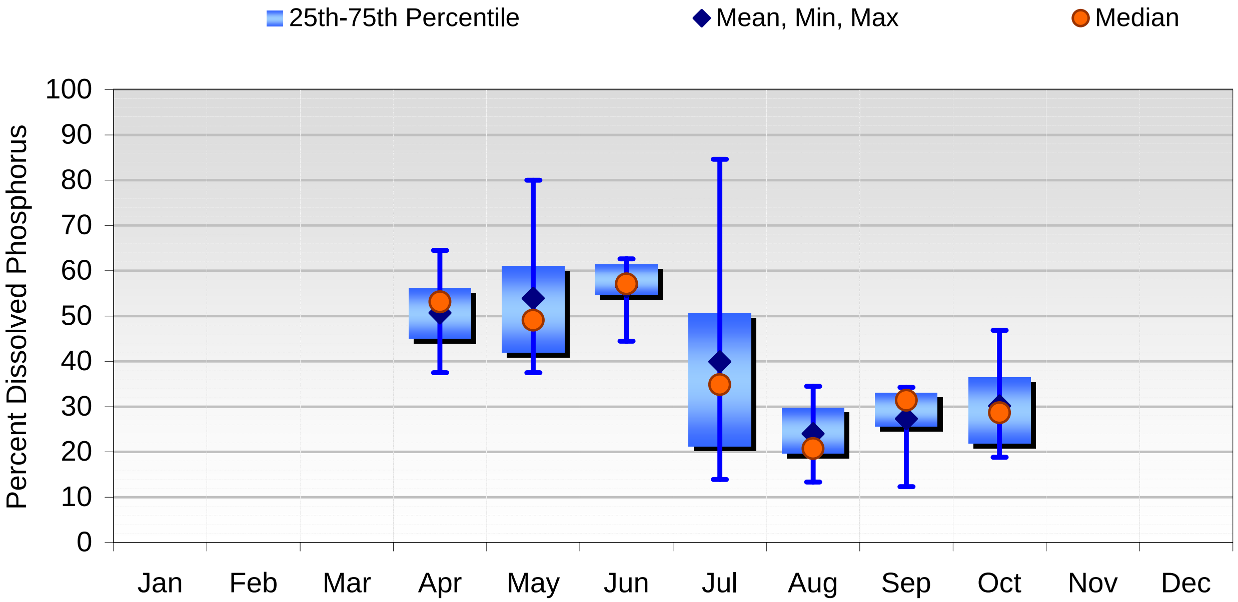

Figure 4-7. Monthly mean and median percentage of dissolved phosphorus comprising total phosphorus for Georgetown Lake, 1983–2002.

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 ration 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 Georgetown Lake is presented in Figure 4-8. Although there is a great deal of variability, TN:TP ratios are usually greater than 10, suggesting that phosphorus is the limiting nutrient in Georgetown Lake. Figure 4-9 displays TN:TP ratios seasonally.

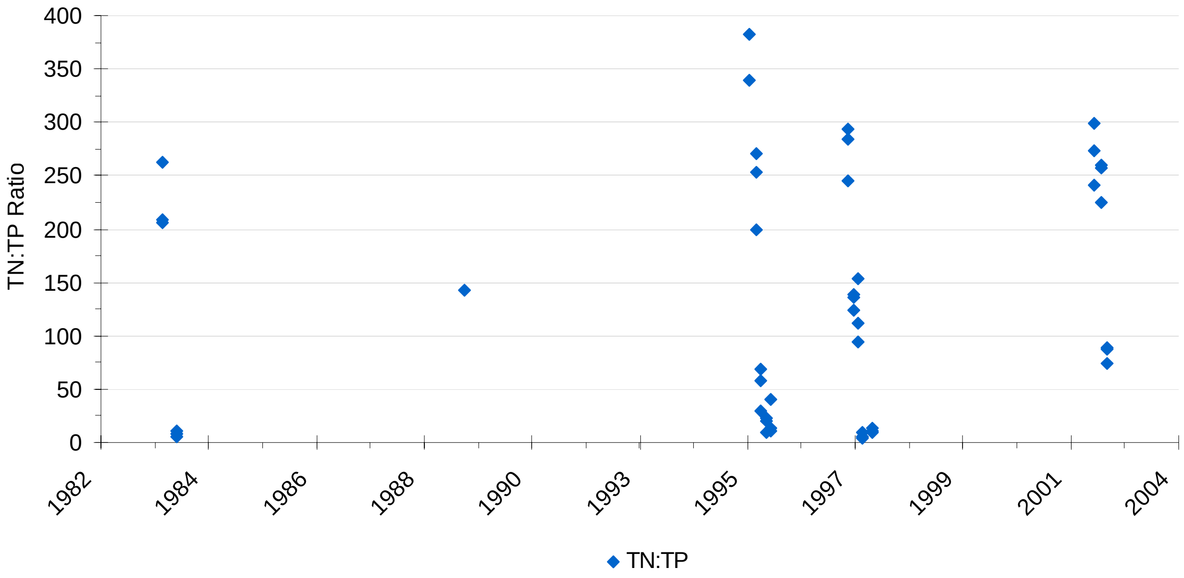

Figure 4-8. TN:TP ratios over the period of record in Georgetown Lake.

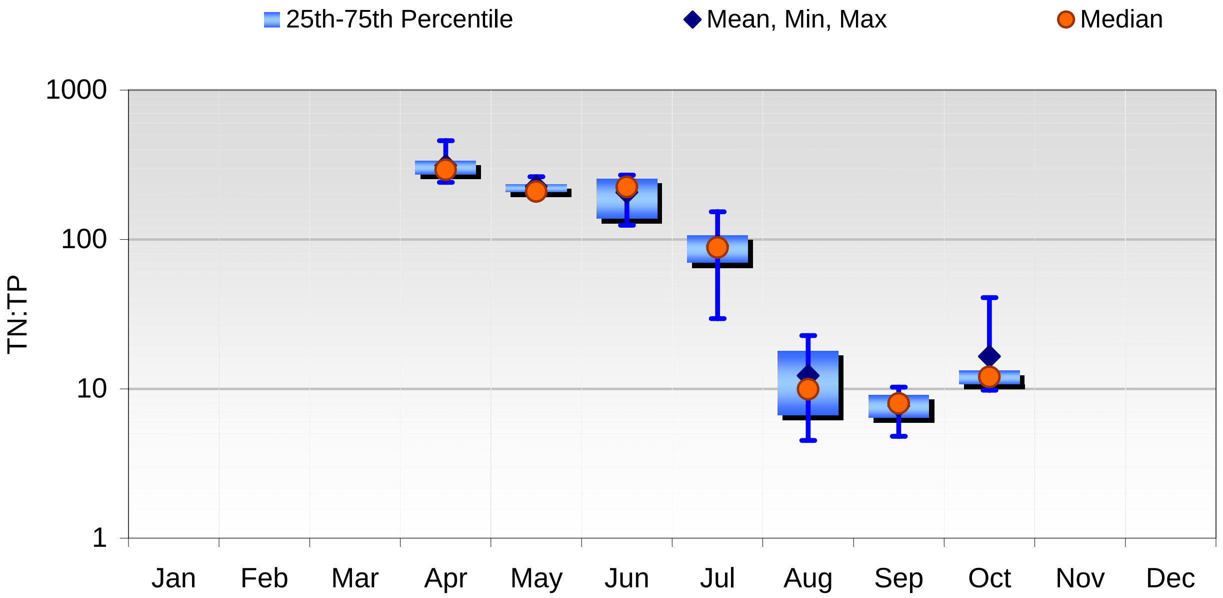

Figure 4-9. Monthly median and mean TN:TP ratios in Georgetown Lake, 1983–2002.

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 Georgetown Lake. Data are not available for the months of January, February, March, September, November, and December. Figure 4-10 displays chlorophyll-*a* concentrations in Georgetown 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 chlorophyll-*a* peak in August. The relationship between chlorophyll-*a* and TP is graphically displayed in Figure 4-12. The figure shows that there is a weak positive relationship between TP and chlorophyll-*a*.

Table 4-5. Summary Statistics for Chlorophyll-*a* in Georgetown Lake.

Parameter	Samples (Count)	Start	End	Minimum (µg/L)	Average (µg/L)	Maximum (µg/L)	CV*
Chlorophyll-a	48	5/18/1983	10/21/2002	0.56	27.45	114.81	1.02

*CV = standard deviation/average

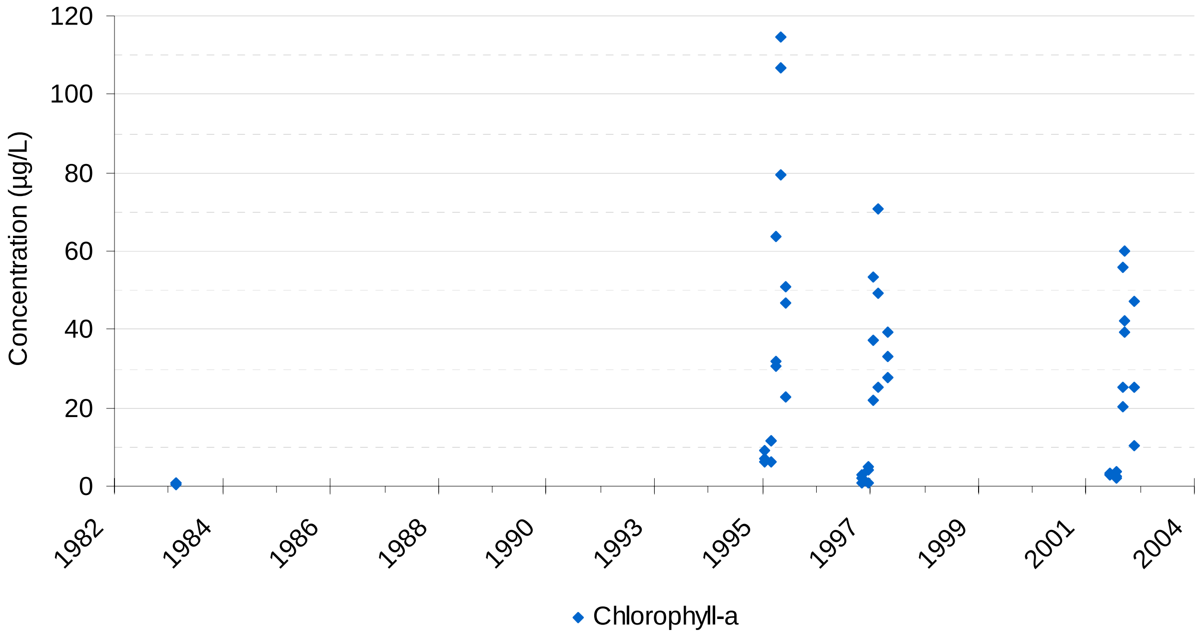

Figure 4-10. Chlorophyll-*a* sampling observations in Georgetown Lake.

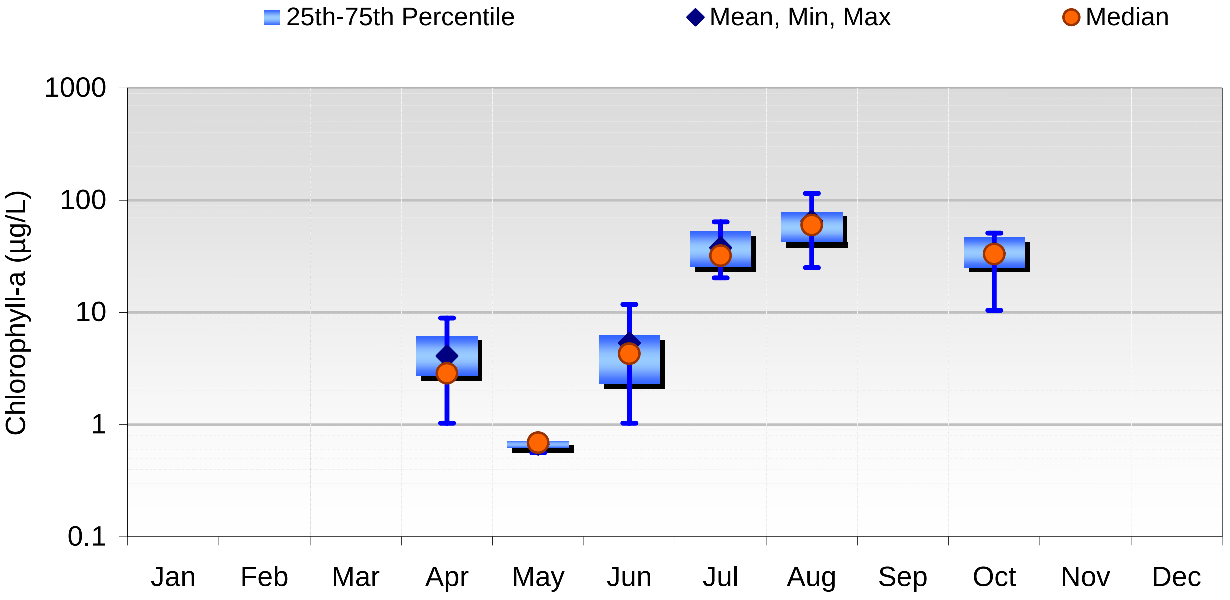

Figure 4-11. Monthly mean and median chlorophyll-*a* concentrations in Georgetown Lake, 1983–2002.

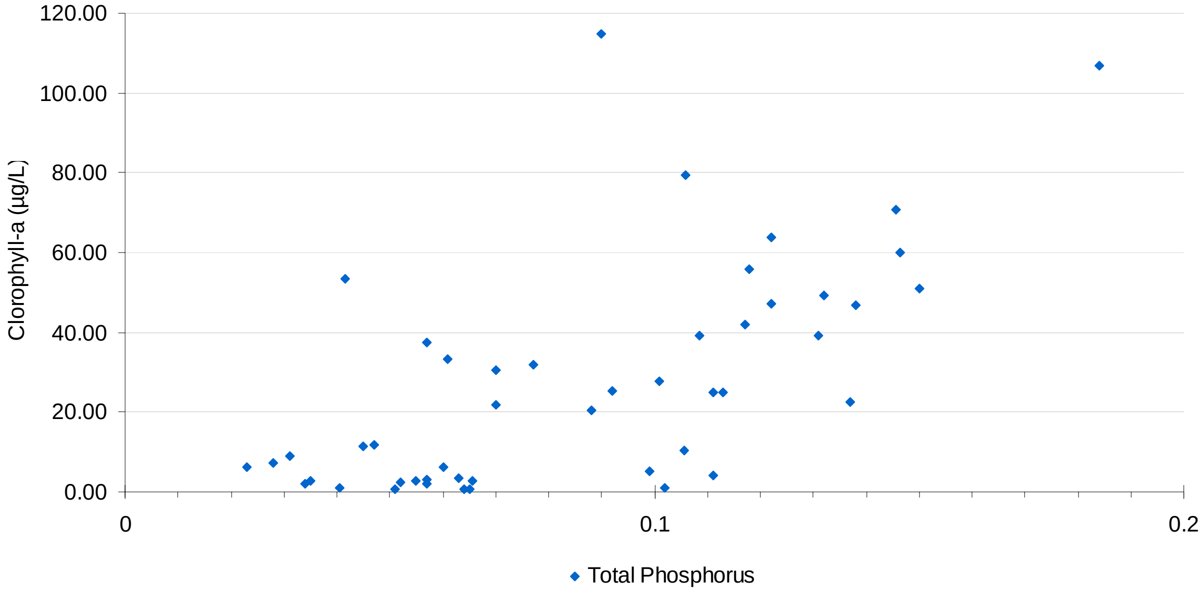

Figure 4-12. Relationship between chlorophyll-a concentration and TP concentration in Georgetown Lake, 1983–2002.

4.5.1.5 Total Suspended Solids

A summary of the total suspended solids (TSS) data collected in Georgetown Lake is given in Table 4-6. Data are not available for the months of January, February, March, November, and December. Figure 4-13 displays the sampling frequency for TSS in Georgetown Lake, and indicates that TSS concentrations are somewhat variable over the period of record. Monthly median and mean TSS concentrations are presented in Figure 4-14. Median and mean TSS concentrations are slightly lower in the months of April and September, 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 Georgetown Lake.

Parameter	Samples (Count)	Start	End	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	CV*
Suspended Solids	62	5/18/1983	10/21/2002	8.00	28.95	96.00	0.57

*CV = standard deviation/average

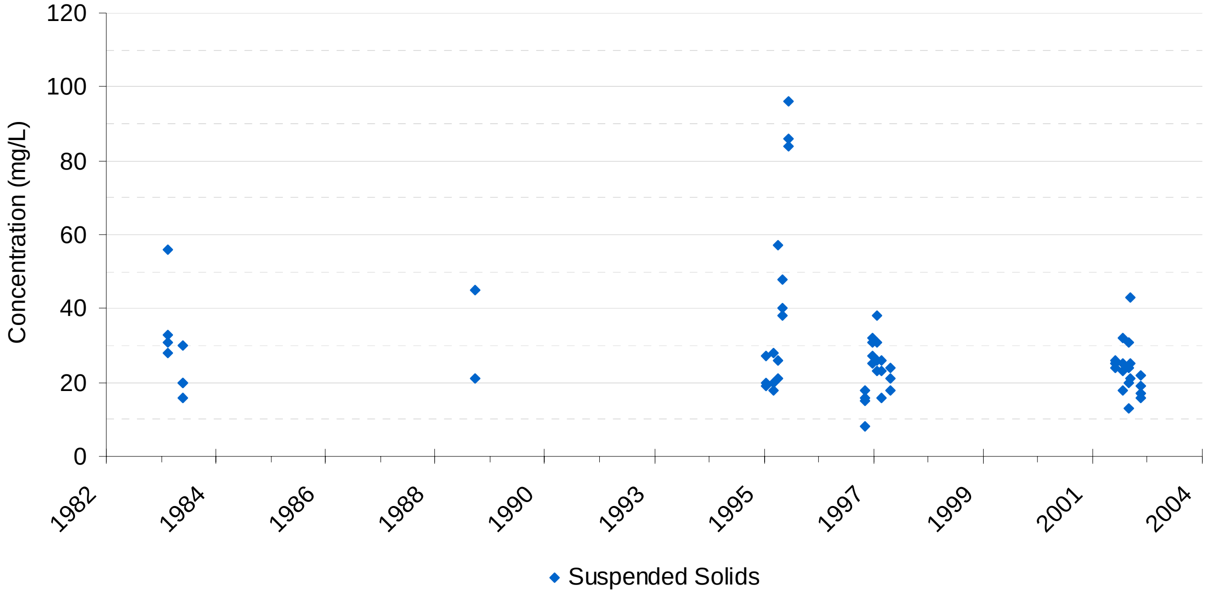

Figure 4-13. Total suspended solids sampling observations in Georgetown Lake.

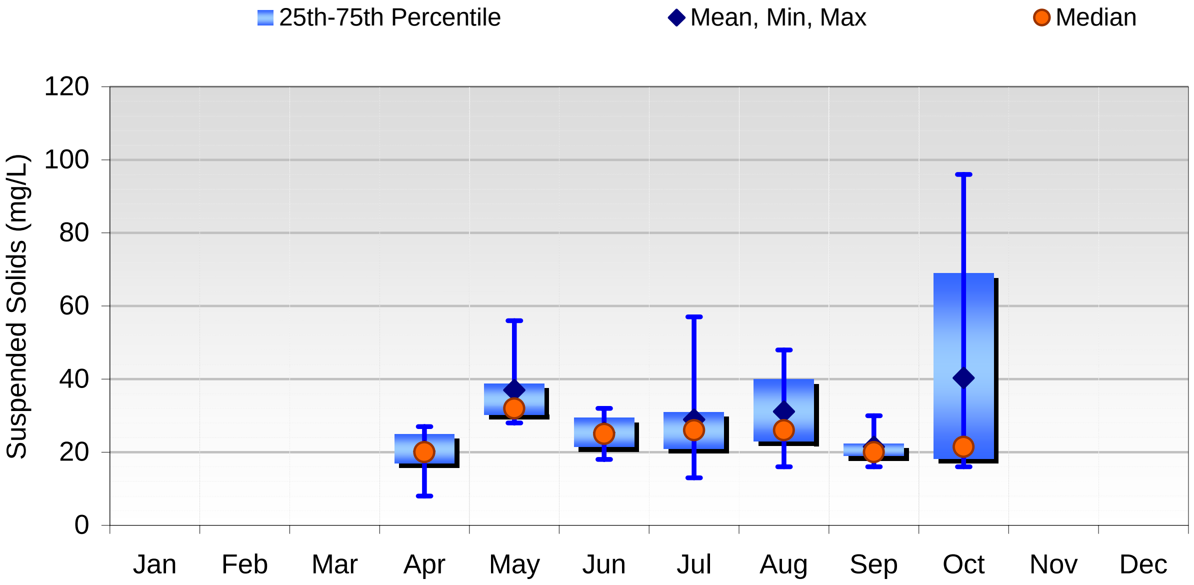

Figure 4-14. Monthly mean and median total suspended solids concentrations in Georgetown Lake, 1983–2002.

4.5.2 Little Vermilion River (BO07)

Segment BO07 of the Little Vermilion River (downstream of Georgetown Lake) is listed as impaired due to fecal coliform. Water quality data collected in Little Vermilion River at IEPA monitoring stations BO-7 and BO-2 are available from 1966 to 1998. A summary of these data is presented in Table 4-7. All but one 1966 sample are from station BO-7.

4.5.2.1 Fecal Coliform

Table 4-7 presents a summary of fecal coliform data collected for segment BO07. As described in Section 4.4.2, one part of the fecal coliform 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. The other part of the fecal coliform standard states that no more than 10 percent of the samples during any 30 day period should exceed 400/100 mL. A significant number of the individual fecal coliform samples exceed 400 colonies/100 mL and the geometric mean for all samples in most months also exceeds 400/100 mL (Table 4-7).

Table 4-7. Summary statistics for fecal coliform in Little Vermilion River.

Fecal Coliform	Samples (Count)	Start	End	Minimum (count/100mL)	Geometric Mean (count/100 mL)	Maximum (count/100mL)
All Data	179	8/31/1966	12/10/1998	10	543	140,000
May	15	5/5/1981	5/9/1996	90	787	8,000
June	13	6/7/1979	6/5/1998	140	1,047	140,000
July	14	7/3/1979	7/18/1995	100	743	60,000
August	17	8/31/1966	8/25/1998	90	686	8,600
September	17	9/10/1979	9/23/1998	10	602	25,000
October	11	10/17/1980	10/27/1998	40	185	3,000

Figure 4-15 displays the fecal coliform data and Figure 4-16 presents monthly mean and median fecal coliform sample concentrations. Figure 4-16 shows that greater mean fecal coliform counts occur in the months of April, May, September, November, and December, while lower mean counts occur in the summer months of June, July, and August. This pattern suggests that fecal coliform loading to Little Vermilion River is associated with the typically wetter months. However, an examination of instantaneous flow and fecal coliform counts, shown in Figure 4-17, does not indicate any significant relationship.

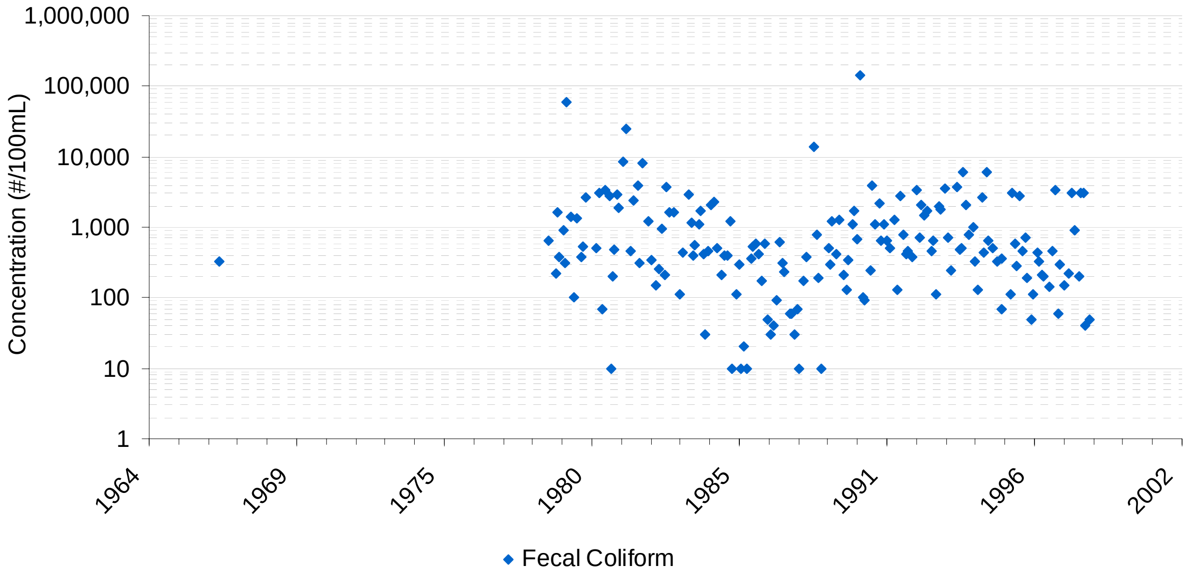

Figure 4-15. Fecal coliform sampling observations in the Little Vermilion River.

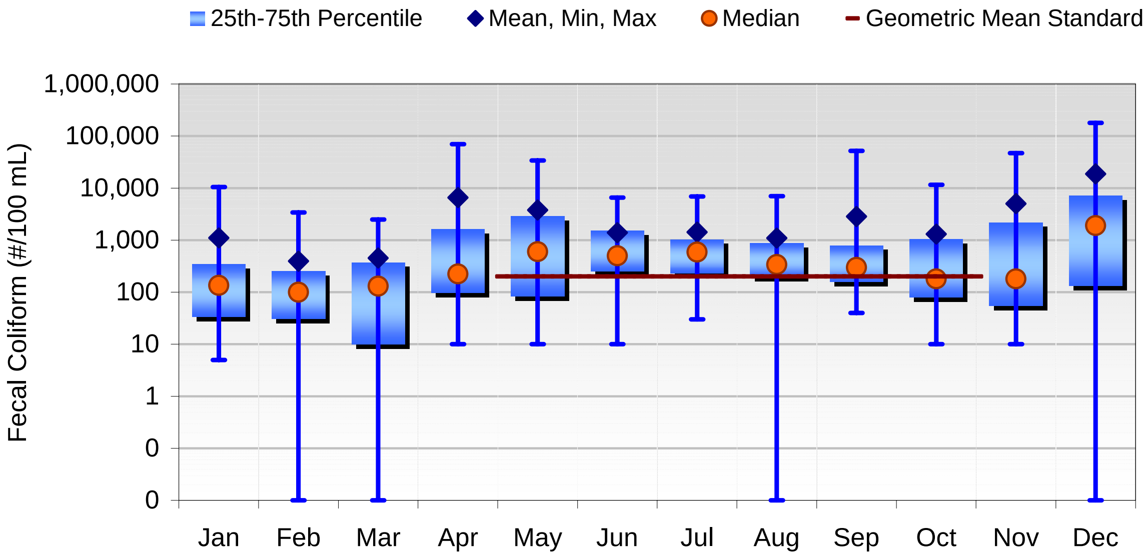

Figure 4-16. Fecal coliform monthly statistics in the Little Vermilion River, 1966–1980.

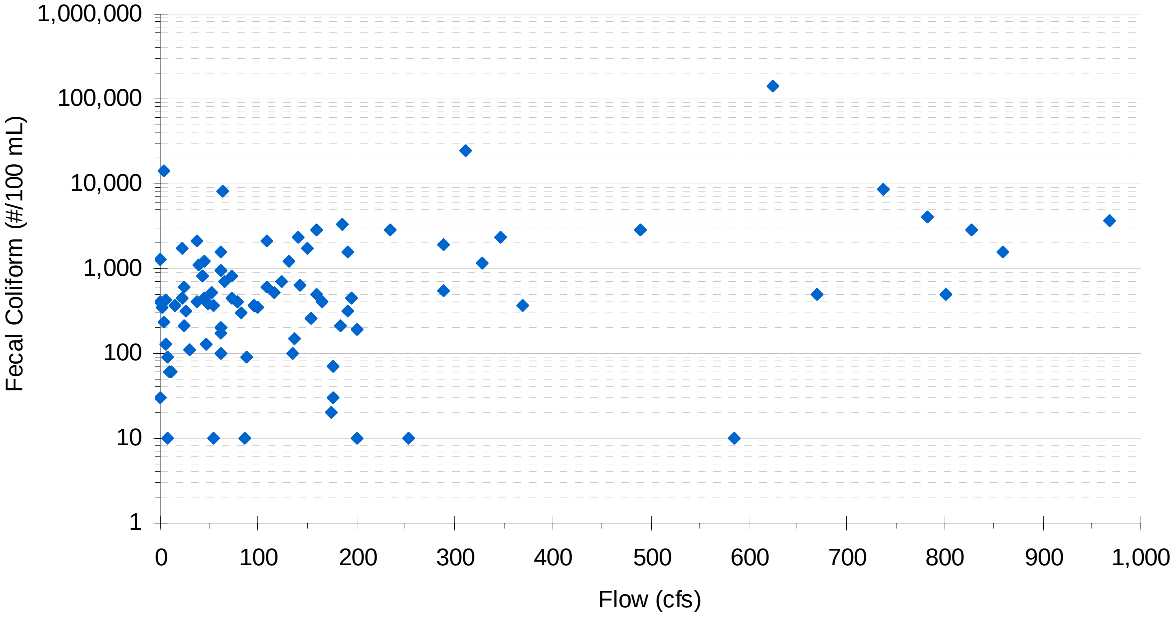

Figure 4-17. Relationship between fecal coliform concentration and flow.

4.5.3 Potential Pollutant Sources

Both point and nonpoint sources represent potential sources of pollutants in the Little Vermilion River watershed and are discussed further below.

4.5.3.1 Point Source Discharges

A query of the National Pollution Discharge Elimination System (NPDES) database revealed five point source dischargers to Little Vermilion River, as presented in Table 4-8. The City of Georgetown has two permitted facilities: a sewage treatment plant and a water treatment plant. The parameters reported to IEPA for each facility are presented in Table 4-8 and the location of the facilities are shown in Figure 4-18.

Table 4-8. NPDES Discharges in the Little Vermilion River Watershed.

NPDES ID	Facility Name	Monitored Parameters
IL0022322	City of Georgetown Sewage Treatment Plant (STP)	TSS Ammonia Fecal Coliform
ILG640168	City of Georgetown Water Treatment Plant (WTP)	TSS
IL0069078	City of Sidell (WTP)	TSS
IL0004511	City of Allerton (WTP)	Total Residual Chlorine Dissolved Iron Total Iron pH TSS
IL0070777	Dynachem	Xylene Toluene Phenol, Single Compound pH Naphthalene Flow, In Conduit Or Thru Treatment Plant Ethylbenzene Benzene 4-Methylphenol 2-Methylphenol 2,4-Dimethylphenol
 IL0074802 IL0071021	Black Beauty Riola Coal Mine Vermilion Grove Portal Riola Portal	Total Suspended Solids Iron (Total) pH Alkalinity/Acidity Sulfates Chloride Manganese (Total)
IL0020966	Farm Ridge STP	BOD Total Residual Chlorine Fecal Coliform TSS Ammonia PH Flow, In Conduit or Thru Treatment Plant

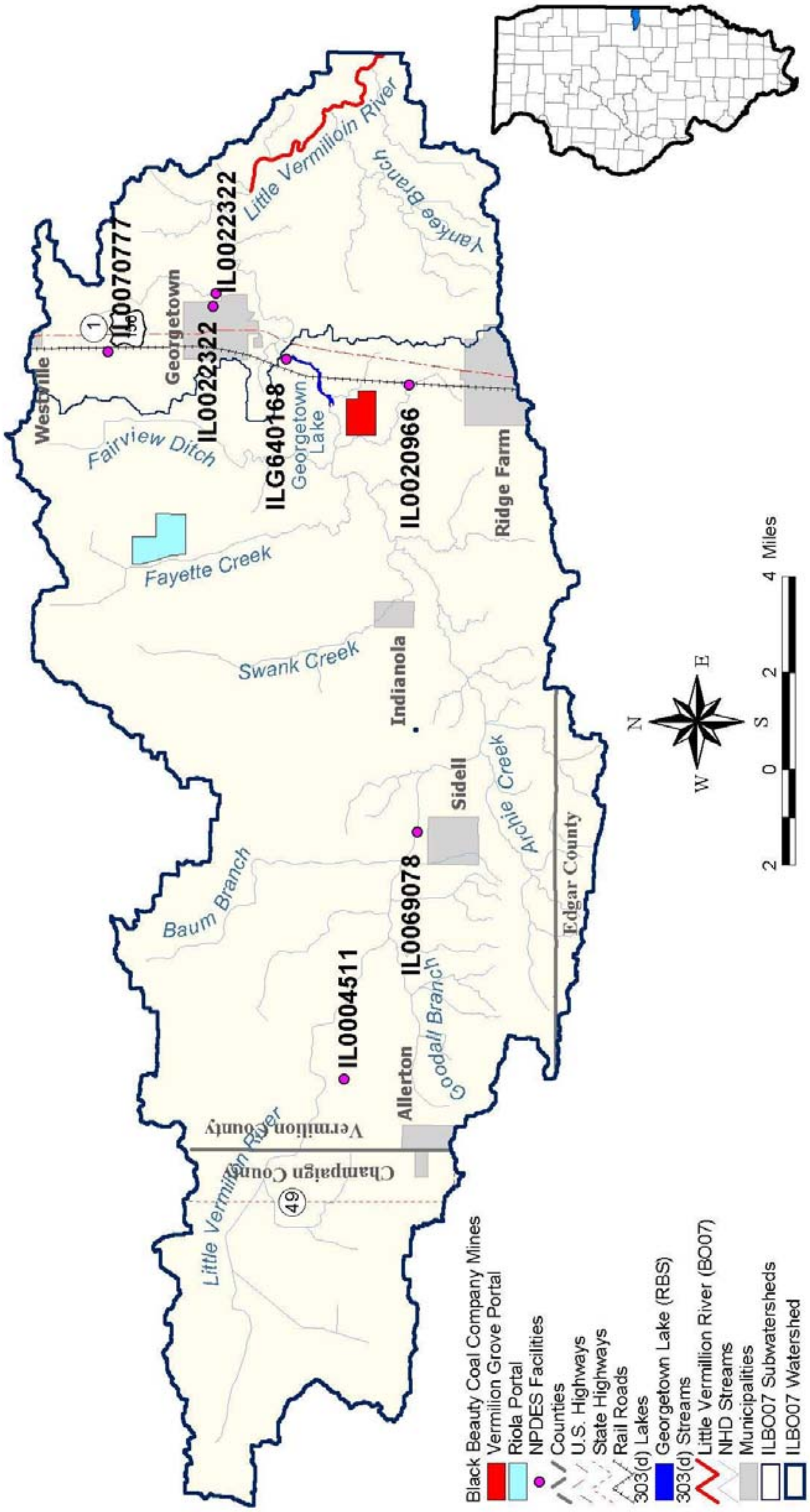

Figure 4-18. Location of coal mines and point sources in the Little Vermilion River watershed.

4.5.3.2 Nonpoint Sources

Potential nonpoint sources of TP and fecal coliform in the Little Vermilion River watershed include fertilizer use, stream channel erosion, sheet and rill erosion, lake shoreline erosion, failing septic systems, livestock operations, storm water runoff, atmospheric deposition, internal lake recycling, and natural sources. There are also two coal mines in the watershed (shown in Figure 4-18) but these mines are not expected to be significant sources of TP or fecal coliform. The relative magnitude of the various sources has not yet been estimated and will be the focus of Stage 2 and 3 activities.

5 Identification of Data Gaps and Sampling Plan

A final identification of data gaps for the Little Vermilion River watershed cannot be made until the data from the University of Illinois are obtained. Both flow and additional water quality data are expected to be available in that data set.

One data gap that has been identified is additional fecal coliform data for the impaired segment of the Little Vermilion River. Additional fecal coliform data are required in this segment 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 May).

Detailed bathymetric data for Georgetown Lake have also not yet been identified. Such data would be very helpful for modeling the lake (see Section 6).

6 Technical Approach

Potential technical approaches for developing phosphorus TMDLs for Georgetown Lake and fecal coliform TMDLs for Little Vermilion River are presented in this section. Both simple and more advanced technical approaches are presented. Additional discussion between IEPA, the University of Illinois, and other key stakeholders will be needed before finalizing the approaches.

6.1 Georgetown Lake TP TMDL

The following discussion provides a description of two different approaches for developing the Georgetown Lake TP TMDL.

6.1.1 Simple Approach

A simple approach to the Georgetown Lake TP TMDL 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 TP 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 TP loads from the Little Vermilion River 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 TP (e.g., from the lake bottom sediments).

6.1.2 Detailed Approach

Under a more detailed approach both a watershed and a lake model would be developed and applied for the Georgetown Lake 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.

A potential option for the detailed approach would be to couple one of the existing watershed models of the watershed with either the BATHTUB or LAKE2K model. It is Tetra Tech's understanding that the University of Illinois has already setup and calibrated the DRAINMOD, Root Zone Water Quality Model (RZWQM), and Soil and Water Assessment Tool (SWAT) models for portions of the Little Vermilion River watershed (Northcott et al., 2002; Walker et al., 2000). It is also Tetra Tech's understanding that the University of Illinois has extensive data that can be used to expand these models to cover the full watershed and additional parameters. Although the DRAINMOD and RZWQM models were focused on predicting nitrate concentrations, it is believed that the models could be modified to evaluate TP. Alternatively, TP can be directly simulated using the SWAT model, although the SWAT model would need to be modified to better simulate the impacts of tile drainage.

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. A comparison of the BATHTUB and LAKE2K models is provided in Table 6-1.

Table 6-1. Comparison of the BATHTUB and LAKE2K models.

	BATHTUB	**LAKE-2K**
Model Basis	Empirical	Physically -based (complicated water quality kinetics, no hydrodynamics)
Time Step	Steady State	Dynamic
Vertical Segmentation	Depth Averaged	Vertically segmented into 3 layers (each constituent simulated for each layer, epi, meta, hypo)
Longitudinal Segmentation	Spatially segmented network	Cannot represent spatially segmented network (may not be appropriate if data show spatial variability in the lake)
Chlorophyll-a Simulation	Can only provide seasonal average predictions; unable to evaluate maximums. Cannot simulate more than one species	Able to simulate 3 types of phytoplankton.
DO Simulation	Meta and Hypolimnetic Depletion Rate	Predicts for each vertical layer
Sediment Diagenisis	No	Yes
Predictive Capability/Scenario Testing	Short-term responses and effects related to structural modifications or responses to variables other than nutrients cannot be evaluated	Represents whole-lake as one box. Model may not be predictive of local impacts due to loadings or in-lake management measures are to be evaluated

6.2 Little Vermilion River Fecal Coliform TMDL

The following discussion provides a description of two different approaches for developing the Little Vermilion River fecal coliform TMDL.

6.2.1 Simple Approach

Required fecal coliform load reductions for the Little Vermilion River can be assessed through the use of a load duration curve. The load duration approach involves calculating the desired loadings over the range of flow conditions expected to occur in the impaired stream and is a simple and accurate method to assess existing and allowable loads. The following specific steps are recommended:

1) A flow duration curve for the stream gage site of interest is developed. This is done by generating a flow frequency table and plotting the data points.
2) The flow curve is translated into a load duration (TMDL) curve. To accomplish this, the flow value is multiplied by the water quality standard and by a conversion factor. The resulting points are graphed.
3) A water quality sample is converted to a load by multiplying the water quality sample concentration by the average daily flow on the day the sample was collected. Then, the load is plotted on the TMDL graph.
4) Points plotting above the curve represent deviations from the water quality standard and the permissible loading function. Those plotting below the curve represent compliance with standards and represent adequate quality support for the appropriate designated use.
5) The area beneath the TMDL curve is the loading capacity of the stream. The difference between this area and the area representing the current loading conditions is the load that must be reduced to meet water quality standards.

Tetra Tech is very familiar with the use of the load duration approach and has developed spreadsheet tools to facilitate its use. The approach helps to identify the issues surrounding the impairment and to roughly differentiate between sources. Loads which plot above the curve in the low flow regime are likely indicative of constant discharge sources. Those plotting above the curve in the high flow regime likely reflect wet weather contributions. Some combination of the two source categories lies in the transition zone. Specific sources of fecal coliform would be identified through a non-modeling approach to facilitate implementation activities. Disadvantages of this approach include the fact that estimating the observed and allowable loads would be disconnected from the analysis of the source of the loads. The approach also does not directly address the geometric mean component of the standard.

6.2.2 Detailed Approach

A more detailed approach to developing the fecal coliform TMDL would be to rely on the watershed model described above in Section 6.1.2 to estimate existing and allowable loads. The watershed model would be developed to include the entire Little Vermilion River watershed (included the impaired segment) and would need to estimate loads from all of the potential sources (e.g., failing septic systems, cattle grazing, storm water runoff). The advantages of this approach are that the sources of fecal coliform would be more explicitly addressed and the effectiveness of potential best management practices could be evaluated with the model. The geometric mean component of the standard could also be directly addressed because the model would provide daily output with which to calculate a 30-day geometric mean.

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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 Little Vermilion River Watershed

Waterbody ID	Station ID	Date	Parameter	Value	Units
RBS	RBS-1	5/18/1983	Ammonia	0.1	mg/L
RBS	RBS-1	9/2/1983	Ammonia	0.1	mg/L
RBS	RBS-1	7/5/1989	Ammonia	0.19	mg/L
RBS	RBS-1	7/5/1989	Ammonia	0.1	mg/L
RBS	RBS-1	4/26/1995	Ammonia	0.12	mg/L
RBS	RBS-1	6/16/1995	Ammonia	0.06	mg/L
RBS	RBS-1	7/20/1995	Ammonia	0.06	mg/L
RBS	RBS-1	8/29/1995	Ammonia	0.01	mg/L
RBS	RBS-1	10/5/1995	Ammonia	0.21	mg/L
RBS	RBS-1	4/21/1997	Ammonia	0.1	mg/L
RBS	RBS-1	6/9/1997	Ammonia	0.12	mg/L
RBS	RBS-1	6/9/1997	Ammonia	0.13	mg/L
RBS	RBS-1	7/14/1997	Ammonia	0.02	mg/L
RBS	RBS-1	7/14/1997	Ammonia	0.07	mg/L
RBS	RBS-1	8/12/1997	Ammonia	0.33	mg/L
RBS	RBS-1	8/12/1997	Ammonia	0.29	mg/L
RBS	RBS-1	10/22/1997	Ammonia	0.2	mg/L
RBS	RBS-1	10/22/1997	Ammonia	0.23	mg/L
RBS	RBS-1	4/24/2002	Ammonia	0.01	mg/L
RBS	RBS-1	4/24/2002	Ammonia	0.01	mg/L
RBS	RBS-1	4/24/2002	Ammonia	0.01	mg/L
RBS	RBS-1	6/18/2002	Ammonia	0.13	mg/L
RBS	RBS-1	6/18/2002	Ammonia	0.02	mg/L
RBS	RBS-1	7/30/2002	Ammonia	0.01	mg/L
RBS	RBS-1	7/30/2002	Ammonia	0.01	mg/L
RBS	RBS-1	8/12/2002	Ammonia	0.01	mg/L
RBS	RBS-1	8/12/2002	Ammonia	0.02	mg/L
RBS	RBS-1	10/21/2002	Ammonia	0.1	mg/L
RBS	RBS-1	10/21/2002	Ammonia	0.22	mg/L
RBS	RBS-1	5/18/1983	Chlorophyll-a	0.74	µg/L
RBS	RBS-1	5/18/1983	Chlorophyll-a	0.69	µg/L
RBS	RBS-1	4/26/1995	Chlorophyll-a	11.41	µg/L
RBS	RBS-1	4/26/1995	Chlorophyll-a	8.9	µg/L
RBS	RBS-1	6/16/1995	Chlorophyll-a	9.82	µg/L
RBS	RBS-1	6/16/1995	Chlorophyll-a	6.28	µg/L
RBS	RBS-1	7/20/1995	Chlorophyll-a	30.656	µg/L
RBS	RBS-1	7/20/1995	Chlorophyll-a	32.842	µg/L
RBS	RBS-1	8/29/1995	Chlorophyll-a	106.8	µg/L
RBS	RBS-1	8/29/1995	Chlorophyll-a	111.22	µg/L
RBS	RBS-1	10/5/1995	Chlorophyll-a	31.201	µg/L
RBS	RBS-1	10/5/1995	Chlorophyll-a	22.695	µg/L
RBS	RBS-1	4/21/1997	Chlorophyll-a	1.03	µg/L
RBS	RBS-1	4/21/1997	Chlorophyll-a	2.62	µg/L
RBS	RBS-1	6/9/1997	Chlorophyll-a	4.27	µg/L
RBS	RBS-1	6/9/1997	Chlorophyll-a	2.44	µg/L
RBS	RBS-1	7/14/1997	Chlorophyll-a	53.4	µg/L
RBS	RBS-1	7/14/1997	Chlorophyll-a	59.23	µg/L

RBS	RBS-1	8/12/1997	Chlorophyll-a	75.8	µg/L
RBS	RBS-1	8/12/1997	Chlorophyll-a	70.81	µg/L
RBS	RBS-1	10/22/1997	Chlorophyll-a	43.03	µg/L
RBS	RBS-1	10/22/1997	Chlorophyll-a	39.22	µg/L
RBS	RBS-1	4/24/2002	Chlorophyll-a	2.75	µg/L
RBS	RBS-1	4/24/2002	Chlorophyll-a	1	µg/L
RBS	RBS-1	6/18/2002	Chlorophyll-a	3.64	µg/L
RBS	RBS-1	6/18/2002	Chlorophyll-a	2.06	µg/L
RBS	RBS-1	7/30/2002	Chlorophyll-a	55.7	µg/L
RBS	RBS-1	7/30/2002	Chlorophyll-a	56.7	µg/L
RBS	RBS-1	8/12/2002	Chlorophyll-a	60	µg/L
RBS	RBS-1	8/12/2002	Chlorophyll-a	67.7	µg/L
RBS	RBS-1	10/21/2002	Chlorophyll-a	10.9	µg/L
RBS	RBS-1	10/21/2002	Chlorophyll-a	10.4	µg/L
RBS	RBS-1	5/18/1983	Dissolved Phosphorus	0.052	mg/L
RBS	RBS-1	5/18/1983	Dissolved Phosphorus	0.02	mg/L
RBS	RBS-1	9/2/1983	Dissolved Phosphorus	0.042	mg/L
RBS	RBS-1	9/2/1983	Dissolved Phosphorus	0.041	mg/L
RBS	RBS-1	7/5/1989	Dissolved Phosphorus	0.056	mg/L
RBS	RBS-1	7/5/1989	Dissolved Phosphorus	0.055	mg/L
RBS	RBS-1	4/26/1995	Dissolved Phosphorus	0.02	mg/L
RBS	RBS-1	6/16/1995	Dissolved Phosphorus	0.037	mg/L
RBS	RBS-1	7/20/1995	Dissolved Phosphorus	0.017	mg/L
RBS	RBS-1	8/29/1995	Dissolved Phosphorus	0.022	mg/L
RBS	RBS-1	10/5/1995	Dissolved Phosphorus	0.037	mg/L
RBS	RBS-1	4/21/1997	Dissolved Phosphorus	0.014	mg/L
RBS	RBS-1	6/9/1997	Dissolved Phosphorus	0.067	mg/L
RBS	RBS-1	7/14/1997	Dissolved Phosphorus	0.023	mg/L
RBS	RBS-1	7/14/1997	Dissolved Phosphorus	0.011	mg/L
RBS	RBS-1	8/12/1997	Dissolved Phosphorus	0.04	mg/L
RBS	RBS-1	8/12/1997	Dissolved Phosphorus	0.042	mg/L
RBS	RBS-1	10/22/1997	Dissolved Phosphorus	0.024	mg/L
RBS	RBS-1	10/22/1997	Dissolved Phosphorus	0.02	mg/L
RBS	RBS-1	4/24/2002	Dissolved Phosphorus	0.04	mg/L
RBS	RBS-1	4/24/2002	Dissolved Phosphorus	0.034	mg/L
RBS	RBS-1	4/24/2002	Dissolved Phosphorus	0.033	mg/L
RBS	RBS-1	6/18/2002	Dissolved Phosphorus	0.038	mg/L
RBS	RBS-1	6/18/2002	Dissolved Phosphorus	0.034	mg/L
RBS	RBS-1	7/30/2002	Dissolved Phosphorus	0.044	mg/L
RBS	RBS-1	7/30/2002	Dissolved Phosphorus	0.049	mg/L
RBS	RBS-1	8/12/2002	Dissolved Phosphorus	0.029	mg/L
RBS	RBS-1	8/12/2002	Dissolved Phosphorus	0.025	mg/L
RBS	RBS-1	10/21/2002	Dissolved Phosphorus	0.052	mg/L
RBS	RBS-1	10/21/2002	Dissolved Phosphorus	0.055	mg/L
RBS	RBS-1	5/18/1983	Nitrate + Nitrite	13	mg/L
RBS	RBS-1	9/2/1983	Nitrate + Nitrite	0.1	mg/L
RBS	RBS-1	7/5/1989	Nitrate + Nitrite	9.7	mg/L
RBS	RBS-1	4/26/1995	Nitrate + Nitrite	10.4	mg/L

RBS	RBS-1	6/16/1995	Nitrate + Nitrite	11.1	mg/L
RBS	RBS-1	7/20/1995	Nitrate + Nitrite	4.2	mg/L
RBS	RBS-1	8/29/1995	Nitrate + Nitrite	0.33	mg/L
RBS	RBS-1	10/5/1995	Nitrate + Nitrite	0.06	mg/L
RBS	RBS-1	4/21/1997	Nitrate + Nitrite	9.4	mg/L
RBS	RBS-1	6/9/1997	Nitrate + Nitrite	12.7	mg/L
RBS	RBS-1	6/9/1997	Nitrate + Nitrite	13	mg/L
RBS	RBS-1	7/14/1997	Nitrate + Nitrite	5.4	mg/L
RBS	RBS-1	8/12/1997	Nitrate + Nitrite	0.02	mg/L
RBS	RBS-1	8/12/1997	Nitrate + Nitrite	0.03	mg/L
RBS	RBS-1	10/22/1997	Nitrate + Nitrite	0.01	mg/L
RBS	RBS-1	4/24/2002	Nitrate + Nitrite	15	mg/L
RBS	RBS-1	4/24/2002	Nitrate + Nitrite	15	mg/L
RBS	RBS-1	4/24/2002	Nitrate + Nitrite	15	mg/L
RBS	RBS-1	6/18/2002	Nitrate + Nitrite	13.1	mg/L
RBS	RBS-1	6/18/2002	Nitrate + Nitrite	13.4	mg/L
RBS	RBS-1	7/30/2002	Nitrate + Nitrite	6.76	mg/L
RBS	RBS-1	7/30/2002	Nitrate + Nitrite	6.68	mg/L
RBS	RBS-1	8/12/2002	Nitrate + Nitrite	1.64	mg/L
RBS	RBS-1	8/12/2002	Nitrate + Nitrite	1.61	mg/L
RBS	RBS-1	10/21/2002	Nitrate + Nitrite	0.03	mg/L
RBS	RBS-1	10/21/2002	Nitrate + Nitrite	0.03	mg/L
RBS	RBS-1	5/18/1983	Suspended Solids	28	mg/L
RBS	RBS-1	5/18/1983	Suspended Solids	31	mg/L
RBS	RBS-1	9/2/1983	Suspended Solids	30	mg/L
RBS	RBS-1	9/2/1983	Suspended Solids	20	mg/L
RBS	RBS-1	7/5/1989	Suspended Solids	21	mg/L
RBS	RBS-1	7/5/1989	Suspended Solids	45	mg/L
RBS	RBS-1	4/26/1995	Suspended Solids	19	mg/L
RBS	RBS-1	6/16/1995	Suspended Solids	28	mg/L
RBS	RBS-1	7/20/1995	Suspended Solids	21	mg/L
RBS	RBS-1	8/29/1995	Suspended Solids	40	mg/L
RBS	RBS-1	10/5/1995	Suspended Solids	84	mg/L
RBS	RBS-1	4/21/1997	Suspended Solids	16	mg/L
RBS	RBS-1	4/21/1997	Suspended Solids	15	mg/L
RBS	RBS-1	6/9/1997	Suspended Solids	32	mg/L
RBS	RBS-1	6/9/1997	Suspended Solids	27	mg/L
RBS	RBS-1	7/14/1997	Suspended Solids	26	mg/L
RBS	RBS-1	7/14/1997	Suspended Solids	23	mg/L
RBS	RBS-1	8/12/1997	Suspended Solids	26	mg/L
RBS	RBS-1	8/12/1997	Suspended Solids	16	mg/L
RBS	RBS-1	10/22/1997	Suspended Solids	24	mg/L
RBS	RBS-1	10/22/1997	Suspended Solids	18	mg/L
RBS	RBS-1	4/24/2002	Suspended Solids	26	mg/L
RBS	RBS-1	4/24/2002	Suspended Solids	24	mg/L
RBS	RBS-1	4/24/2002	Suspended Solids	25	mg/L
RBS	RBS-1	6/18/2002	Suspended Solids	23	mg/L
RBS	RBS-1	6/18/2002	Suspended Solids	32	mg/L

RBS	RBS-1	7/30/2002	Suspended Solids	31	mg/L
RBS	RBS-1	7/30/2002	Suspended Solids	24	mg/L
RBS	RBS-1	8/12/2002	Suspended Solids	21	mg/L
RBS	RBS-1	8/12/2002	Suspended Solids	25	mg/L
RBS	RBS-1	10/21/2002	Suspended Solids	16	mg/L
RBS	RBS-1	10/21/2002	Suspended Solids	19	mg/L
RBS	RBS-1	5/18/1983	TKN	0.2	mg/L
RBS	RBS-1	5/18/1983	TKN	0.6	mg/L
RBS	RBS-1	9/2/1983	TKN	1.3	mg/L
RBS	RBS-1	9/2/1983	TKN	1.2	mg/L
RBS	RBS-1	7/5/1989	TKN	0.5	mg/L
RBS	RBS-1	7/5/1989	TKN	0.3	mg/L
RBS	RBS-1	4/26/1995	TKN	0.11	mg/L
RBS	RBS-1	6/16/1995	TKN	0.88	mg/L
RBS	RBS-1	7/20/1995	TKN	0.6	mg/L
RBS	RBS-1	8/29/1995	TKN	1.5	mg/L
RBS	RBS-1	10/5/1995	TKN	1.4	mg/L
RBS	RBS-1	4/21/1997	TKN	0.61	mg/L
RBS	RBS-1	4/21/1997	TKN	0.48	mg/L
RBS	RBS-1	6/9/1997	TKN	0.93	mg/L
RBS	RBS-1	6/9/1997	TKN	1	mg/L
RBS	RBS-1	7/14/1997	TKN	0.99	mg/L
RBS	RBS-1	7/14/1997	TKN	0.92	mg/L
RBS	RBS-1	8/12/1997	TKN	0.81	mg/L
RBS	RBS-1	8/12/1997	TKN	0.76	mg/L
RBS	RBS-1	10/22/1997	TKN	1.3	mg/L
RBS	RBS-1	10/22/1997	TKN	1.1	mg/L
RBS	RBS-1	4/24/2002	TKN	1.24	mg/L
RBS	RBS-1	4/24/2002	TKN	0.84	mg/L
RBS	RBS-1	4/24/2002	TKN	0.53	mg/L
RBS	RBS-1	6/18/2002	TKN	0.92	mg/L
RBS	RBS-1	6/18/2002	TKN	0.9	mg/L
RBS	RBS-1	7/30/2002	TKN	1.91	mg/L
RBS	RBS-1	7/30/2002	TKN	2	mg/L
RBS	RBS-1	5/18/1983	Total Phosphorus	0.056	mg/L
RBS	RBS-1	5/18/1983	Total Phosphorus	0.046	mg/L
RBS	RBS-1	9/2/1983	Total Phosphorus	0.422	mg/L
RBS	RBS-1	9/2/1983	Total Phosphorus	0.14	mg/L
RBS	RBS-1	7/5/1989	Total Phosphorus	0.076	mg/L
RBS	RBS-1	7/5/1989	Total Phosphorus	0.065	mg/L
RBS	RBS-1	4/26/1995	Total Phosphorus	0.031	mg/L
RBS	RBS-1	6/16/1995	Total Phosphorus	0.06	mg/L
RBS	RBS-1	7/20/1995	Total Phosphorus	0.07	mg/L
RBS	RBS-1	8/29/1995	Total Phosphorus	0.184	mg/L
RBS	RBS-1	10/5/1995	Total Phosphorus	0.137	mg/L
RBS	RBS-1	4/21/1997	Total Phosphorus	0.04	mg/L
RBS	RBS-1	4/21/1997	Total Phosphorus	0.041	mg/L
RBS	RBS-1	6/9/1997	Total Phosphorus	0.11	mg/L

RBS	RBS-1	6/9/1997	Total Phosphorus	0.112	mg/L
RBS	RBS-1	7/14/1997	Total Phosphorus	0.044	mg/L
RBS	RBS-1	7/14/1997	Total Phosphorus	0.039	mg/L
RBS	RBS-1	8/12/1997	Total Phosphorus	0.15	mg/L
RBS	RBS-1	8/12/1997	Total Phosphorus	0.141	mg/L
RBS	RBS-1	10/22/1997	Total Phosphorus	0.104	mg/L
RBS	RBS-1	10/22/1997	Total Phosphorus	0.113	mg/L
RBS	RBS-1	4/24/2002	Total Phosphorus	0.064	mg/L
RBS	RBS-1	4/24/2002	Total Phosphorus	0.071	mg/L
RBS	RBS-1	4/24/2002	Total Phosphorus	0.062	mg/L
RBS	RBS-1	6/18/2002	Total Phosphorus	0.065	mg/L
RBS	RBS-1	6/18/2002	Total Phosphorus	0.061	mg/L
RBS	RBS-1	7/30/2002	Total Phosphorus	0.104	mg/L
RBS	RBS-1	7/30/2002	Total Phosphorus	0.132	mg/L
RBS	RBS-1	8/12/2002	Total Phosphorus	0.144	mg/L
RBS	RBS-1	8/12/2002	Total Phosphorus	0.149	mg/L
RBS	RBS-1	10/21/2002	Total Phosphorus	0.105	mg/L
RBS	RBS-1	10/21/2002	Total Phosphorus	0.106	mg/L
RBS	RBS-1	5/18/1983	Un-inonized Ammonia	0.001036	mg/L
RBS	RBS-1	5/18/1983	Un-inonized Ammonia	0.00099	mg/L
RBS	RBS-1	9/2/1983	Un-inonized Ammonia	0.006375	mg/L
RBS	RBS-1	9/2/1983	Un-inonized Ammonia	0.001176	mg/L
RBS	RBS-1	4/26/1995	Un-inonized Ammonia	0.006577	mg/L
RBS	RBS-1	6/16/1995	Un-inonized Ammonia	0.006271	mg/L
RBS	RBS-1	8/29/1995	Un-inonized Ammonia	0.004284	mg/L
RBS	RBS-1	10/5/1995	Un-inonized Ammonia	0.01286	mg/L
RBS	RBS-1	4/21/1997	Un-inonized Ammonia	0.001153	mg/L
RBS	RBS-1	4/21/1997	Un-inonized Ammonia	0.001262	mg/L
RBS	RBS-1	6/9/1997	Un-inonized Ammonia	0.000691	mg/L
RBS	RBS-1	6/9/1997	Un-inonized Ammonia	0.000872	mg/L
RBS	RBS-1	7/14/1997	Un-inonized Ammonia	0.000808	mg/L
RBS	RBS-1	7/14/1997	Un-inonized Ammonia	0.002807	mg/L
RBS	RBS-1	8/12/1997	Un-inonized Ammonia	0.018337	mg/L
RBS	RBS-1	8/12/1997	Un-inonized Ammonia	0.010433	mg/L
RBS	RBS-1	10/22/1997	Un-inonized Ammonia	0.007043	mg/L
RBS	RBS-1	10/22/1997	Un-inonized Ammonia	0.006217	mg/L
RBS	RBS-2	5/18/1983	Ammonia	0.1	mg/L
RBS	RBS-2	9/2/1983	Ammonia	0.11	mg/L
RBS	RBS-2	4/26/1995	Ammonia	0.07	mg/L
RBS	RBS-2	6/16/1995	Ammonia	0.07	mg/L
RBS	RBS-2	7/20/1995	Ammonia	0.04	mg/L
RBS	RBS-2	8/29/1995	Ammonia	0.01	mg/L
RBS	RBS-2	10/5/1995	Ammonia	0.11	mg/L
RBS	RBS-2	4/21/1997	Ammonia	0.09	mg/L
RBS	RBS-2	6/9/1997	Ammonia	0.18	mg/L
RBS	RBS-2	7/14/1997	Ammonia	0.19	mg/L
RBS	RBS-2	8/12/1997	Ammonia	0.38	mg/L
RBS	RBS-2	10/22/1997	Ammonia	0.21	mg/L

RBS	RBS-2	4/24/2002	Ammonia	0.01	mg/L
RBS	RBS-2	6/18/2002	Ammonia	0.01	mg/L
RBS	RBS-2	7/30/2002	Ammonia	0.01	mg/L
RBS	RBS-2	8/12/2002	Ammonia	0.06	mg/L
RBS	RBS-2	10/21/2002	Ammonia	0.04	mg/L
RBS	RBS-2	5/18/1983	Chlorophyll-a	0.56	µg/L
RBS	RBS-2	5/18/1983	Chlorophyll-a	0.84	µg/L
RBS	RBS-2	4/26/1995	Chlorophyll-a	12.21	µg/L
RBS	RBS-2	4/26/1995	Chlorophyll-a	7.16	µg/L
RBS	RBS-2	6/16/1995	Chlorophyll-a	11.23	µg/L
RBS	RBS-2	6/16/1995	Chlorophyll-a	11.78	µg/L
RBS	RBS-2	7/20/1995	Chlorophyll-a	36.476	µg/L
RBS	RBS-2	7/20/1995	Chlorophyll-a	32.04	µg/L
RBS	RBS-2	8/29/1995	Chlorophyll-a	95.344	µg/L
RBS	RBS-2	8/29/1995	Chlorophyll-a	79.507	µg/L
RBS	RBS-2	10/5/1995	Chlorophyll-a	46.725	µg/L
RBS	RBS-2	10/5/1995	Chlorophyll-a	55.333	µg/L
RBS	RBS-2	4/21/1997	Chlorophyll-a	2.05	µg/L
RBS	RBS-2	4/21/1997	Chlorophyll-a	2.68	µg/L
RBS	RBS-2	6/9/1997	Chlorophyll-a	1.03	µg/L
RBS	RBS-2	6/9/1997	Chlorophyll-a	1.04	µg/L
RBS	RBS-2	7/14/1997	Chlorophyll-a	37.38	µg/L
RBS	RBS-2	7/14/1997	Chlorophyll-a	43.93	µg/L
RBS	RBS-2	8/12/1997	Chlorophyll-a	29.98	µg/L
RBS	RBS-2	8/12/1997	Chlorophyll-a	25.08	µg/L
RBS	RBS-2	10/22/1997	Chlorophyll-a	39.99	µg/L
RBS	RBS-2	10/22/1997	Chlorophyll-a	27.62	µg/L
RBS	RBS-2	4/24/2002	Chlorophyll-a	1	µg/L
RBS	RBS-2	4/24/2002	Chlorophyll-a	3.14	µg/L
RBS	RBS-2	6/18/2002	Chlorophyll-a	1.95	µg/L
RBS	RBS-2	6/18/2002	Chlorophyll-a	1	µg/L
RBS	RBS-2	7/30/2002	Chlorophyll-a	24.3	µg/L
RBS	RBS-2	7/30/2002	Chlorophyll-a	25.4	µg/L
RBS	RBS-2	8/12/2002	Chlorophyll-a	45.2	µg/L
RBS	RBS-2	8/12/2002	Chlorophyll-a	42.1	µg/L
RBS	RBS-2	10/21/2002	Chlorophyll-a	25.1	µg/L
RBS	RBS-2	10/21/2002	Chlorophyll-a	28.3	µg/L
RBS	RBS-2	5/18/1983	Dissolved Phosphorus	0.021	mg/L
RBS	RBS-2	9/2/1983	Dissolved Phosphorus	0.052	mg/L
RBS	RBS-2	4/26/1995	Dissolved Phosphorus	0.014	mg/L
RBS	RBS-2	6/16/1995	Dissolved Phosphorus	0.023	mg/L
RBS	RBS-2	7/20/1995	Dissolved Phosphorus	0.016	mg/L
RBS	RBS-2	8/29/1995	Dissolved Phosphorus	0.012	mg/L
RBS	RBS-2	10/5/1995	Dissolved Phosphorus	0.031	mg/L
RBS	RBS-2	4/21/1997	Dissolved Phosphorus	0.015	mg/L
RBS	RBS-2	6/9/1997	Dissolved Phosphorus	0.063	mg/L
RBS	RBS-2	7/14/1997	Dissolved Phosphorus	0.008	mg/L
RBS	RBS-2	8/12/1997	Dissolved Phosphorus	0.039	mg/L

RBS	RBS-2	10/22/1997	Dissolved Phosphorus	0.019	mg/L
RBS	RBS-2	4/24/2002	Dissolved Phosphorus	0.032	mg/L
RBS	RBS-2	6/18/2002	Dissolved Phosphorus	0.031	mg/L
RBS	RBS-2	7/30/2002	Dissolved Phosphorus	0.048	mg/L
RBS	RBS-2	8/12/2002	Dissolved Phosphorus	0.023	mg/L
RBS	RBS-2	10/21/2002	Dissolved Phosphorus	0.043	mg/L
RBS	RBS-2	5/18/1983	Nitrate + Nitrite	13	mg/L
RBS	RBS-2	9/2/1983	Nitrate + Nitrite	0.1	mg/L
RBS	RBS-2	4/26/1995	Nitrate + Nitrite	10.4	mg/L
RBS	RBS-2	6/16/1995	Nitrate + Nitrite	11.2	mg/L
RBS	RBS-2	7/20/1995	Nitrate + Nitrite	4	mg/L
RBS	RBS-2	8/29/1995	Nitrate + Nitrite	0.9	mg/L
RBS	RBS-2	10/5/1995	Nitrate + Nitrite	0.04	mg/L
RBS	RBS-2	4/21/1997	Nitrate + Nitrite	9.4	mg/L
RBS	RBS-2	6/9/1997	Nitrate + Nitrite	13	mg/L
RBS	RBS-2	7/14/1997	Nitrate + Nitrite	5.6	mg/L
RBS	RBS-2	8/12/1997	Nitrate + Nitrite	0.01	mg/L
RBS	RBS-2	10/22/1997	Nitrate + Nitrite	0.01	mg/L
RBS	RBS-2	4/24/2002	Nitrate + Nitrite	15	mg/L
RBS	RBS-2	6/18/2002	Nitrate + Nitrite	13.6	mg/L
RBS	RBS-2	7/30/2002	Nitrate + Nitrite	6.66	mg/L
RBS	RBS-2	8/12/2002	Nitrate + Nitrite	1.45	mg/L
RBS	RBS-2	10/21/2002	Nitrate + Nitrite	0.01	mg/L
RBS	RBS-2	5/18/1983	Suspended Solids	56	mg/L
RBS	RBS-2	9/2/1983	Suspended Solids	20	mg/L
RBS	RBS-2	4/26/1995	Suspended Solids	20	mg/L
RBS	RBS-2	6/16/1995	Suspended Solids	18	mg/L
RBS	RBS-2	7/20/1995	Suspended Solids	57	mg/L
RBS	RBS-2	8/29/1995	Suspended Solids	38	mg/L
RBS	RBS-2	10/5/1995	Suspended Solids	96	mg/L
RBS	RBS-2	4/21/1997	Suspended Solids	8	mg/L
RBS	RBS-2	6/9/1997	Suspended Solids	25	mg/L
RBS	RBS-2	7/14/1997	Suspended Solids	31	mg/L
RBS	RBS-2	8/12/1997	Suspended Solids	16	mg/L
RBS	RBS-2	10/22/1997	Suspended Solids	21	mg/L
RBS	RBS-2	4/24/2002	Suspended Solids	24	mg/L
RBS	RBS-2	6/18/2002	Suspended Solids	25	mg/L
RBS	RBS-2	7/30/2002	Suspended Solids	20	mg/L
RBS	RBS-2	8/12/2002	Suspended Solids	25	mg/L
RBS	RBS-2	10/21/2002	Suspended Solids	22	mg/L
RBS	RBS-2	5/18/1983	TKN	0.6	mg/L
RBS	RBS-2	9/2/1983	TKN	1.4	mg/L
RBS	RBS-2	4/26/1995	TKN	0.32	mg/L
RBS	RBS-2	6/16/1995	TKN	0.71	mg/L
RBS	RBS-2	7/20/1995	TKN	0.42	mg/L
RBS	RBS-2	8/29/1995	TKN	1.3	mg/L
RBS	RBS-2	10/5/1995	TKN	5.6	mg/L
RBS	RBS-2	4/21/1997	TKN	0.56	mg/L

RBS	RBS-2	6/9/1997	TKN	0.81	mg/L
RBS	RBS-2	7/14/1997	TKN	0.76	mg/L
RBS	RBS-2	8/12/1997	TKN	0.5	mg/L
RBS	RBS-2	10/22/1997	TKN	0.98	mg/L
RBS	RBS-2	4/24/2002	TKN	0.59	mg/L
RBS	RBS-2	6/18/2002	TKN	1.03	mg/L
RBS	RBS-2	7/30/2002	TKN	1.34	mg/L
RBS	RBS-2	5/18/1983	Total Phosphorus	0.065	mg/L
RBS	RBS-2	9/2/1983	Total Phosphorus	0.146	mg/L
RBS	RBS-2	4/26/1995	Total Phosphorus	0.028	mg/L
RBS	RBS-2	6/16/1995	Total Phosphorus	0.047	mg/L
RBS	RBS-2	7/20/1995	Total Phosphorus	0.077	mg/L
RBS	RBS-2	8/29/1995	Total Phosphorus	0.106	mg/L
RBS	RBS-2	10/5/1995	Total Phosphorus	0.138	mg/L
RBS	RBS-2	4/21/1997	Total Phosphorus	0.034	mg/L
RBS	RBS-2	6/9/1997	Total Phosphorus	0.102	mg/L
RBS	RBS-2	7/14/1997	Total Phosphorus	0.057	mg/L
RBS	RBS-2	8/12/1997	Total Phosphorus	0.113	mg/L
RBS	RBS-2	10/22/1997	Total Phosphorus	0.101	mg/L
RBS	RBS-2	4/24/2002	Total Phosphorus	0.057	mg/L
RBS	RBS-2	6/18/2002	Total Phosphorus	0.057	mg/L
RBS	RBS-2	7/30/2002	Total Phosphorus	0.092	mg/L
RBS	RBS-2	8/12/2002	Total Phosphorus	0.117	mg/L
RBS	RBS-2	10/21/2002	Total Phosphorus	0.111	mg/L
RBS	RBS-2	5/18/1983	Un-inonized Ammonia	0.001067	mg/L
RBS	RBS-2	9/2/1983	Un-inonized Ammonia	0.001568	mg/L
RBS	RBS-2	4/26/1995	Un-inonized Ammonia	0.003893	mg/L
RBS	RBS-2	6/16/1995	Un-inonized Ammonia	0.006811	mg/L
RBS	RBS-2	7/20/1995	Un-inonized Ammonia	0.004639	mg/L
RBS	RBS-2	8/29/1995	Un-inonized Ammonia	0.003796	mg/L
RBS	RBS-2	10/5/1995	Un-inonized Ammonia	0.008818	mg/L
RBS	RBS-2	4/21/1997	Un-inonized Ammonia	0.001447	mg/L
RBS	RBS-2	6/9/1997	Un-inonized Ammonia	0.001116	mg/L
RBS	RBS-2	7/14/1997	Un-inonized Ammonia	0.010141	mg/L
RBS	RBS-2	8/12/1997	Un-inonized Ammonia	0.019732	mg/L
RBS	RBS-2	10/22/1997	Un-inonized Ammonia	0.008653	mg/L
RBS	RBS-3	5/18/1983	Ammonia	0.1	mg/L
RBS	RBS-3	9/2/1983	Ammonia	0.1	mg/L
RBS	RBS-3	4/26/1995	Ammonia	0.05	mg/L
RBS	RBS-3	6/16/1995	Ammonia	0.04	mg/L
RBS	RBS-3	7/20/1995	Ammonia	0.01	mg/L
RBS	RBS-3	8/29/1995	Ammonia	0.01	mg/L
RBS	RBS-3	10/5/1995	Ammonia	0.08	mg/L
RBS	RBS-3	4/21/1997	Ammonia	0.08	mg/L
RBS	RBS-3	6/9/1997	Ammonia	0.11	mg/L
RBS	RBS-3	7/14/1997	Ammonia	0.12	mg/L
RBS	RBS-3	8/12/1997	Ammonia	0.31	mg/L
RBS	RBS-3	10/22/1997	Ammonia	0.16	mg/L

RBS	RBS-3	4/24/2002	Ammonia	0.02	mg/L
RBS	RBS-3	6/18/2002	Ammonia	0.01	mg/L
RBS	RBS-3	7/30/2002	Ammonia	0.01	mg/L
RBS	RBS-3	8/12/2002	Ammonia	0.07	mg/L
RBS	RBS-3	10/21/2002	Ammonia	0.01	mg/L
RBS	RBS-3	5/18/1983	Chlorophyll-a	1.07	µg/L
RBS	RBS-3	5/18/1983	Chlorophyll-a	0.75	µg/L
RBS	RBS-3	4/26/1995	Chlorophyll-a	6.2	µg/L
RBS	RBS-3	4/26/1995	Chlorophyll-a	7.66	µg/L
RBS	RBS-3	6/16/1995	Chlorophyll-a	11.55	µg/L
RBS	RBS-3	6/16/1995	Chlorophyll-a	13.78	µg/L
RBS	RBS-3	7/20/1995	Chlorophyll-a	63.889	µg/L
RBS	RBS-3	7/20/1995	Chlorophyll-a	66.839	µg/L
RBS	RBS-3	8/29/1995	Chlorophyll-a	122.73	µg/L
RBS	RBS-3	8/29/1995	Chlorophyll-a	114.81	µg/L
RBS	RBS-3	10/5/1995	Chlorophyll-a	61.751	µg/L
RBS	RBS-3	10/5/1995	Chlorophyll-a	50.857	µg/L
RBS	RBS-3	4/21/1997	Chlorophyll-a	2.86	µg/L
RBS	RBS-3	4/21/1997	Chlorophyll-a	2.06	µg/L
RBS	RBS-3	6/9/1997	Chlorophyll-a	5.09	µg/L
RBS	RBS-3	6/9/1997	Chlorophyll-a	2.34	µg/L
RBS	RBS-3	7/14/1997	Chlorophyll-a	24.64	µg/L
RBS	RBS-3	7/14/1997	Chlorophyll-a	21.78	µg/L
RBS	RBS-3	8/12/1997	Chlorophyll-a	49.29	µg/L
RBS	RBS-3	8/12/1997	Chlorophyll-a	52.51	µg/L
RBS	RBS-3	10/22/1997	Chlorophyll-a	33.15	µg/L
RBS	RBS-3	10/22/1997	Chlorophyll-a	34.02	µg/L
RBS	RBS-3	4/24/2002	Chlorophyll-a	1	µg/L
RBS	RBS-3	4/24/2002	Chlorophyll-a	2.72	µg/L
RBS	RBS-3	6/18/2002	Chlorophyll-a	2.3	µg/L
RBS	RBS-3	6/18/2002	Chlorophyll-a	1.04	µg/L
RBS	RBS-3	7/30/2002	Chlorophyll-a	20.3	µg/L
RBS	RBS-3	7/30/2002	Chlorophyll-a	20.5	µg/L
RBS	RBS-3	8/12/2002	Chlorophyll-a	39.2	µg/L
RBS	RBS-3	8/12/2002	Chlorophyll-a	38.4	µg/L
RBS	RBS-3	10/21/2002	Chlorophyll-a	47.1	µg/L
RBS	RBS-3	5/18/1983	Dissolved Phosphorus	0.035	mg/L
RBS	RBS-3	9/2/1983	Dissolved Phosphorus	0.05	mg/L
RBS	RBS-3	4/26/1995	Dissolved Phosphorus	0.012	mg/L
RBS	RBS-3	6/16/1995	Dissolved Phosphorus	0.02	mg/L
RBS	RBS-3	7/20/1995	Dissolved Phosphorus	0.015	mg/L
RBS	RBS-3	8/29/1995	Dissolved Phosphorus	0.012	mg/L
RBS	RBS-3	10/5/1995	Dissolved Phosphorus	0.043	mg/L
RBS	RBS-3	4/21/1997	Dissolved Phosphorus	0.013	mg/L
RBS	RBS-3	6/9/1997	Dissolved Phosphorus	0.062	mg/L
RBS	RBS-3	7/14/1997	Dissolved Phosphorus	0.021	mg/L
RBS	RBS-3	8/12/1997	Dissolved Phosphorus	0.043	mg/L
RBS	RBS-3	10/22/1997	Dissolved Phosphorus	0.018	mg/L

RBS	RBS-3	4/24/2002	Dissolved Phosphorus	0.031	mg/L
RBS	RBS-3	6/18/2002	Dissolved Phosphorus	0.029	mg/L
RBS	RBS-3	7/30/2002	Dissolved Phosphorus	0.044	mg/L
RBS	RBS-3	8/12/2002	Dissolved Phosphorus	0.023	mg/L
RBS	RBS-3	10/21/2002	Dissolved Phosphorus	0.034	mg/L
RBS	RBS-3	5/18/1983	Nitrate + Nitrite	13	mg/L
RBS	RBS-3	9/2/1983	Nitrate + Nitrite	0.1	mg/L
RBS	RBS-3	4/26/1995	Nitrate + Nitrite	10.4	mg/L
RBS	RBS-3	6/16/1995	Nitrate + Nitrite	11.2	mg/L
RBS	RBS-3	7/20/1995	Nitrate + Nitrite	3.5	mg/L
RBS	RBS-3	8/29/1995	Nitrate + Nitrite	0.95	mg/L
RBS	RBS-3	10/5/1995	Nitrate + Nitrite	0.04	mg/L
RBS	RBS-3	4/21/1997	Nitrate + Nitrite	9.4	mg/L
RBS	RBS-3	6/9/1997	Nitrate + Nitrite	13.2	mg/L
RBS	RBS-3	7/14/1997	Nitrate + Nitrite	5.9	mg/L
RBS	RBS-3	8/12/1997	Nitrate + Nitrite	0.01	mg/L
RBS	RBS-3	10/22/1997	Nitrate + Nitrite	0.01	mg/L
RBS	RBS-3	4/24/2002	Nitrate + Nitrite	16	mg/L
RBS	RBS-3	6/18/2002	Nitrate + Nitrite	13.4	mg/L
RBS	RBS-3	7/30/2002	Nitrate + Nitrite	6.14	mg/L
RBS	RBS-3	8/12/2002	Nitrate + Nitrite	1.23	mg/L
RBS	RBS-3	10/21/2002	Nitrate + Nitrite	0.01	mg/L
RBS	RBS-3	5/18/1983	Suspended Solids	33	mg/L
RBS	RBS-3	9/2/1983	Suspended Solids	16	mg/L
RBS	RBS-3	4/26/1995	Suspended Solids	27	mg/L
RBS	RBS-3	6/16/1995	Suspended Solids	20	mg/L
RBS	RBS-3	7/20/1995	Suspended Solids	26	mg/L
RBS	RBS-3	8/29/1995	Suspended Solids	48	mg/L
RBS	RBS-3	10/5/1995	Suspended Solids	86	mg/L
RBS	RBS-3	4/21/1997	Suspended Solids	18	mg/L
RBS	RBS-3	6/9/1997	Suspended Solids	31	mg/L
RBS	RBS-3	7/14/1997	Suspended Solids	38	mg/L
RBS	RBS-3	8/12/1997	Suspended Solids	23	mg/L
RBS	RBS-3	10/22/1997	Suspended Solids	18	mg/L
RBS	RBS-3	4/24/2002	Suspended Solids	25	mg/L
RBS	RBS-3	6/18/2002	Suspended Solids	18	mg/L
RBS	RBS-3	7/30/2002	Suspended Solids	13	mg/L
RBS	RBS-3	8/12/2002	Suspended Solids	43	mg/L
RBS	RBS-3	10/21/2002	Suspended Solids	17	mg/L
RBS	RBS-3	5/18/1983	TKN	0.2	mg/L
RBS	RBS-3	9/2/1983	TKN	0.9	mg/L
RBS	RBS-3	4/26/1995	TKN	0.16	mg/L
RBS	RBS-3	6/16/1995	TKN	0.96	mg/L
RBS	RBS-3	7/20/1995	TKN	0.1	mg/L
RBS	RBS-3	8/29/1995	TKN	1.1	mg/L
RBS	RBS-3	10/5/1995	TKN	1.9	mg/L
RBS	RBS-3	4/21/1997	TKN	0.56	mg/L
RBS	RBS-3	6/9/1997	TKN	0.51	mg/L

RBS	RBS-3	7/14/1997	TKN	0.73	mg/L
RBS	RBS-3	8/12/1997	TKN	1.3	mg/L
RBS	RBS-3	10/22/1997	TKN	0.81	mg/L
RBS	RBS-3	4/24/2002	TKN	0.46	mg/L
RBS	RBS-3	6/18/2002	TKN	0.1	mg/L
RBS	RBS-3	7/30/2002	TKN	1.74	mg/L
RBS	RBS-3	5/18/1983	Total Phosphorus	0.064	mg/L
RBS	RBS-3	9/2/1983	Total Phosphorus	0.125	mg/L
RBS	RBS-3	4/26/1995	Total Phosphorus	0.023	mg/L
RBS	RBS-3	6/16/1995	Total Phosphorus	0.045	mg/L
RBS	RBS-3	7/20/1995	Total Phosphorus	0.122	mg/L
RBS	RBS-3	8/29/1995	Total Phosphorus	0.09	mg/L
RBS	RBS-3	10/5/1995	Total Phosphorus	0.15	mg/L
RBS	RBS-3	4/21/1997	Total Phosphorus	0.035	mg/L
RBS	RBS-3	6/9/1997	Total Phosphorus	0.099	mg/L
RBS	RBS-3	7/14/1997	Total Phosphorus	0.07	mg/L
RBS	RBS-3	8/12/1997	Total Phosphorus	0.132	mg/L
RBS	RBS-3	10/22/1997	Total Phosphorus	0.061	mg/L
RBS	RBS-3	4/24/2002	Total Phosphorus	0.055	mg/L
RBS	RBS-3	6/18/2002	Total Phosphorus	0.052	mg/L
RBS	RBS-3	7/30/2002	Total Phosphorus	0.088	mg/L
RBS	RBS-3	8/12/2002	Total Phosphorus	0.131	mg/L
RBS	RBS-3	10/21/2002	Total Phosphorus	0.122	mg/L
RBS	RBS-3	5/18/1983	Un-inonized Ammonia	0.001067	mg/L
RBS	RBS-3	9/2/1983	Un-inonized Ammonia	0.00605	mg/L
RBS	RBS-3	4/26/1995	Un-inonized Ammonia	0.002643	mg/L
RBS	RBS-3	6/16/1995	Un-inonized Ammonia	0.003741	mg/L
RBS	RBS-3	8/29/1995	Un-inonized Ammonia	0.004122	mg/L
RBS	RBS-3	10/5/1995	Un-inonized Ammonia	0.006283	mg/L
RBS	RBS-3	4/21/1997	Un-inonized Ammonia	0.001296	mg/L
RBS	RBS-3	6/9/1997	Un-inonized Ammonia	0.000784	mg/L
RBS	RBS-3	7/14/1997	Un-inonized Ammonia	0.006447	mg/L
RBS	RBS-3	8/12/1997	Un-inonized Ammonia	0.010285	mg/L
RBS	RBS-3	10/22/1997	Un-inonized Ammonia	0.008033	mg/L
BO-07	BO-2	8/31/1966	Fecal Coliform	320	#/100 mL
BO-07	BO-7	11/30/1978	Fecal Coliform	650	#/100 mL
BO-07	BO-7	2/27/1979	Fecal Coliform	220	#/100 mL
BO-07	BO-7	3/20/1979	Fecal Coliform	1600	#/100 mL
BO-07	BO-7	4/3/1979	Fecal Coliform	370	#/100 mL
BO-07	BO-7	6/7/1979	Fecal Coliform	800	#/100 mL
BO-07	BO-7	6/7/1979	Fecal Coliform	1000	#/100 mL
BO-07	BO-7	7/3/1979	Fecal Coliform	320	#/100 mL
BO-07	BO-7	7/3/1979	Fecal Coliform	300	#/100 mL
BO-07	BO-7	7/26/1979	Fecal Coliform	60000	#/100 mL
BO-07	BO-7	9/10/1979	Fecal Coliform	1400	#/100 mL
BO-07	BO-7	11/8/1979	Fecal Coliform	100	#/100 mL
BO-07	BO-7	12/7/1979	Fecal Coliform	1370	#/100 mL
BO-07	BO-7	2/7/1980	Fecal Coliform	378	#/100 mL

BO-07	BO-7	3/7/1980	Fecal Coliform	530	#/100 mL
BO-07	BO-7	4/15/1980	Fecal Coliform	2500	#/100 mL
BO-07	BO-7	4/15/1980	Fecal Coliform	2900	#/100 mL
BO-07	BO-7	9/5/1980	Fecal Coliform	500	#/100 mL
BO-07	BO-7	10/17/1980	Fecal Coliform	3000	#/100 mL
BO-07	BO-7	11/25/1980	Fecal Coliform	70	#/100 mL
BO-07	BO-7	12/31/1980	Fecal Coliform	3400	#/100 mL
BO-07	BO-7	2/19/1981	Fecal Coliform	2800	#/100 mL
BO-07	BO-7	3/24/1981	Fecal Coliform	10	#/100 mL
BO-07	BO-7	3/31/1981	Fecal Coliform	200	#/100 mL
BO-07	BO-7	5/5/1981	Fecal Coliform	490	#/100 mL
BO-07	BO-7	5/28/1981	Fecal Coliform	2900	#/100 mL
BO-07	BO-7	6/25/1981	Fecal Coliform	1900	#/100 mL
BO-07	BO-7	8/27/1981	Fecal Coliform	8600	#/100 mL
BO-07	BO-7	9/30/1981	Fecal Coliform	25000	#/100 mL
BO-07	BO-7	12/2/1981	Fecal Coliform	460	#/100 mL
BO-07	BO-7	1/19/1982	Fecal Coliform	2400	#/100 mL
BO-07	BO-7	3/17/1982	Fecal Coliform	4000	#/100 mL
BO-07	BO-7	4/14/1982	Fecal Coliform	310	#/100 mL
BO-07	BO-7	5/20/1982	Fecal Coliform	8000	#/100 mL
BO-07	BO-7	8/11/1982	Fecal Coliform	1200	#/100 mL
BO-07	BO-7	9/23/1982	Fecal Coliform	350	#/100 mL
BO-07	BO-7	11/4/1982	Fecal Coliform	150	#/100 mL
BO-07	BO-7	12/21/1982	Fecal Coliform	260	#/100 mL
BO-07	BO-7	1/27/1983	Fecal Coliform	930	#/100 mL
BO-07	BO-7	3/16/1983	Fecal Coliform	210	#/100 mL
BO-07	BO-7	4/14/1983	Fecal Coliform	3700	#/100 mL
BO-07	BO-7	5/18/1983	Fecal Coliform	1600	#/100 mL
BO-07	BO-7	7/7/1983	Fecal Coliform	1600	#/100 mL
BO-07	BO-7	9/27/1983	Fecal Coliform	110	#/100 mL
BO-07	BO-7	11/15/1983	Fecal Coliform	440	#/100 mL
BO-07	BO-7	1/26/1984	Fecal Coliform	2900	#/100 mL
BO-07	BO-7	3/7/1984	Fecal Coliform	1180	#/100 mL
BO-07	BO-7	4/11/1984	Fecal Coliform	390	#/100 mL
BO-07	BO-7	5/2/1984	Fecal Coliform	560	#/100 mL
BO-07	BO-7	6/13/1984	Fecal Coliform	1100	#/100 mL
BO-07	BO-7	7/11/1984	Fecal Coliform	1700	#/100 mL
BO-07	BO-7	8/16/1984	Fecal Coliform	410	#/100 mL
BO-07	BO-7	9/5/1984	Fecal Coliform	30	#/100 mL
BO-07	BO-7	10/24/1984	Fecal Coliform	450	#/100 mL
BO-07	BO-7	11/29/1984	Fecal Coliform	2100	#/100 mL
BO-07	BO-7	1/17/1985	Fecal Coliform	2300	#/100 mL
BO-07	BO-7	2/28/1985	Fecal Coliform	500	#/100 mL
BO-07	BO-7	4/16/1985	Fecal Coliform	210	#/100 mL
BO-07	BO-7	5/21/1985	Fecal Coliform	400	#/100 mL
BO-07	BO-7	7/2/1985	Fecal Coliform	400	#/100 mL
BO-07	BO-7	8/20/1985	Fecal Coliform	1200	#/100 mL
BO-07	BO-7	9/17/1985	Fecal Coliform	10	#/100 mL

BO-07	BO-7	11/7/1985	Fecal Coliform	110	#/100 mL
BO-07	BO-7	12/12/1985	Fecal Coliform	300	#/100 mL
BO-07	BO-7	1/9/1986	Fecal Coliform	10	#/100 mL
BO-07	BO-7	2/19/1986	Fecal Coliform	20	#/100 mL
BO-07	BO-7	4/9/1986	Fecal Coliform	10	#/100 mL
BO-07	BO-7	5/20/1986	Fecal Coliform	360	#/100 mL
BO-07	BO-7	6/25/1986	Fecal Coliform	520	#/100 mL
BO-07	BO-7	7/21/1986	Fecal Coliform	600	#/100 mL
BO-07	BO-7	9/11/1986	Fecal Coliform	410	#/100 mL
BO-07	BO-7	10/28/1986	Fecal Coliform	170	#/100 mL
BO-07	BO-7	12/3/1986	Fecal Coliform	600	#/100 mL
BO-07	BO-7	1/14/1987	Fecal Coliform	50	#/100 mL
BO-07	BO-7	2/18/1987	Fecal Coliform	30	#/100 mL
BO-07	BO-7	4/7/1987	Fecal Coliform	40	#/100 mL
BO-07	BO-7	5/7/1987	Fecal Coliform	90	#/100 mL
BO-07	BO-7	6/25/1987	Fecal Coliform	610	#/100 mL
BO-07	BO-7	7/21/1987	Fecal Coliform	300	#/100 mL
BO-07	BO-7	7/21/1987	Fecal Coliform	320	#/100 mL
BO-07	BO-7	8/25/1987	Fecal Coliform	230	#/100 mL
BO-07	BO-7	10/27/1987	Fecal Coliform	60	#/100 mL
BO-07	BO-7	11/24/1987	Fecal Coliform	60	#/100 mL
BO-07	BO-7	1/5/1988	Fecal Coliform	30	#/100 mL
BO-07	BO-7	2/11/1988	Fecal Coliform	70	#/100 mL
BO-07	BO-7	3/14/1988	Fecal Coliform	10	#/100 mL
BO-07	BO-7	5/12/1988	Fecal Coliform	170	#/100 mL
BO-07	BO-7	6/21/1988	Fecal Coliform	370	#/100 mL
BO-07	BO-7	9/21/1988	Fecal Coliform	13900	#/100 mL
BO-07	BO-7	10/25/1988	Fecal Coliform	800	#/100 mL
BO-07	BO-7	11/23/1988	Fecal Coliform	190	#/100 mL
BO-07	BO-7	1/11/1989	Fecal Coliform	10	#/100 mL
BO-07	BO-7	4/5/1989	Fecal Coliform	500	#/100 mL
BO-07	BO-7	5/4/1989	Fecal Coliform	300	#/100 mL
BO-07	BO-7	5/31/1989	Fecal Coliform	1190	#/100 mL
BO-07	BO-7	8/1/1989	Fecal Coliform	420	#/100 mL
BO-07	BO-7	8/31/1989	Fecal Coliform	1300	#/100 mL
BO-07	BO-7	10/31/1989	Fecal Coliform	210	#/100 mL
BO-07	BO-7	12/6/1989	Fecal Coliform	130	#/100 mL
BO-07	BO-7	1/9/1990	Fecal Coliform	350	#/100 mL
BO-07	BO-7	2/23/1990	Fecal Coliform	1100	#/100 mL
BO-07	BO-7	3/21/1990	Fecal Coliform	1700	#/100 mL
BO-07	BO-7	5/3/1990	Fecal Coliform	690	#/100 mL
BO-07	BO-7	6/20/1990	Fecal Coliform	140000	#/100 mL
BO-07	BO-7	7/18/1990	Fecal Coliform	100	#/100 mL
BO-07	BO-7	8/16/1990	Fecal Coliform	90	#/100 mL
BO-07	BO-7	10/25/1990	Fecal Coliform	240	#/100 mL
BO-07	BO-7	11/28/1990	Fecal Coliform	4000	#/100 mL
BO-07	BO-7	1/3/1991	Fecal Coliform	1100	#/100 mL
BO-07	BO-7	2/21/1991	Fecal Coliform	2200	#/100 mL

BO-07	BO-7	3/20/1991	Fecal Coliform	640	#/100 mL
BO-07	BO-7	5/7/1991	Fecal Coliform	1100	#/100 mL
BO-07	BO-7	6/5/1991	Fecal Coliform	630	#/100 mL
BO-07	BO-7	7/17/1991	Fecal Coliform	500	#/100 mL
BO-07	BO-7	9/11/1991	Fecal Coliform	1300	#/100 mL
BO-07	BO-7	10/22/1991	Fecal Coliform	130	#/100 mL
BO-07	BO-7	12/4/1991	Fecal Coliform	2800	#/100 mL
BO-07	BO-7	1/15/1992	Fecal Coliform	800	#/100 mL
BO-07	BO-7	2/26/1992	Fecal Coliform	410	#/100 mL
BO-07	BO-7	3/25/1992	Fecal Coliform	460	#/100 mL
BO-07	BO-7	5/19/1992	Fecal Coliform	370	#/100 mL
BO-07	BO-7	7/22/1992	Fecal Coliform	3300	#/100 mL
BO-07	BO-7	8/27/1992	Fecal Coliform	700	#/100 mL
BO-07	BO-7	9/24/1992	Fecal Coliform	2100	#/100 mL
BO-07	BO-7	11/4/1992	Fecal Coliform	1500	#/100 mL
BO-07	BO-7	12/17/1992	Fecal Coliform	1700	#/100 mL
BO-07	BO-7	1/27/1993	Fecal Coliform	470	#/100 mL
BO-07	BO-7	2/24/1993	Fecal Coliform	640	#/100 mL
BO-07	BO-7	4/7/1993	Fecal Coliform	110	#/100 mL
BO-07	BO-7	5/18/1993	Fecal Coliform	2000	#/100 mL
BO-07	BO-7	6/10/1993	Fecal Coliform	1800	#/100 mL
BO-07	BO-7	8/12/1993	Fecal Coliform	3500	#/100 mL
BO-07	BO-7	9/22/1993	Fecal Coliform	720	#/100 mL
BO-07	BO-7	11/1/1993	Fecal Coliform	240	#/100 mL
BO-07	BO-7	1/12/1994	Fecal Coliform	3800	#/100 mL
BO-07	BO-7	2/16/1994	Fecal Coliform	490	#/100 mL
BO-07	BO-7	3/15/1994	Fecal Coliform	500	#/100 mL
BO-07	BO-7	4/12/1994	Fecal Coliform	6000	#/100 mL
BO-07	BO-7	5/23/1994	Fecal Coliform	2100	#/100 mL
BO-07	BO-7	7/5/1994	Fecal Coliform	800	#/100 mL
BO-07	BO-7	8/23/1994	Fecal Coliform	1000	#/100 mL
BO-07	BO-7	9/13/1994	Fecal Coliform	320	#/100 mL
BO-07	BO-7	11/3/1994	Fecal Coliform	130	#/100 mL
BO-07	BO-7	12/20/1994	Fecal Coliform	2700	#/100 mL
BO-07	BO-7	1/18/1995	Fecal Coliform	440	#/100 mL
BO-07	BO-7	2/16/1995	Fecal Coliform	6100	#/100 mL
BO-07	BO-7	3/21/1995	Fecal Coliform	660	#/100 mL
BO-07	BO-7	5/10/1995	Fecal Coliform	510	#/100 mL
BO-07	BO-7	7/18/1995	Fecal Coliform	330	#/100 mL
BO-07	BO-7	9/8/1995	Fecal Coliform	360	#/100 mL
BO-07	BO-7	9/22/1995	Fecal Coliform	68	#/100 mL
BO-07	BO-7	1/9/1996	Fecal Coliform	110	#/100 mL
BO-07	BO-7	2/6/1996	Fecal Coliform	3000	#/100 mL
BO-07	BO-7	3/7/1996	Fecal Coliform	600	#/100 mL
BO-07	BO-7	3/27/1996	Fecal Coliform	280	#/100 mL
BO-07	BO-7	5/9/1996	Fecal Coliform	2800	#/100 mL
BO-07	BO-7	6/26/1996	Fecal Coliform	460	#/100 mL
BO-07	BO-7	8/5/1996	Fecal Coliform	700	#/100 mL

BO-07	BO-7	8/28/1996	Fecal Coliform	190	#/100 mL
BO-07	BO-7	10/28/1996	Fecal Coliform	50	#/100 mL
BO-07	BO-7	11/19/1996	Fecal Coliform	110	#/100 mL
BO-07	BO-7	1/7/1997	Fecal Coliform	440	#/100 mL
BO-07	BO-7	2/5/1997	Fecal Coliform	320	#/100 mL
BO-07	BO-7	3/11/1997	Fecal Coliform	210	#/100 mL
BO-07	BO-7	4/8/1997	Fecal Coliform	200	#/100 mL
BO-07	BO-7	6/13/1997	Fecal Coliform	140	#/100 mL
BO-07	BO-7	8/4/1997	Fecal Coliform	450	#/100 mL
BO-07	BO-7	9/11/1997	Fecal Coliform	3300	#/100 mL
BO-07	BO-7	10/30/1997	Fecal Coliform	60	#/100 mL
BO-07	BO-7	11/19/1997	Fecal Coliform	300	#/100 mL
BO-07	BO-7	1/6/1998	Fecal Coliform	150	#/100 mL
BO-07	BO-7	3/12/1998	Fecal Coliform	220	#/100 mL
BO-07	BO-7	4/30/1998	Fecal Coliform	3100	#/100 mL
BO-07	BO-7	6/5/1998	Fecal Coliform	900	#/100 mL
BO-07	BO-7	8/5/1998	Fecal Coliform	200	#/100 mL
BO-07	BO-7	8/25/1998	Fecal Coliform	3100	#/100 mL
BO-07	BO-7	9/23/1998	Fecal Coliform	3100	#/100 mL
BO-07	BO-7	10/27/1998	Fecal Coliform	40	#/100 mL
BO-07	BO-7	12/10/1998	Fecal Coliform	50	#/100 mL

TMDL Development for Georgetown Lake

FINAL REPORT

April 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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Key Findings

As part of the Section 303(d) listing process, the Illinois Environmental Protection Agency (IEPA) has identified two waterbodies in the Little Vermilion River watershed as impaired:

- Georgetown Lake (segment RBS)
- Little Vermilion River (segment BO07)

The purpose of this report is to describe the watershed in which these waters are located and review the available water quality data to confirm the impairments. This report also identifies several potential options for proceeding with developing total maximum daily loads (TMDLs) for these waters.

A review of the available water quality data confirms most of these impairments. However, insufficient data have been collected with which to make a direct comparison of the fecal coliform criteria as it applies to Little Vermilion River segment BO07.

Other key findings described in this report include:

- Mean total phosphorus concentrations exceed IEPA water quality criteria for several months in Georgetown Lake. Furthermore, dissolved phosphorus appears to comprise a significant proportion of the total phosphorus loading. On a monthly average basis, dissolved phosphorus comprises approximately 20 to 50 percent of total phosphorus in Georgetown Lake.

- There does not appear to be any significant improving or degrading trend over time for the assessed water quality parameters. Nutrient levels in Georgetown Lake, particularly total phosphorus, have remained relatively constant over the period of record. Similarly, fecal coliform counts collected in the Little Vermilion River have remained at nearly the same levels over the period of record.

- A lack of continuous streamflow data for Little Vermilion River poses a challenge for developing the TMDLs, as does the significant area of the watershed that is tile drained.

- Fecal coliform sampling is recommended for Little Vermilion River segment BMO07 to gather five samples within 30 days to allow for a direct comparison with the state's water quality standard.

- The University of Illinois has conducted an extensive amount of research in the Little Vermilion River watershed as part of the Little Vermilion River Agricultural Nonpoint Source Hydrologic Unit Area Project. Water quality and flow data are available, as are various tools that have been developed to better understand hydrology and water quality in the watershed. This research provides a strong foundation for moving forward with TMDL development.

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 five National Pollution Discharge Elimination System (NPDES) facilities upstream of Georgetown Lake:

- City of Allerton Water Treatment Plant (ID IL0004511)
- City of Sidell Water Treatment Plant (ID IL0069078)
- Ridge Farm Sewage Treatment Plant (IL0020966)
- Black Beauty Riola Coal Mine (IL0074802)
- Vermilion Grove Portal Riola Portal (IL0071021)

The location of each of these facilities is shown in **Error! Reference source not found.**.

None of these five facilities are required to monitor for TP in their effluent so their actual loads are unknown. Reported flow data were also not available for the two coal mines, although effluent load of TP from these facilities is not considered to be significant. Loads of TP from the water treatment plants and the Ridge Farm sewage treatment plant were estimated by multiplying their average reported effluent flows by estimates of their TP concentrations. Ambient Little Vermilion River TP concentrations in the vicinity of Allerton and Sidell (approximately 0.03 mg/L) were used for the water treatment plant effluent and a literature value of 4 mg/L (Litke, 1999) was used for the Ridge Farm Sewage Treatment Plant effluent. The resulting estimates of TP loads are shown in Table 7-1.

Table 7-1. Estimated loads of TP from point sources upstream of Georgetown Lake.

Facility	Average Flow (mgd)	Estimated TP Concentration (mg/L)	Estimated TP Load (kg/yr)
City of Allerton Water Treatment Plant	0.000006	0.03	<1 kg/yr
City of Sidell Water Treatment Plant	0.002	0.03	<1 kg/yr
Ridge Farm Sewage Treatment Plant	0.219	4.0	1,210 kg/yr

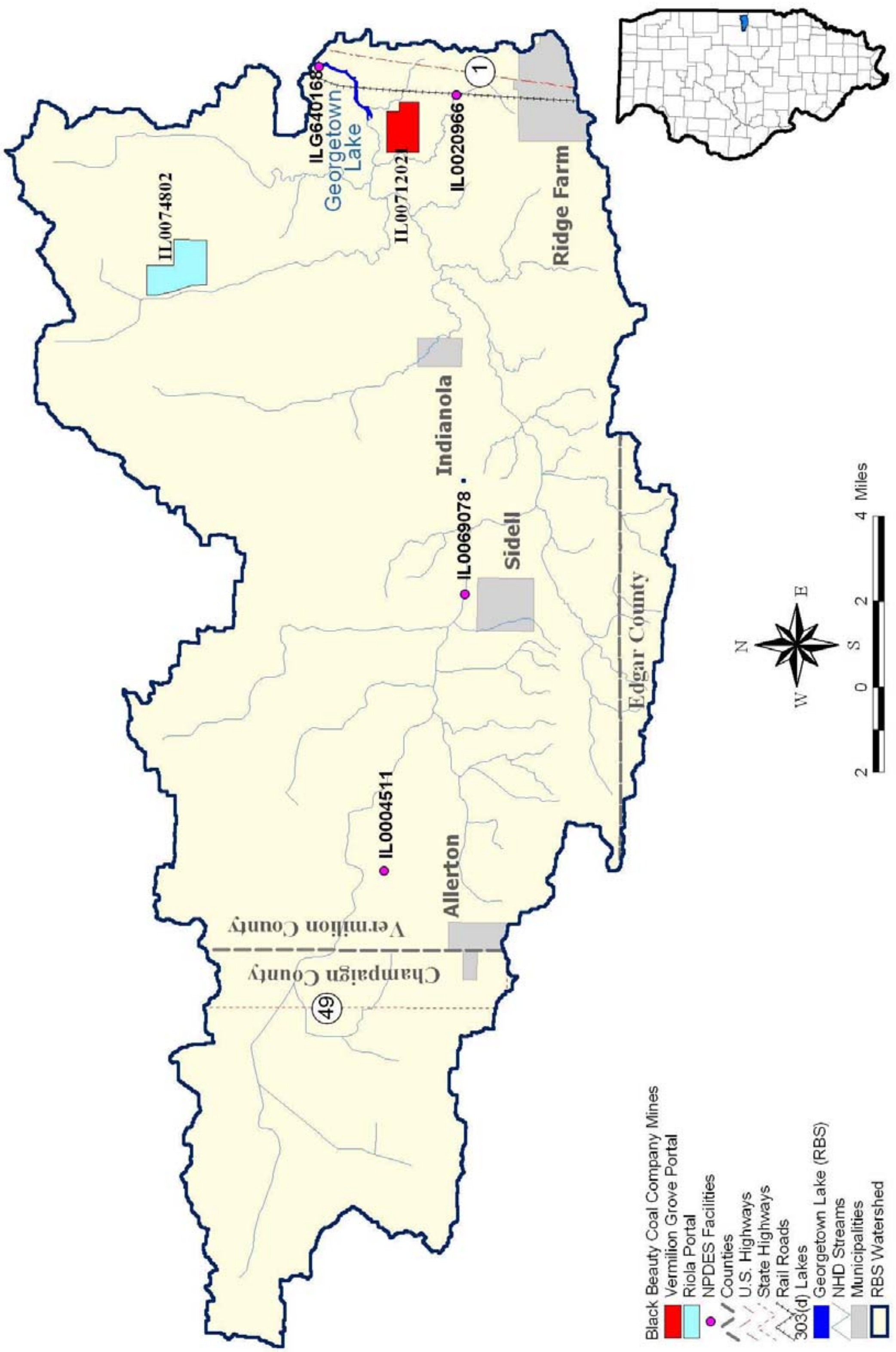

Figure 7-1. Location of point sources in the Georgetown Lake watershed.

7.2 Nonpoint Sources

Potential nonpoint sources of TP to Georgetown Lake include sheet and rill erosion, lake shoreline erosion, stream channel erosion, fertilizers applied to both crops and lawns, livestock operations, storm water runoff, atmospheric deposition, and natural sources. Internal recycling of phosphorus is not considered a significant source because the lake is so shallow and therefore likely does not experience prolonged periods of low oxygen. 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 estimates of TP loading with the resulting concentrations in Georgetown Lake.

8.1 Modeling Approach and Model Selection

BATHTUB was selected for modeling water quality in Georgetown Lake. 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 IEPA’s sampling data and maps of the lake:

Table 8-1. Bathymetry Data for Georgetown Lake

Parameter	Georgetown Lake
Surface Area (ha)	25.8
Maximum Depth (m)	2.7
Mean Depth (m)	1.2

Tributary flows and corresponding phosphorus concentrations are not available for the Little Vermilion River upstream of Georgetown Lake. Daily stream flow and phosphorus loading into the 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 soy production. Furthermore, the station has water quality data available from 1980 through 1997.

Stream flow for the drainage area above Georgetown Lake was estimated from observed West Okaw River daily stream flows. Stream flows were calculated as proportional to flow at Georgetown Lake based upon the ratio of drainage area upstream of the lake to the West Okaw River drainage area. The ratio of the Georgetown Lake drainage area to the West Okaw River drainage area is 161 mi^2 to 112 mi^2 or 1.4. Thus, the West Okaw River daily stream flows were multiplied by 1.4 to estimate daily tributary inflow to Georgetown Lake

A daily stream flow and total phosphorus time series of tributary flows entering Georgetown Lake 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 Little Vermilion River through use of unit area weighting method and flow data observed at West Okaw River.

The initial estimated nutrient loading to Georgetown Lake resulted in extremely high simulated in-lake concentrations, even with calibration factors set at their maximum recommended values. This resulted in a consistent over-prediction of simulated concentrations compared to observed concentrations. Similar problems were not encountered when using the same approach to model several nearby lakes. In exploring this issue further, it was discovered that there is a great deal more riparian forest cover in the Georgetown Lake watershed compared to the surrogate watershed (12 percent riparian forest cover compared to less than 1 percent forest cover). Wooded riparian buffers can be instrumental in the detention, removal, and assimilation of nutrients from or by the water column. In addition, riparian forests significantly reduce stream bank erosion. The initial estimated loads were therefore reduced to account for this “trapping” associated with the Little Vermilion River riparian cover. A 50 percent reduction in the initial estimated loads was found to result in a relatively good match between predicted and observed concentrations for almost all years and was therefore used during model calibration. The final estimated loads are presented in Table 8-2.

Table 8-2. Watershed Loading To Georgetown Lake.

Year	Average Stream flow (cubic feet per second)	TP (1000 kg)	TP (lbs)
1992	170	17.0	37,408
1993	274	25.5	56,224
1994	143	12.6	27,776
1995	131	11.7	25,760
1996	191	23.4	51,520
1997	98	7.3	16,128
1998	238	26.7	58,912
1999	153	13.7	30,240
2000	98	5.5	12,096
2001	176	14.8	32,704
2002	261	32.7	72,128
2003	86	7.9	17,472

The BATHTUB model requires input of the fraction of inorganic nutrient load. Inorganic fractions for Georgetown Lake were assumed 0.3 for phosphorus based on the long-term median of observed data at the most upstream sampling station (RBS-3).

The BATHTUB model (Walker, 1987) was set up to simulate nutrient responses in Georgetown Lake for the years 1992 through 2003 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. Second order nutrient response models were used to simulate both nitrogen and phosphorus. Nutrient calibration factors were set to 0.33 for nitrogen and 1 for phosphorus. Calibration factors were adjusted within the default range so that the average ratio of simulated to observed nutrient concentrations was close to 1. A calibration factor of 1 indicates that no adjustment to the model was needed.

Table 8-3 and Figure 8-1 compare the simulated and observed TP concentrations in Georgetown Lake. A relatively good match between predicted and observed concentrations was obtained for almost all years given the limitations regarding the loading data.

Table 8-3. Simulated and Observed Nutrient Concentrations in Georgetown Lake

Year	Simulated TP (mg/L)	Observed TP (mg/L)	Relative Error
1992	0.097		N/A
1993	0.091		N/A
1994	0.085		N/A
1995	0.086	0.088	-2.27%
1996	0.118		N/A
1997	0.071	0.084	-15.48%
1998	0.110		N/A
1999	0.087		N/A
2000	0.054		N/A
2001	0.083		N/A
2002	0.122	0.093	31.18%
2003	0.087		N/A
1992 to 2003 Average	0.091	0.088	3%

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

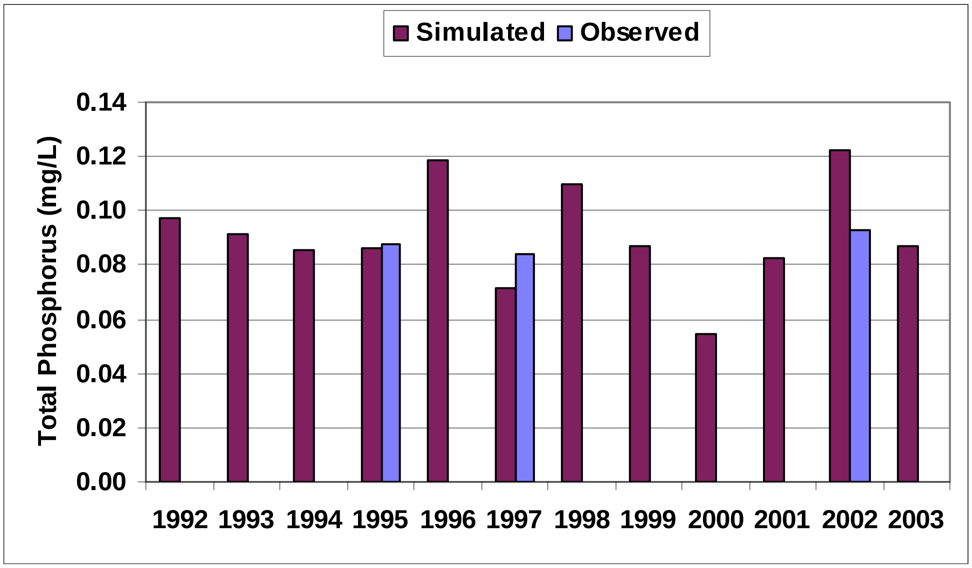

Figure 8-1. Comparison of Simulated and Observed Total Phosphorus Concentrations in Georgetown Lake.

9 TMDL

This section of the report presents the various components of the 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 total phosphorus. A 60 percent load reduction is needed to meet the target during all modeled years. However, this reduction is driven by the need to reduce loads to meet the simulated total phosphorus concentration in 2002, and the BATHTUB model over-predicts the concentration for that year (see Figure 8-1). Due to this concern, the model was re-run to identify the percent reduction in loads that is necessary to meet the 0.05 mg/L target as an average for the entire modeling period. The resulting reduction (46 percent) was selected for TMDL development purposes. Table 9-1 shows the predicted annual average total phosphorus concentrations if a 46 percent reduction is implemented.

Table 9-1. Average Total Phosphorus Concentration in Georgetown Lake with 46 Percent Reduction in Loading.

Year	Georgetown Lake TP (mg/L)
1992	0.053
1993	0.050
1994	0.047
1995	0.047
1996	0.065
1997	0.039
1998	0.060
1999	0.048
2000	0.030
2001	0.045
2002	0.067
2003	0.048
Average	0.050

9.2 Allocations

The allocation of loads for the Georgetown Lake TMDL is summarized in Table 9-2. The existing loads are the average loads to Georgetown Lake for the period 1992 to 2003 (to correspond to the modeling analysis). The loading capacity represents the 46 percent reduction from existing loads determined to be necessary from the modeling analysis. The wasteload allocation is the same as the existing estimated load for the Ridge Farm Sewage Treatment Plant. Five percent of the loading capacity is reserved for a margin of safety (as required by the Clean Water Act; see Section 9.4).

Table 9-2. TMDL Summary for Georgetown Lake.

Category	Phosphorus (kg/yr)
Existing Load	16,570
Loading Capacity	8,948
Wasteload Allocation	1,210
Margin of Safety	447
Load Allocation	7,291

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 Georgetown Lake, 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. The TMDL can therefore 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 Georgetown Lake TMDL by reserving a portion of the loading capacity. 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.

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. IEPA will work with local agencies and stakeholder groups to identify best management practices that will result in meeting water quality goals. A separate public meeting will be held to specifically discuss issues related to implementation once the Implementation Plan is completed.

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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 Little Vermilion River Watershed

(Included in Appendix B of the Stage One Report)

Fecal Coliform TMDL Development for the Little Vermilion River, Illinois

FINAL REPORT

October 2006

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

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

NOTE: This document is an addendum to the report titled *TMDL Development for the Little Vermilion River Watershed -- Final Report* that was finalized on April 8, 2005. Additional background information on the Little Vermilion River watershed and the TMDL process is available in the April 2005 document.

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1.0 BACKGROUND

The Little Vermilion River watershed (ILBO07) is located in east-central Illinois and drains approximately 200 square miles (Figure 1). Approximately 85 percent of the total watershed area is in eastern Vermilion County with smaller portions of the watershed in Champaign (13 percent) and Edgar (2 percent) counties.

As part of the Section 303(d) listing process, the Illinois Environmental Protection Agency (IEPA) has identified two waterbodies in the Little Vermilion River watershed as impaired (Table 1 and Figure 1):

- Georgetown Lake (segment RBS)
- Little Vermilion River (segment BO07)

Table 1. 2004 303(d) List Information for the Little Vermilion River Watershed (ILBO07)

Segment (Area)	Name	Designated Uses and Support Status	Causes of Impairment	Potential Sources of Impairment
RBS (46.10 ac)	Georgetown Lake	Overall Use (Not Assessed); Fish Consumption (Full); Drinking Water Supply (Not Assessed); Aquatic Life Support (Full); Primary Contact (Not Supporting); Secondary Contact (Partial)	Habitat Assessment, Total Suspended Solids, Excessive Algal Growth, Total Phosphorus	Agriculture (non-irrigated crop production, grazing related sources/pasture land), Urban Runoff/Storm Sewers, Contaminated Sediments, Herbicide/ Algicide Application
BO07 (5.11 mi)	Little Vermilion River	Aquatic Life Support (Full), Primary Contact/swimming (Not Supporting)	Fecal Coliform	Source Unknown

The Clean Water Act and USEPA regulations require that states develop TMDLs for waters on the Section 303(d) lists. IEPA is currently developing TMDLs for pollutants that have numeric water quality standards. Of the pollutants impairing Georgetown Lake, total phosphorus is the only parameter with a numeric water quality standard for lakes and a total phosphorus TMDL for Georgetown Lake was developed and approved by USEPA in September 2005 (Illinois EPA, 2005). There are also numeric water quality standards for fecal coliform and this report presents the results of the TMDL analysis for the Little Vermilion River fecal coliform impairment.

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 Georgetown Lake and Little Vermilion River TMDLs include:

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

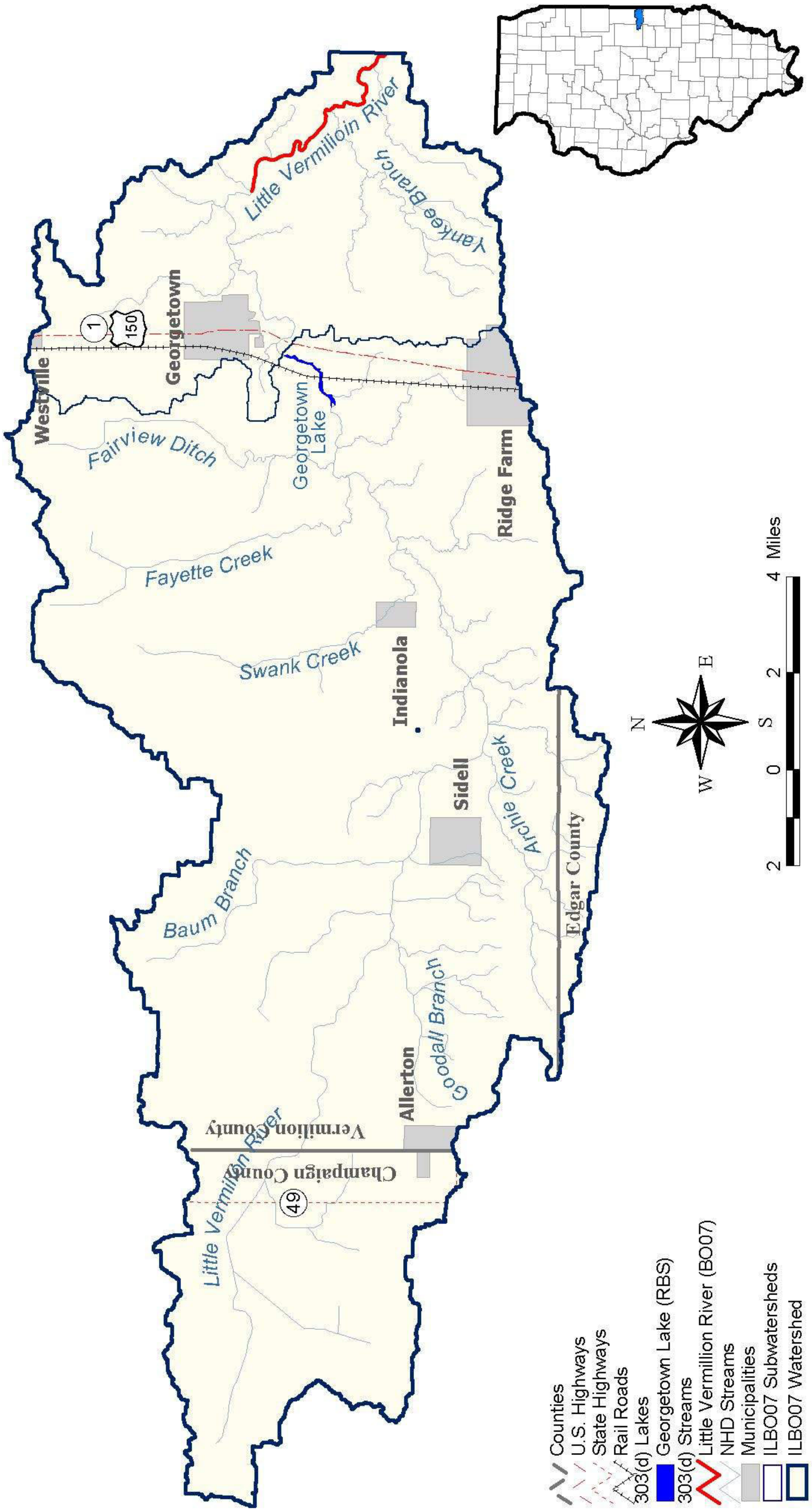

Figure 1. Location of the Little Vermilion River watershed.

- Use the best available science and available data to determine the maximum load the waterbodies can receive and fully support all of their designated uses.

- Use the best available science and available data to determine current loads of pollutants to the impaired waterbodies.

- If current loads exceed the maximum allowable load, determine the load reduction that is needed.

- Identify feasible and cost-effective actions that can be taken to reduce loads.

- Inform and involve the public throughout the project to ensure that key concerns are addressed and the best available information is used.

- Submit a final TMDL report to USEPA for review and approval.

The project is being initiated in three stages. Stage One involved the characterization of the watershed, an assessment of the available water quality data, and identification of potential technical approaches (Appendix G). Stage Two involved additional fecal coliform data collection for the Little Vermilion River (this is the reason the fecal coliform TMDL was not developed at the same time as the Georgetown Lake phosphorus TMDL). Portions of Stage Three for the Georgetown Lake total phosphorus TMDL are already completed and involved model development, model calibration, and TMDL report preparation. This report documents the Stage Three modeling and TMDL analysis for the Little Vermilion River fecal coliform impairment. An implementation plan for both the Georgetown Lake and Little Vermilion River TMDLs will be prepared in the near future.

2.0 APPLICABLE WATER QUALITY STANDARDS

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

2.1 Use Support Guidelines

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 that apply to water bodies in the Little Vermilion River watershed:

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

The following numeric criteria have been adopted to protect the general use fecal coliform standard:

> *"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)*

3.0 TECHNICAL APPROACH

This section presents the technical approach used to estimate current and allowable fecal coliform loading to the Little Vermilion River. As discussed below, a load duration approach was used to make these loading estimates.

3.1 Load Duration Curves

Load reductions for fecal coliform were determined through the use of load duration curves. The load duration curve approach involves calculating the allowable loadings of a pollutant over the range of flow conditions expected to occur in the impaired stream. The following steps are taken:

1. A flow duration curve for the stream is developed by generating a flow frequency table and plotting the data points. Since the bacteria water quality standards in Illinois are seasonal, the load duration approach employed in the Little Vermilion watershed only evaluated stream flows that occur during the recreational season of May 1 through October 31.

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

3. Each water quality sample is converted to a load by multiplying the water quality sample concentration by the average daily flow on the day the sample was collected and a conversion factor. Then, the individual loads are plotted on the TMDL graph.

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

5. The area beneath the TMDL curve is interpreted as the loading capacity of the stream. The difference between this area and the area representing the current loading conditions is the load that must be reduced to meet water quality standards.

Both the geometric mean (200 cfu/100 mL) and the not-to-exceed (400 cfu/100 mL) components of Illinois's water quality standard were evaluated as part of this study. The TMDL is based on meeting the geometric mean component of the standard because it is more restrictive and ensures both standards will be met. The necessary reductions from the geometric mean analysis are presented in Section 4[1]. An analysis was also conducted where a geometric mean was calculated for each recreation season (i.e., all the data in one particular year were used to determine a geometric mean) and compared to the 200

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[1] The results of the load duration analysis based on the not-to-exceed 400 cfu/100 mL standard are presented in Appendix A for information purposes.

cfu/100 mL standard. The results are presented in Appendix B and indicate that similar or somewhat larger reductions are needed for all flow ranges compared to the results used for the TMDL.

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

- High flow zone: stream flows that plot in the 0 to 10-percentile range, related to flood flows.
- Moist zone: flows in the 10 to 40-percentile range, related to wet weather conditions.
- Mid-range zone: flows in the 40 to 50 percentile range, median stream flow conditions;
- Dry zone: flows in the 60 to 90-percentile range, related to dry weather flows.
- Low flow zone: flows in the 90 to 100-percentile range, related to drought conditions.

The load duration approach helps to identify the issues surrounding the impairment and to roughly differentiate between sources. Table 2 summarizes the relationship between the five hydrologic zones and potentially contributing source areas.

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

Table 2. Relationship Between Load Duration Curve Zones and Contributing Sources.

Contributing Source Area	**Duration Curve Zone**				
	High	**Moist**	**Mid-Range**	**Dry**	**Low**
Point source				M	H
Livestock direct access to streams				M	H
On-site wastewater systems	M	M-H	H	H	H
Riparian areas		H	H	M	
Stormwater: Impervious		H	H	H	
Combined sewer overflow (CSO)	H	H	H		
Stormwater: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	
Bank erosion	H	M			
Note: Potential relative importance of source area to contribute loads under given hydrologic condition (H: High; M: Medium; L: Low)					

3.2 Stream Flow Estimates

Daily stream flows are needed to apply the load duration curve. Although some flow measurements are available for the Little Vermilion River (only on those days when water quality samples were taken) continuous stream flow data are not available. To estimate stream flows for the Little Vermilion River, a surrogate stream gage, Whitley Creek near Allenville, IL (USGS 05591550) was identified. The Whitley Creek flow gage is located approximately 56 miles southwest of the Little Vermilion River watershed and drains 33.7 square miles of land use dominated by agricultural row crop. At the time this analysis was conducted continuous stream flow data were available from February 20, 1980 through September 30, 2004 in the USGS National Water Information System (NWIS) online database. The USGS and the Illinois State Water Survey also made provisional stream flow data collected from October 1, 2004 through September 30, 2005 available for this study. (Provisional data are data that have not been reviewed or edited. Provisional data may be changed after review because the stage-discharge relationship may have been affected by: backwater from ice or debris such as log jams, algal and aquatic growth in the stream, sediment movement, or malfunction of recording equipment).

Stream flows were extrapolated from the Whitley Creek stream flow record by using a multiplier based upon a comparison of the two drainage areas. The drainage area downstream of Georgetown Lake to the IEPA monitoring station station BO07 is 38.5 square miles and the drainage area of the Whitley Creek flow gage is 33.7 square miles. The drainage area ratio therefore equals 1.142 and the daily stream flows for Whitley Creek were multiplied by 1.142 to estimate the daily stream flows at the Little Vermilion River monitoring site. Additional constant flows were added to account for the discharges from Georgetown Lake and from the Georgetown Sewage Treatment Plant (STP). A comparison between the estimated daily mean stream flows and the observed instantaneous stream flow measurements made during the water quality sampling events are presented in Appendix C. The results indicate that the estimated flows are very similar to the observed instaneous flows with several exceptions where the estimated flows are too low. These exceptions could result from storm events that occurred in the Little Vermilion watershed but not the Whitley Creek watershed, or an underestimate of the flows from Georgetown Lake or the Georgetown STP.

4.0 TMDL

This section of the report presents the various components of the TMDL, as required by the Clean Water Act.

4.1 Loading Capacity

A TMDL must identify the loading capacity of a waterbody for the applicable pollutant. USEPA regulations define loading capacity as the greatest amount of a pollutant that a water can receive without violating water quality standards. The loading capacity is often referred to as the “allowable” load.

A total of 215 fecal coliform samples collected between March 7, 1980 and August 3, 2005 are available at station BO07 located on the Little Vermilion River[2] (Appendix D). As shown in Figure 2, station BO07 is located approximately 0.4 miles downstream of the confluence with the Yankee Branch of the Little Vermilion River on the impaired segment BO07. A total of 205 fecal coliform samples were collected at this station from March 7, 1980 to October 28, 2004. Ten additional samples were collected at the station between May 19, 2005 and August 3, 2005 as part of Stage Two of the TMDL study. Table 3 summarizes the period of record, number of observations, and geometric mean, minimum and maximum values for each sampling time period, and also presents descriptive statistics for the entire data set. The data are shown graphically in Figure 3.

Figure 3 illustrates that there are no apparent trends in the fecal coliform counts over time. Furthermore, a load duration analysis completed using only the data after January 1, 2000 (Appendix E) results in load reductions that are similar to that conducted using all the data. Based on this finding, and to take advantage of as many data as possible, the TMDL was developed using all of the data between March 7, 1980 and August 3, 2005.

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[2] Several additional samples from the 1960s and 1970s are available but were excluded from this analysis because there was no corresponding flow data at the surrogate flow gaging station.

It should also be noted that ten fecal coliform samples from 2005 are available for an upstream monitoring site (station BO06 – see Figure 2) and the fecal coliform counts observed at this location are similar but somewhat lower than those observed during 2005 at the downstream station BO07. This suggests that there are additional sources of fecal coliform downstream of station BO06.

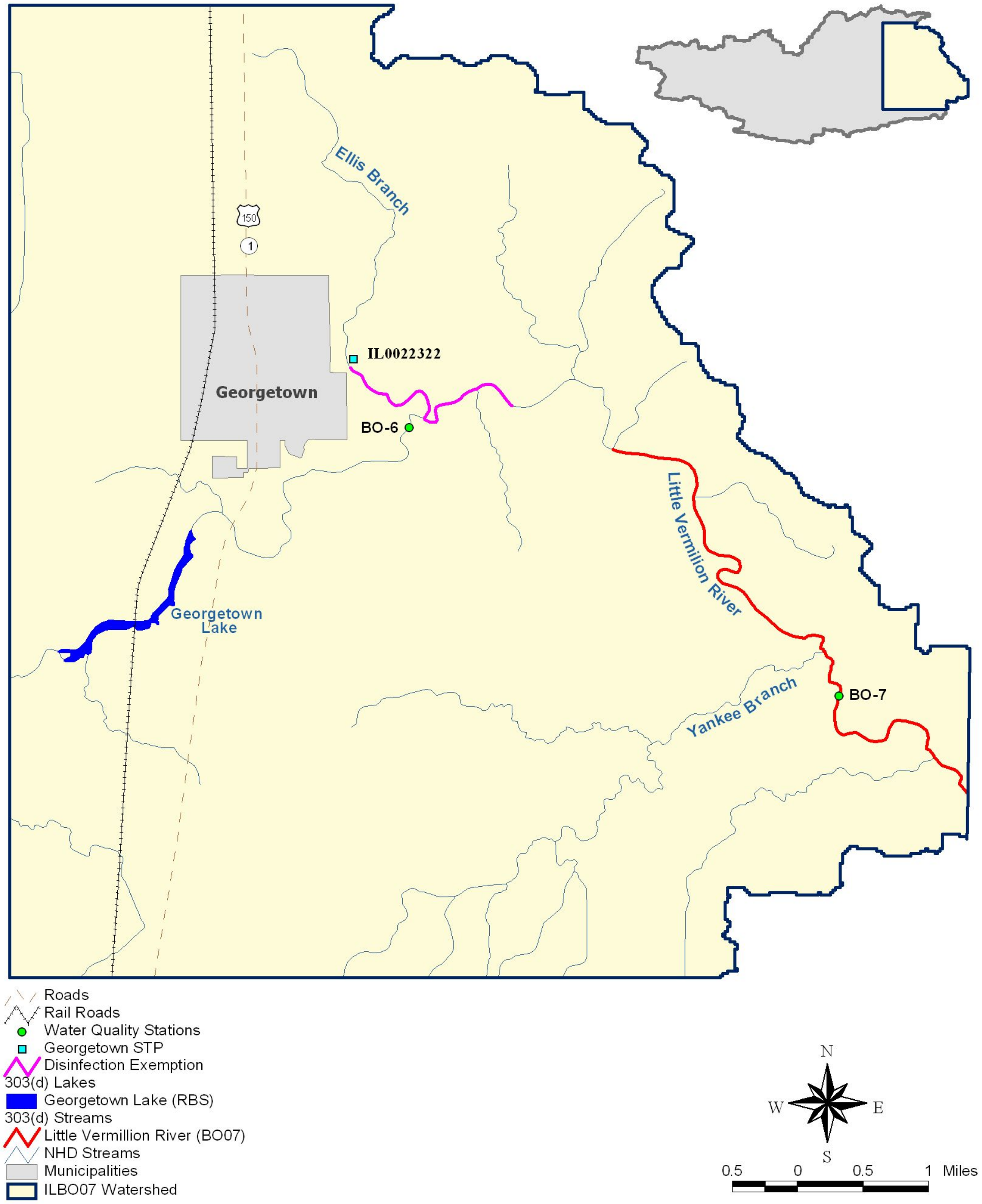

Figure 2. Location of IEPA monitoring sites BO06 and BO07, segment BO07, and the City of Georgetown's disinfection exemption.

Table 3. Summary of Available Fecal Coliform Data for Station BO07.

Period of Record	Count	Geometric Mean (cfu/100 mL)	Min (cfu/100 mL)	Max (cfu/100 mL)
3-07-1980 to 10-28-2004	215	377	2	140,000
5-19-2005 to 6-14-2005	5	315	160	640
7-6-2005 to 8-03-2005	5	263	230	330
3-07-1980 to 8-03-2005	225	372	2	140,000

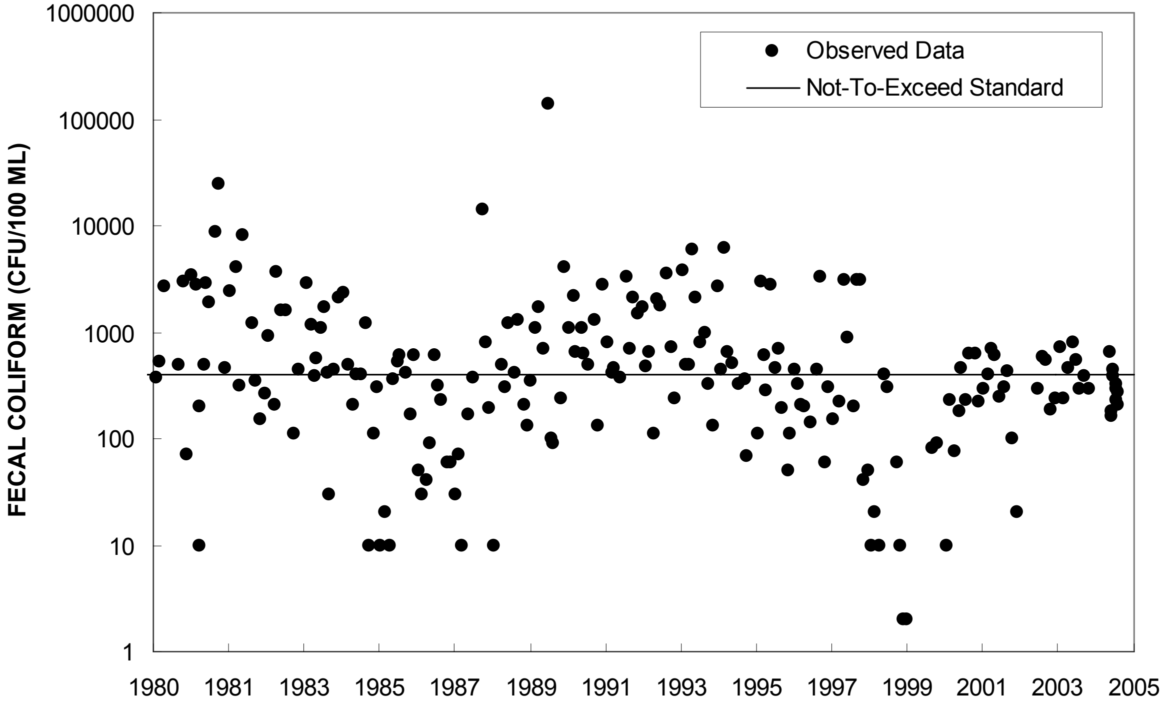

Figure 3. Available Fecal Coliform Data for Station BO07 (January 1, 1980 to December 31, 2005).

Table 4. Summary of Fecal Coliform Data Sampled at Station BO06.

Period of Record	Count	Geometric Mean (cfu/100 mL)	Min (cfu/100 mL)	Max (cfu/100 mL)
5-19-2005 to 6-14-2005	5	182	100	290
7-6-2005 to 8-03-2005	5	253	120	490

To be consistent with the seasonal Illinois water quality bacteria standard, only fecal coliform data collected during the months of May through October were used in the load duration analysis. This subset of the fecal coliform data consists of 116 samples and is summarized in Table 5. Figure 4 presents the number of observations for each of the duration curve hydrologic zones used in the load duration analysis and illustrates that the data are well distributed across all hydrologic flow zones.

Table 5. Summary of Fecal Coliform Data Used at Load Duration Site BO07.

Period of Record	Count	Geometric Mean (cfu/100 mL)	Min (cfu/100 mL)	Max (cfu/100 mL)
9-05-1980 to 8-03-2005	116	473	10	140,000

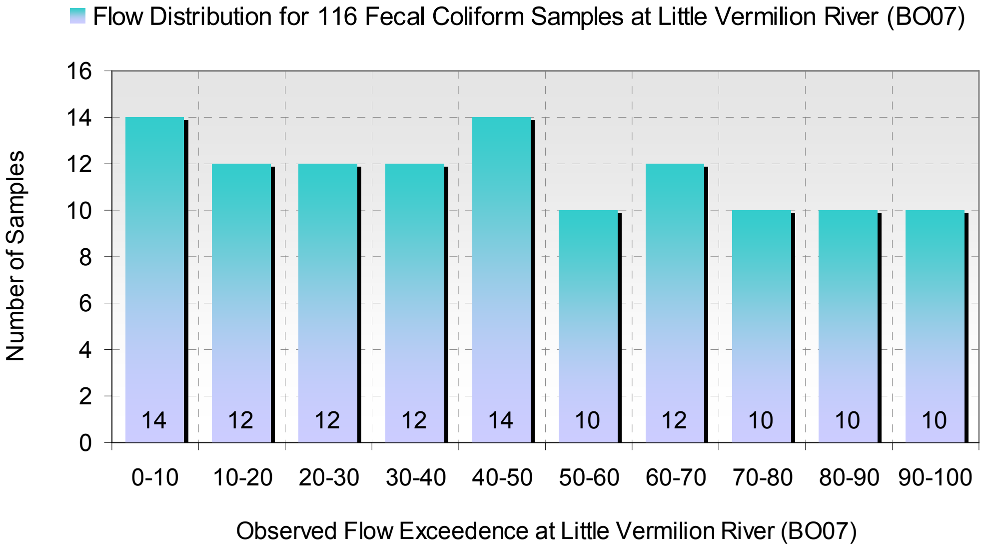

Figure 4. Summary of flow and fecal coliform sample distribution at load duration site BO07.

Figure 5 presents the results of the load duration analysis and indicates that fecal coliform observations exceed the loading limit most frequently at very high and very low flows. Sources of fecal coliform during wet periods likely include the washoff of fecal matter from land surfaces in the watershed, loads from the Georgetown combined sewer overflow (CSO), and the re-suspension of fecal material stored in the stream sediment. Sources during dry conditions likely include a persistent source such as the Georgetown Sewage Treatment Plant, failing onsite wastewater systems, onsite wastewater systems directly connected to agricultural tile drains, or livestock with direct access to the stream. No confined animal feeding operations or Municipal Separate Storm Sewer Systems (MS4s) are located in the watershed. The most significant of the nonpoint sources of fecal coliform will be determined when the implementation plan is developed and best management practices will be identified.

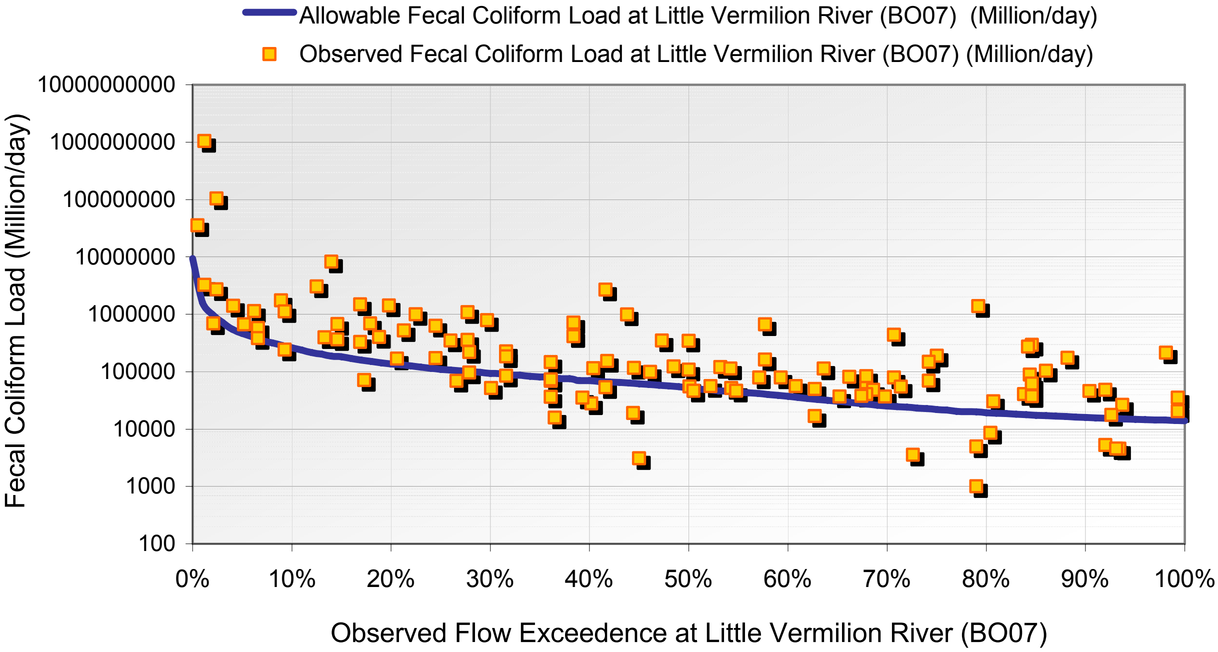

Figure 5. Existing fecal coliform loading and loading capacity for load duration site BO07. Loading capacity calculated based on geometric mean standard of 200 cfu/100 mL.

The calculated allowable and existing loads displayed in Figure 5 were grouped based on hydrologic zones and are summarized in Table 6. The existing loads exceed the allowable loads during high flow, moist, and dry conditions.

Table 6. Fecal Coliform TMDL Summary for the Little Vermilion River.

Zone	Flow Exceedence Ranges	115-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Existing Load (Million/day)	Outfall 001 WLA (Million/day)	Outfall 002 WLA (CSO) (million/day)	LA (million/day)
High Flows	0-10	14	95.32	466,425	1,268,502	11,355	18,168	436,902
Moist Conditions	10-20	12	37.08	181,438	536,326	11,355	0	170,083
	20-30	12	22.23	108,794	352,102	11,355	0	97,439
	30-40	12	16.52	80,854	78,949	11,355	0	69,499
Mid-Range Flows	40-50	14	12.55	61,397	115,274	11,355	0	50,042
	50-60	10	8.99	43,974	79,010	11,355	0	32,619
Dry Conditions	60-70	12	6.25	30,563	49,003	11,355	0	19,208
	70-80	10	4.49	21,969	74,013	11,355	0	10,614
	80-90	10	3.56	17,431	75,062	11,355	0	6,076
Low Flows	90-100	10	3.02	14,791	23,446	11,355	0	3,436

Table 7. Load reductions needed for Little Vermilion River Fecal Coliform TMDL.

		Existing Loads			TMDL Loads			Percent Reductions		
Zone	Flow Exceedence Ranges	Outfall 001 (million/day)	Outfall 002 (CSO) (million/day)	Nonpoint Sources (million/day)	Outfall 001 (million/day)	Outfall 002 (CSO) (million/day)	Nonpoint Sources (million/day)	Outfall 001 (%)	Outfall 002 (CSO) (%)	Nonpoint Sources (%)
High Flows	0-10	Unknown	172,596	1,073,196	11,355	18,168	436,902	Unknown	-89%	-60%
Moist Conditions	10-20	Unknown	0	513,616	11,355	0	170,083	Unknown	0%	-68%
	20-30	Unknown	0	329,392	11,355	0	97,439	Unknown	0%	-71%
	30-40	Unknown	0	56,239	11,355	0	69,499	Unknown	0%	0%
Mid-Range Flows	40-50	Unknown	0	92,564	11,355	0	50,042	Unknown	0%	-52%
	50-60	Unknown	0	56,300	11,355	0	32,619	Unknown	0%	-52%
Dry Conditions	60-70	Unknown	0	26,293	11,355	0	19,208	Unknown	0%	-49%
	70-80	Unknown	0	51,303	11,355	0	10,614	Unknown	0%	-83%
	80-90	Unknown	0	52,352	11,355	0	6,076	Unknown	0%	-90%
Low Flows	90-100	Unknown	0	736	11,355	0	3,436	Unknown	0%	-72%

4.2 Allocations

The allocations of loads to point sources (WLA) and nonpoint sources (LA) are presented in Table 6. The allocations are presented in terms of a maximum daily load for each flow category and apply to each of the 184 days from May 1 to October 31 (to be consistent with the water quality standards). The existing loads, allowable loads, and necessary percent reductions by source category are presented in Table 7 and further discussed below.

4.2.1 Georgetown Sewage Treatment Plant (STP) Outfalls 001 and 002

The only NPDES permitted facility that discharges to the Little Vermilion River downstream of Georgetown Lake is the wastewater treatment facility operated by the City of Georgetown (NPDES ID IL0022322). The design average flow for the facility is 0.6 million gallons per day (MGD) and the design maximum flow for the facility's main outfall (001) is 1.5 MGD. Treatment consists of screening, grit removal, CSO sedimentation and chlorination, primary clarification, trickling filtration, packed bed reactor, final clarification, intermittent sand filtration, anaerobic digestion, drying beds, and land application of sludge. Because the receiving stream (Ellis Branch) has been determined to be unsuited to support primary contact activities (swimming) due to physical, hydrologic or geographic configuration, the facility has a disinfection exemption that allows the discharge of treated wastewater from its wastewater treatment plant without first disinfecting the treated effluent. The extent of the disinfection exemption is shown in Figure 2. Because of the disinfection exemption, no fecal coliform limit applies to Outfall 001 and the city does not routinely monitor fecal coliform from this outfall. Recent sampling performed in support of this TMDL suggests that average fecal coliform counts fluctuate considerably and are occasionally well above water quality standards as shown in Table 8. The City of Georgetown also has a CSO outfall (Outfall 002) and is required to treat and monitor fecal coliform from this outfall.

Table 8. Fecal coliform counts from City of Georgetown Outfalls 001 and 002.

Date	Outfall 001		Outfall 002 Total Fecal Coliform (cfu/100ml)
	Total Fecal Coliform (cfu/100ml)	MGD	
5/9/2006	66	0.939	
5/17/2006	26,000	1.191	3,600
5/24/2006	280	1.057	
6/1/2006	89,000	0.463	

Separate wasteload allocations for Outfalls 001 and 002 are presented in Table 6. The WLA for Outfall 001 is based on the design maximum flow of 1.5 MGD multiplied by the geometric mean water quality standard of 200 cfu/100 mL and applies for each day in the recreation season. The reductions needed from this outfall are unknown due to the lack of historic data (i.e., existing loads are unknown). However, based on the limited data shown in Table 8, it appears that reductions are needed. The analysis conducted for this TMDL suggests that loads from Outfall 001 might represent a considerable proportion of the allowable downstream loads during low flow conditions. For example, at the observed discharge count of 89,000 cfu/100 mL water quality standards at monitoring site BO07 would be exceeded even assuming that more than 95 percent of the fecal coliform dies off.

The WLA for the CSO (Outfall 002) is based on the historic average flow of approximately 1.2 MGD for overflows that occur during the recreation season multiplied by the permit limit of 400 cfu/100 mL (see Appendix F for more information on reported overflow events). The WLA for the CSO only applies to the high flow zone because the CSO is assumed to only discharge during these very wet periods.

Approximately a 90 percent reduction in loads is needed from the CSO to meet water quality standards because monitoring data suggest CSO effluent averages approximately 3,800 cfu/100 mL for overflows that occur during the recreation season (Table 8 and Appendix F).

4.2.2 Margin of Safety

The Clean Water Act requires that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality. USEPA guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS). An implicit MOS has been applied as part of this TMDL by comparing individual samples to the geometric mean component of the standard to determine the needed load reductions. This is considered conservative because the geometric mean component of the standard is intended to be used when five samples in a 30 day period are available (i.e., taking the geometric mean of five samples will "dampen" the effect of high values).

An additional implicit margin of safety is also included in this TMDL because no die-off of fecal coliform is assumed for the loads from Outfalls 001 and 002 (i.e., the entire load is assumed to be transported downstream to the assessment monitoring station at BO-07). In reality, significant die-off of the fecal coliform would occur, perhaps as high as 70 or 80 percent.

4.2.3 Nonpoint Sources

Allocations to nonpoint sources are based on subtracting the allocations for WLAs from the allowable load. Fairly significant reductions are needed during high flows and dry conditions. The specific nonpoint sources of fecal coliform (e.g., agricultural runoff, wildlife) will be further explored when the implementation plan is developed.

4.3 Critical Conditions and Seasonality

The Clean Water Act requires that TMDLs take into account critical conditions for stream flow, loading, and water quality parameters as part of the analysis of loading capacity. Through the load duration curve approach it has been determined that load reductions are needed for specific flow conditions; however, the critical conditions (the periods when the greatest reductions are required) occur during dry conditions. Both point and nonpoint sources are believed to contribute to loads during these critical periods and the specific sources will be further evaluated during the preparation of an implementation plan. The allocation of point source loads (i.e., the WLA) also takes into account critical conditions by assuming the Georgetown Sewage Treatment Plant will always discharge at the facility's maximum design flow of 1.5 MGD. In reality, the discharge volume is usually much less.

The Clean Water Act also requires that TMDLs be established with consideration of seasonal variations. Seasonal variations are addressed in this TMDL by only assessing conditions during the season when the water quality standard applies (May through October). The load duration approach also accounts for seasonality by evaluating allowable loads on a daily basis over the entire range of observed flows and presenting daily allowable loads that vary by flow.

5.0 REFERENCES

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Illinois EPA, 2005. TMDL Development for Georgetown Lake in the Little Vermilion River Watershed. Final Report. April 8, 2005. Available at: http://www.epa.state.il.us/water/tmdl/report-status.html

Appendix A: Load Duration Analyses with Fecal Coliform Criteria of 400 cfu/100 mL

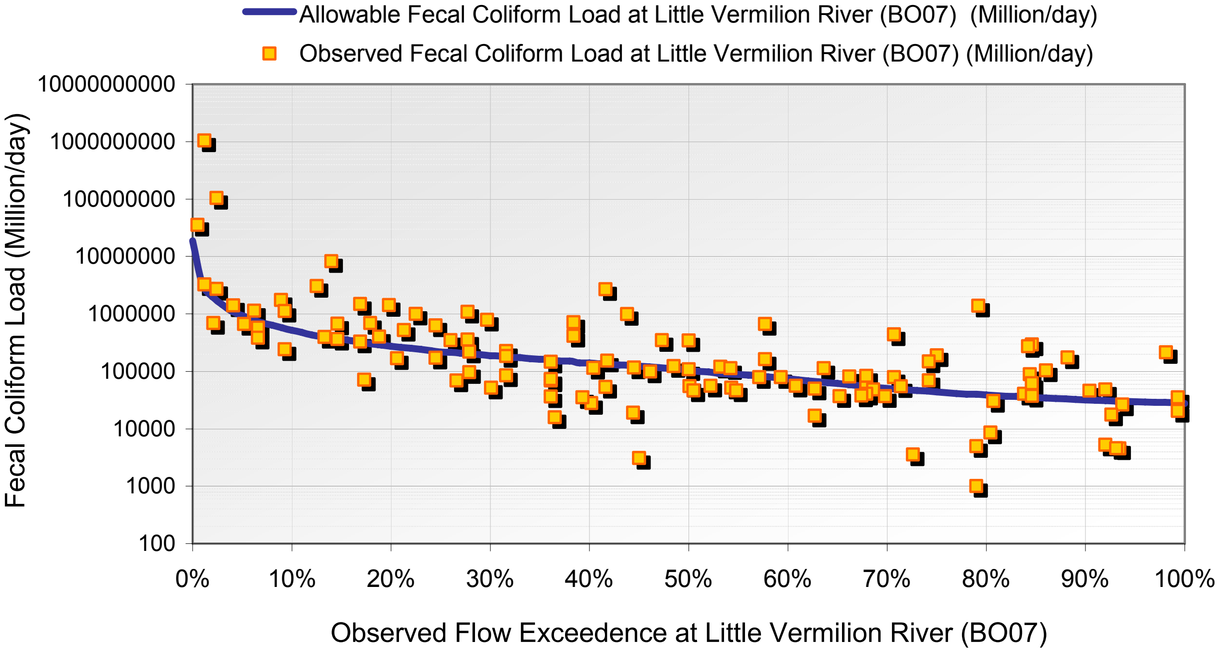


Figure A-1. Existing fecal coliform loading and loading capacity for BO07 using 400 cfu/100 mL.

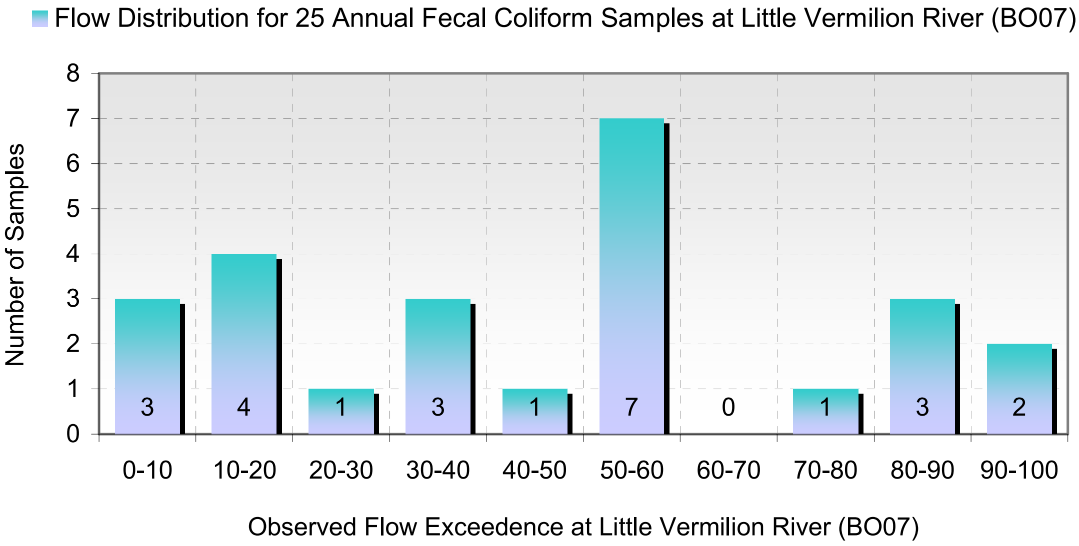
Table A-1. Fecal Coliform reductions using 400 cfu/100 mL.

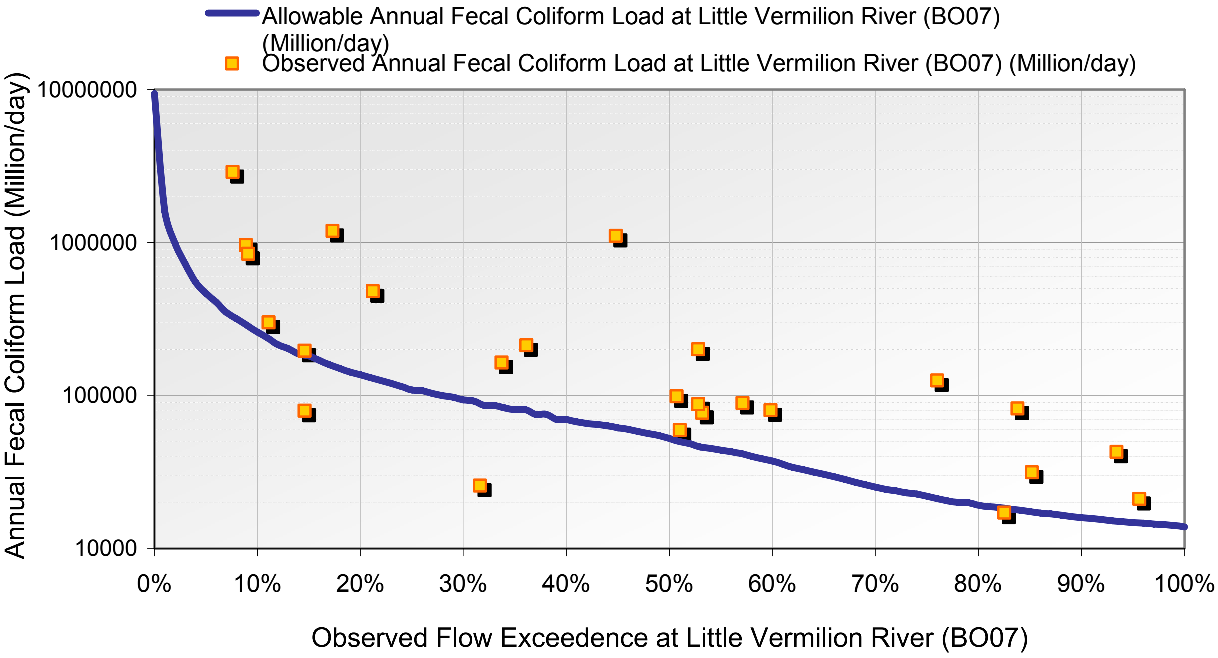
Flow Exceedence Ranges	116-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
0-10	14	95.32	932,850	1,268,502	26.46%
10-20	12	37.08	362,876	536,326	32.34%
20-30	12	22.23	217,589	352,102	38.20%
30-40	12	16.52	161,709	78,949	0.00%
40-50	14	12.55	122,795	115,274	0.00%
50-60	10	8.99	87,948	79,010	0.00%
60-70	12	6.25	61,125	49,003	0.00%
70-80	10	4.49	43,939	74,013	40.63%
80-90	10	3.56	34,862	75,062	53.56%
90-100	10	3.02	29,581	23,446	0.00%

Appendix B: Load Duration Analysis Using Annual Geometric Mean

An annual geomean was calculated for each of the 25 years where fecal coliform were collected. Flows were based on July 1st flows each year and used to develop a load duration curves using the 200 cfu/100 mL geometric mean standard. The results are presented below and indicate that the level of exceedances and the estimated reductions are similar to the analyses made for the TMDL.

1. Annual Load Duration Analyses with Fecal Coliform Criteria of 200-cfu/100 mL





Flow Exceedence Ranges	25-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
0-10	3	95.32	466,425	960,892	51.5%
10-20	4	37.08	181,438	248,186	26.9%
20-30	1	22.23	108,794	479,305	77.3%
30-40	3	16.52	80,854	163,846	50.7%
40-50	1	12.55	61,397	1,104,343	94.4%
50-60	7	8.99	43,974	87,690	49.9%
60-70	0	6.25	30,563	No Data	No Data
70-80	1	4.49	21,969	125,133	82.4%
80-90	3	3.56	17,431	31,550	44.8%
90-100	2	3.02	14,791	32,000	53.8%

Appendix C. Comparison of Estimated Stream Flows and Stream Flows Measured by IEPA

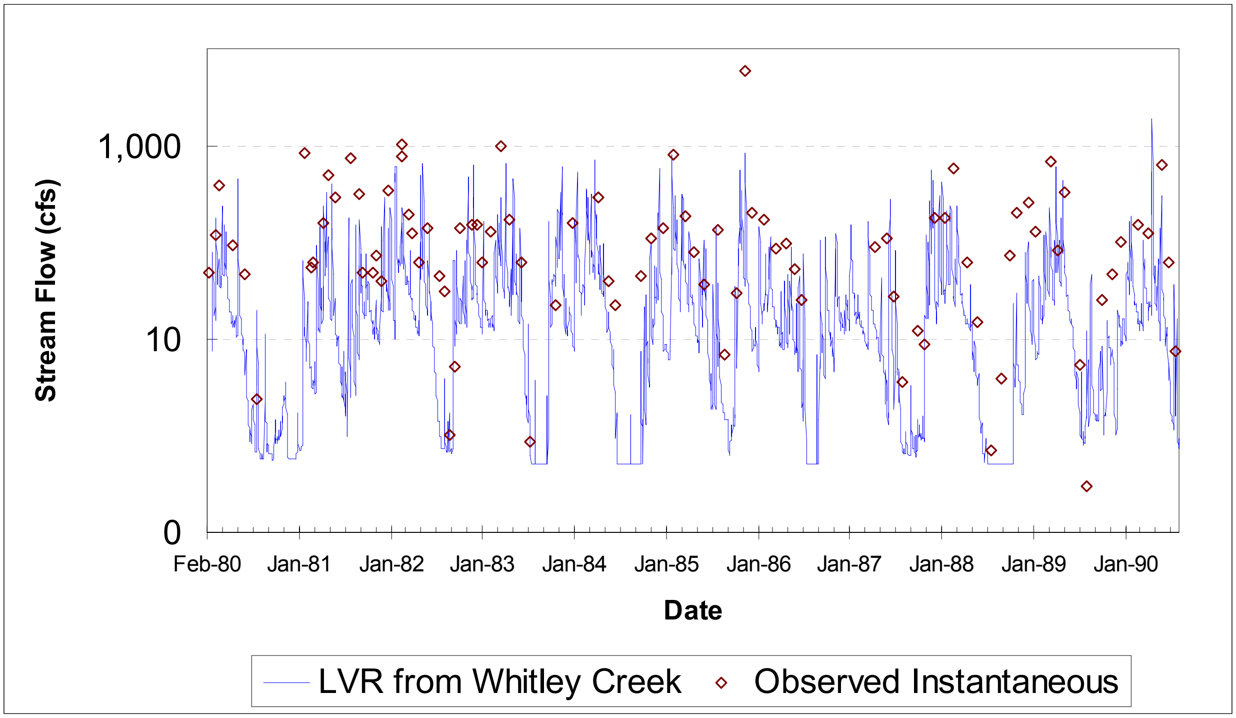


Figure C-1. Comparison of stream flow estimates for Little Vermilion Creek and observed instantaneous flow values.

Appendix D: Available Fecal Coliform Data for Little Vermilion River Segment BO-07

Date	Fecal Coliform at Station BO-07 (cfu/100 mL)
8/31/1966	320
11/30/1978	650
2/27/1979	220
3/20/1979	1600
4/3/1979	370
6/7/1979	900
7/3/1979	310
7/26/1979	60000
9/10/1979	1400
11/8/1979	100
12/7/1979	1370
2/7/1980	378
3/7/1980	530
4/15/1980	2700
9/5/1980	500
10/17/1980	3000
11/25/1980	70
12/31/1980	3400
2/19/1981	2800
3/24/1981	10
3/31/1981	200
5/5/1981	490
5/28/1981	2900
6/25/1981	1900
8/27/1981	8600
9/30/1981	25000
12/2/1981	460
1/19/1982	2400
3/17/1982	4000
4/14/1982	310
5/20/1982	8000
8/11/1982	1200
9/23/1982	350
11/4/1982	150
12/21/1982	260
1/27/1983	930
3/16/1983	210
4/14/1983	3700
5/18/1983	1600
7/7/1983	1600
9/27/1983	110
11/15/1983	440

Date	Fecal Coliform at Station BO-07 (cfu/100 mL)
1/26/1984	2900
3/7/1984	1180
4/11/1984	390
5/2/1984	560
6/13/1984	1100
7/11/1984	1700
8/16/1984	410
9/5/1984	30
10/24/1984	450
11/29/1984	2100
1/17/1985	2300
2/28/1985	500
4/16/1985	210
5/21/1985	400
7/2/1985	400
8/20/1985	1200
9/17/1985	10
11/7/1985	110
12/12/1985	300
1/9/1986	10
2/19/1986	20
4/9/1986	10
5/20/1986	360
6/25/1986	520
7/21/1986	600
9/11/1986	410
10/28/1986	170
12/3/1986	600
1/14/1987	50
2/18/1987	30
4/7/1987	40
5/7/1987	90
6/25/1987	610
7/21/1987	310
8/25/1987	230
10/27/1987	60
11/24/1987	60
1/5/1988	30
2/11/1988	70
3/14/1988	10
5/12/1988	170
6/21/1988	370
9/21/1988	13900

Date	Fecal Coliform at Station BO-07 (cfu/100 mL)
10/25/1988	800
11/23/1988	190
1/11/1989	10
4/5/1989	500
5/4/1989	300
5/31/1989	1190
8/1/1989	420
8/31/1989	1300
10/31/1989	210
12/6/1989	130
1/9/1990	350
2/23/1990	1100
3/21/1990	1700
5/3/1990	690
6/20/1990	140000
7/18/1990	100
8/16/1990	90
10/25/1990	240
11/28/1990	4000
1/3/1991	1100
2/21/1991	2200
3/20/1991	640
5/7/1991	1100
6/5/1991	630
7/17/1991	500
9/11/1991	1300
10/22/1991	130
12/4/1991	2800
1/15/1992	800
2/26/1992	410
3/25/1992	460
5/19/1992	370
7/22/1992	3300
8/27/1992	700
9/24/1992	2100
11/4/1992	1500
12/17/1992	1700
1/27/1993	470
2/24/1993	640
4/7/1993	110
5/18/1993	2000
6/10/1993	1800
8/12/1993	3500

Date	Fecal Coliform at Station BO-07 (cfu/100 mL)
9/22/1993	720
11/1/1993	240
1/12/1994	3800
2/16/1994	490
3/15/1994	500
4/12/1994	6000
5/23/1994	2100
7/5/1994	800
8/23/1994	1000
9/13/1994	320
11/3/1994	130
12/20/1994	2700
1/18/1995	440
2/16/1995	6100
3/21/1995	660
5/10/1995	510
7/18/1995	330
9/8/1995	360
9/22/1995	68
1/9/1996	110
2/6/1996	3000
3/7/1996	600
3/27/1996	280
5/9/1996	2800
6/26/1996	460
8/5/1996	700
8/28/1996	190
10/28/1996	50
11/19/1996	110
1/7/1997	440
2/5/1997	320
3/11/1997	210
4/8/1997	200
6/13/1997	140
8/4/1997	450
9/11/1997	3300
10/30/1997	60
11/19/1997	300
1/6/1998	150
3/12/1998	220
4/30/1998	3100
6/5/1998	900
8/5/1998	200

Date	Fecal Coliform at Station BO-07 (cfu/100 mL)
8/25/1998	3100
9/23/1998	3100
10/27/1998	40
12/10/1998	50
1/21/1999	10
2/22/1999	20
3/30/1999	10
5/17/1999	400
6/22/1999	300
9/14/1999	60
10/19/1999	10
11/15/1999	2
12/20/1999	2
8/24/2000	80
10/17/2000	90
1/10/2001	10
2/13/2001	230
3/29/2001	75
5/15/2001	180
6/7/2001	460
7/18/2001	230
8/20/2001	620
10/17/2001	630
11/27/2001	220
1/7/2002	295
2/25/2002	395
3/21/2002	700
4/25/2002	600
6/3/2002	245
7/22/2002	300
8/28/2002	430
10/10/2002	100
11/19/2002	20
6/17/2003	290
7/29/2003	580
9/8/2003	550
10/20/2003	185
12/8/2003	235
1/15/2004	720
2/25/2004	240
4/1/2004	460
5/26/2004	800
6/21/2004	540

Date	Fecal Coliform at Station BO-07 (cfu/100 mL)
7/22/2004	290
9/1/2004	390
10/28/2004	295
05/19/05	640
05/24/05	160
06/01/05	180
06/09/05	380
06/14/05	440
07/06/05	290
07/14/05	330
07/20/05	230
07/28/05	210
08/03/05	270

Appendix E: Load Duration Analysis Using Only Data After January 1, 2000

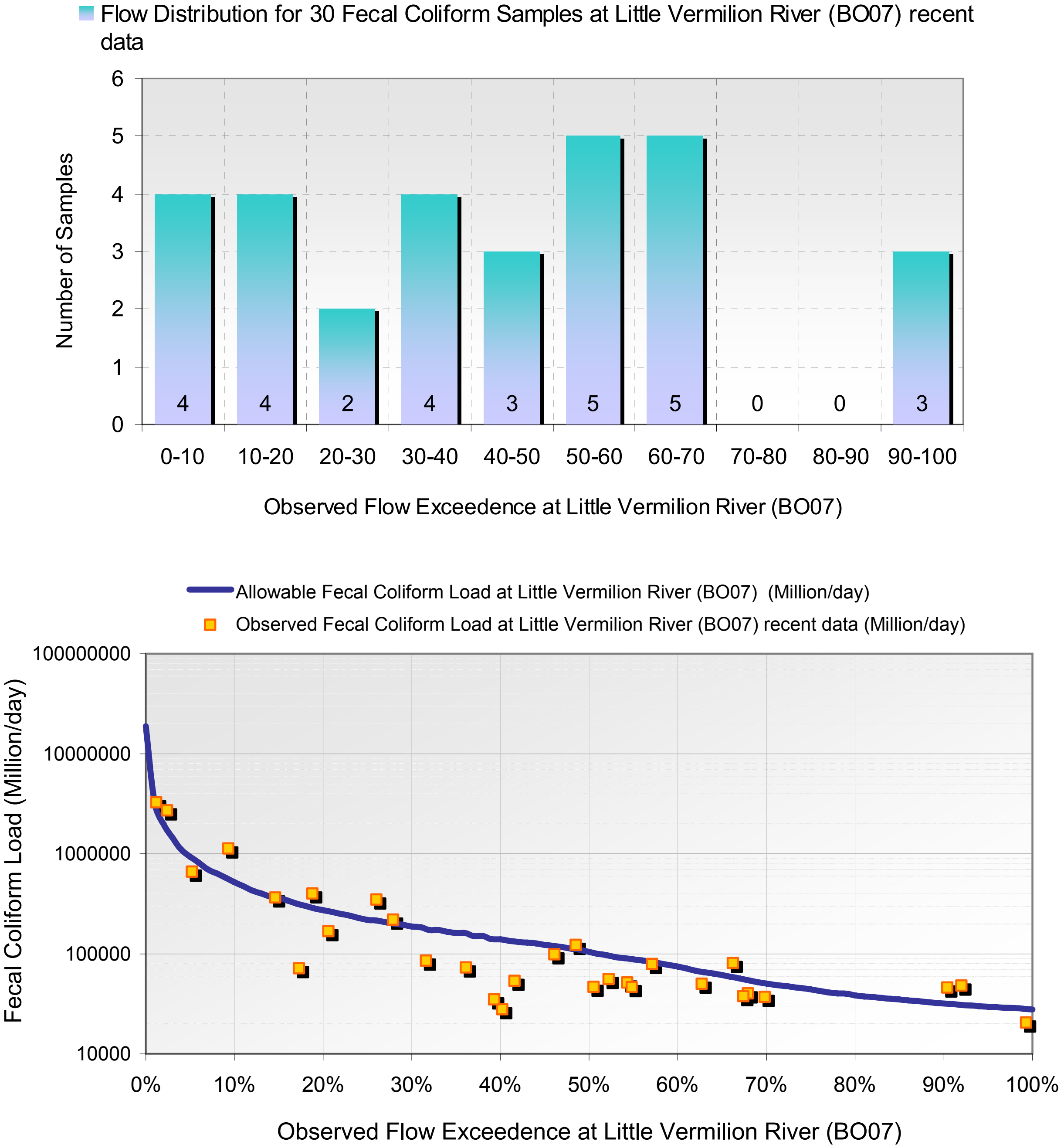


Figure E-1. Existing fecal coliform loading and loading capacity for BO07 using 400 cfu/100 mL and only data collected after January 1, 2000.

Table E-1. Existing fecal coliform loading and loading capacity for BO07 using 200 cfu/100 mL and only data collected after January 1, 1996.

Flow Exceedence Ranges	30-Sample Distribution	Median Observed Flow (cfs)	Allowable Load (Million/day)	Observed Load (Million/day)	Estimated Reduction (%)
0-10	4	95.32	932,850	1,914,737	51.3%
10-20	4	37.08	362,876	266,100	0.0%
20-30	2	22.23	217,589	283,589	23.3%
30-40	4	16.52	161,709	53,891	0.0%
40-50	3	12.55	122,795	98,762	0.0%
50-60	5	8.99	87,948	51,548	0.0%
60-70	5	6.25	61,125	40,265	0.0%
70-80	0	4.49	43,939	No Data	No Data
80-90	0	3.56	34,862	No Data	No Data
90-100	3	3.02	29,581	46,012	35.7%

Appendix F: Georgetown CSO Data

Table F-1. Flow and fecal coliform data available for Georgetown CSO Outfall 002. Note that total overflow volumes are reported for an entire month and the duration of the overflow(s) (e.g., 10 hours) are not available. For the purposes of estimating existing loads in the TMDL, it was assumed that each month's overflow volume occurred within a 24-hour period.

Month	Overflow Flow (million gallons)	Overflow Count (cfu/100 mL)	Rec Season
June-96	0.184	150000	Yes
July-96	0.581	59000	Yes
August-96			Yes
September-96			Yes
October-96			Yes
November-96			No
December-96			No
January-97	0.2	800	No
February-97	0.28	25000	No
March-97	0.28	570	No
April-97			Yes
May-97			Yes
June-97			Yes
July-97			Yes
August-97			Yes
September-97			Yes
October-97			Yes
November-97			No
December-97	0.28	1600	No
January-98	0.28	390	No
February-98			No
March-98	7.2	4600	No
April-98	0.644	3800	Yes
May-98	19.953	19000	Yes
June-98	6.312	3300	Yes
July-98	4.714	2100	Yes
August-98			Yes
September-98			Yes
October-98			Yes
November-98			No
December-98			No
January-99	4.481	4400	No
February-99	9.089	1000	No
March-99	1.426	230	No
April-99			Yes
May-99			Yes
June-99	1.557	3800	Yes
July-99	1.528	90	Yes
August-99			Yes
September-99			Yes
October-99			Yes
November-99			No
December-99			No
January-00			No
February-00			No
March-00			No
April-00			Yes
May-00			Yes
June-00	1.116	250	Yes
July-00	0.974	300	Yes
August-00			Yes
September-00			Yes

Month	Overflow Flow (million gallons)	Overflow Count (cfu/100 mL)	Rec Season
October-00			Yes
November-00			No
December-00			No
January-01			No
February-01	5.188	20	No
March-01	1.044	0	No
April-01			Yes
May-01			Yes
June-01			Yes
July-01			Yes
August-01			Yes
September-01			Yes
October-01	4.253	10	Yes
November-01			No
December-01			No
January-02			No
February-02	3.28	0	No
March-02			No
April-02	14.04	2200	Yes
May-02	13.44	600	Yes
June-02	2.8	60	Yes
July-02			Yes
August-02			Yes
September-02			Yes
October-02			Yes
November-02			No
December-02			No
January-03			No
February-03			No
March-03			No
April-03			Yes
May-03			Yes
June-03			Yes
July-03			Yes
August-03			Yes
September-03	0.9	8000	Yes
October-03			Yes
November-03	1.8	11000	No
December-03	1.35	60	No
January-04	3.6	5600	No
February-04			No
March-04	4.05	1400	No
April-04	0.45	340	Yes
May-04	0.45	600	Yes
June-04	1.35	3000	Yes
July-04			Yes
August-04			Yes
September-04			Yes
October-04			Yes
November-04	1.35	35000	No
December-04	2.7	1300	No
January-05	6.75	1600	No
February-05	2.7	1000	No
March-05			No
April-05			Yes
May-05			Yes
July-05			Yes

Month	Overflow Flow (million gallons)	Overflow Count (cfu/100 mL)	Rec Season
August-05			Yes
September-05			Yes
October-05			Yes
November-05			No
December-05			No

Appendix G: Responsiveness Summary

Responsiveness Summary

This responsiveness summary responds to substantive questions and comments received during the public comment period from July 14, 2006 through August 23, 2006 postmarked, including those from the August 9, 2006 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 Little Vermilion River Stage 3 TMDL report details the necessary reduction in pollutant loads to the impaired water bodies to 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 the Little Vermilion River, which is in Vermilion County. The watershed encompasses an area of approximately 200 square miles. Land use in the watershed is predominately agriculture. Little Vermilion River segment BO-07 is 5.11 miles in length and is on the *Illinois Integrated Water Quality Report and Section 303(d) List-2006* as being impaired for total fecal coliform. 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. The Illinois EPA contracted with Tetra Tech, Inc., to prepare a TMDL report for the Little Vermilion River watershed.

Public Meetings

Public meetings were held in the Village of Georgetown on March 9, 2005, and August 9, 2006. The Illinois EPA provided public notice for both meetings by placing display ads in the Danville Commercial News. 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 125 individuals and organizations were also sent the public notice by first class mail. The draft TMDL Report was available for review on the Agency's web page at http://www.epa.state.il.us/public-notices . Hardcopies were available upon request.

The Stage 3 public meeting started at 6:00 p.m. on Wednesday, August 9, 2006. It was attended by approximately 11 people and concluded at 7:45 p.m. with the meeting record remaining open until midnight, August 23, 2006.

Questions and Comments

1. Is there an active watershed group in this watershed?

   Response: A Vermilion River Ecosystem Partnership group exists that could include the Little Vermilion River watershed.

2. Will the Georgetown STP be required to begin disinfecting their effluent as a result of this TMDL? It seems that the plant would be a major contributor of fecal coliform to this stream segment.

   Response: When the City of Georgetown's NPDES permit is revised, the Agency will require the City to examine and further evaluate their disinfection exemption. The City will have to comply with the wasteload allocation (WLA) at the end of the stream reach that is not protected for whole body contact (Primary Contact use). If the City cannot meet the WLA at this point under all flow regimes, then they would have to begin disinfecting their effluent.

3. I don't think livestock in this watershed is a major cause of fecal coliform, since there isn't that much livestock present in the watershed near segment BO07. Instead, the major source is septic systems, many of which discharge directly to streams or field tile.

   Response: Thank you for your comment. The implementation plan for this watershed will provide recommendations about methods that could be employed to reduce fecal coliform, and ways to prioritize each source.

4. Was water quality sampling done above and below Lake Georgetown? There are towns upstream of the lake that are unsewered. Many of those septics may be old and failing.

   Response: IEPA is not aware of any total fecal coliform samples that have been collected immediately above and below the lake. The Stage 3 draft TMDL report includes total fecal coliform data taken at IEPA station BO-06, which is several miles downstream of Lake Georgetown.

5. The Vermilion County Health Department notes that it is difficult to prove a rural resident's septic is failing or that it is connected directly to a field tile. The health department inspects new septic systems when they are installed, but cannot force a homeowner to install a new system unless it is proven that the current system is failing.

   Response: Thank you for your comment.

6. The Vermilion County Health Department states that most rural residents have sub-surface leach fields, with some aeration systems. The department maintains records of all septic systems that have been installed since the early 1970s. This includes about 8,000 for Vermilion County.

   Response: Thank you for your comment.

7. There is interest in Vermilion County, Indiana with respect to the Little Vermilion River watershed that enters into Indiana. A coalition is being formed with the goal of obtaining tax money to form a sanitary district to get grants for unsewered communities to install sewer collection and treatment systems.

   Response: Thank you for your comment.

8. It seems there needs to be a combination of education and financial incentives for septic owners to install and maintain proper systems. The Agency is also interested in this goal and can provide additional information and direction in the implementation plan.

   Response: Thank you for your comment.

9. Is there a chance that fecal coliform loads in the stream can contaminate well water?

   Response: It is not likely that fecal coliform bacteria would enter an aquifer from a small stream and impact a private well. Generally groundwater flows from the aquifer into the stream.

10. What is the lab cost for performing total fecal coliform samples?

    Response: While costs can vary, private labs charge approximately $30 per fecal sample analysis.

11. More sampling needs to be performed along Little Vermilion River, as well as Ellis Branch upstream of the STP discharge.

    Response: We agree. Further monitoring of Little Vermilion River as well as its tributaries will give local stakeholders a better idea as to the sources of fecal coliform, as well as the ability to track the effectiveness of implementation.

12. We are very concerned about this TMDL being able to achieve the desired reduction of loads given the lack of specific data on both point and nonpoint source of fecal coliform data. We urge you to obtain at least some data for fecal coliform sources, such as confined animal feeding operations, the Georgetown sewage treatment plant, and private sewage treatment systems.

Response: Thank you for your comment. The need for additional data and Identifying potential sources of total fecal coliform will be addressed in the implementation plan.

Georgetown Lake TMDL Implementation Plan

FINAL REPORT

March 4, 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 (IEPA) has identified Georgetown Lake in the Little Vermilion River watershed as impaired for total phosphorus. Illinois water quality standards require that total phosphorus concentrations in lakes not exceed 0.05 mg/L. Historic sampling within Georgetown Lake indicates that this standard is often exceeded with the long-term concentration averaging approximately 0.09 mg/L.

Tributary flows and corresponding phosphorus concentrations are not available for the Little Vermilion River upstream of Georgetown Lake. Daily stream flow and phosphorus loading into the lake were therefore estimated from a U.S. Geological Survey (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 soy production. Furthermore, the station has water quality data available from 1980 through 1997.

The US Army Corps of Engineers BATHTUB model (Walker, 1987) was set up for Georgetown Lake based on available bathymetry data and the surrogate flows and total phosphorus loads. Inlake water quality data collected from 1992 to 2003 was used to calibrate the model. The loads estimated from the surrogate water quality station over-predicted total phosphorus concentrations in the lake and had to be reduced by 53 percent to develop a model within the parameter ranges for BATHTUB. The need for scaling down the loads may be attributed to differences between the Georgetown Lake and West Okaw River watersheds (e.g., the riparian cover present in the Georgetown Lake watershed), unaccounted for best management practices (BMPs), or other unknown factors.

The BATHTUB model was then used to determine the load reductions necessary to meet the 0.05 mg/L water quality standard. A 60 percent load reduction is needed to meet the target during all modeled years. However, this reduction is driven by the need to reduce loads to meet the simulated total phosphorus concentration in 2002, and the BATHTUB model over-predicts the concentration for that year. Due to this concern, the model was re-run to identify the percent reduction in loads that is necessary to meet the 0.05 mg/L target as an average for the entire modeling period. The resulting reduction (46 percent) was selected for Total Maximum Daily Load (TMDL) development purposes.

Based on the findings of this implementation plan, 97percent of the phosphorus load to Georgetown Lake originates from crop production and animal operations. It is anticipated that cost-effective agricultural best management practices, such as conservation tillage, grassed waterways, nutrient management planning, controlled drainage, altered feeding strategies, and cattle exclusion from streams, can reduce loads to the levels required by the TMDL.

The Ridge Farm Sewage Treatment Plant and potential failing septic systems located throughout the watershed comprise less than two percent of the loading to Georgetown Lake. BMPs to control phosphorus loading from these sources will likely not be necessary to meet the 46 percent reduction required by the TMDL. However, repairing or replacing failing septic systems is recommended in the fecal coliform TMDL implementation plan for a downstream segment of the Little Vermillion River. The BMPs implemented to reduce fecal coliform loading from these systems will have secondary benefits of reducing phosphorus loads as well. The fecal coliform TMDL also suggest that the Ridge Farm STP disinfect its primary effluent to reduce loading. This change in process will not impact total phosphorus loads from the plant.

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1.0 INTRODUCTION

The Clean Water Act and USEPA regulations require that states develop Total Maximum Daily Loads (TMDLs) for waters identified as impaired on the Section 303(d) lists. Georgetown Lake, located in the Little Vermilion River watershed, is listed on Illinois' 2006 303(d) list as described in Table 1-1.

Table 1-1. 2006 303(d) List Information for Georgetown Lake.

Segment (Area)	Name	Designated Uses and Support Status	Causes of Impairment	Potential Sources of Impairment
RBS	Georgetown Lake	Overall Use (Not Assessed); Fish Consumption (Full); Drinking Water Supply (Not Assessed); Aquatic Life Support (Full); Primary Contact (Not Supporting); Secondary Contact (Partial)	Habitat Assessment, Total Suspended Solids, Excessive Algal Growth, Total Phosphorus	Agriculture (non-irrigated crop production, grazing related sources/ pasture land), Urban Runoff/Storm Sewers, Contaminated Sediments, Herbicide/ Algicide Application

IEPA is currently developing TMDLs for pollutants that have numeric water quality standards. Of the pollutants impairing Georgetown Lake, total phosphorus is the only parameter with a numeric water quality standard. IEPA believes that addressing the phosphorus impairment for Georgetown Lake should lead to an overall improvement in water quality due to the interrelated nature of the other listed pollutants. For example, reducing loads of phosphorus should result in less algal growth and some of the management measures taken to reduce phosphorus loads (e.g., reducing agricultural erosion) should also reduce loads of suspended solids.

This 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. Stage Two involves additional data collection for waters where a TMDL could not yet be developed (i.e., the Little Vermilion River). Stage Three involves model development and calibration, TMDL scenarios, and implementation planning. The TMDL report was approved by USEPA in October 2005. This implementation plan is the last component of Stage Three.

The TMDL for Georgetown Lake was based on application of the U.S. Army Corps of Engineers BATHTUB model. The total phosphorus loads required to simulate the observed concentrations with the BATHTUB model are listed in Table 1-2.

Table 1-2. Watershed Loading to Georgetown Lake.

Year	Average Stream Flow (cubic feet per second)	Total Phosphorus (lb/yr)
1992	170	37,000
1993	274	55,400
1994	143	27,200
1995[1]	131	25,400
1996	191	50,600
1997[1]	98	15,800
1998	238	57,800
1999	153	29,800
2000	98	11,800
2001	176	32,200
2002[1]	261	70,800
2003	86	17,000

[1] Years during which inlake total phosphorus concentrations were measured.

The BATHTUB model was used to identify the load reductions necessary to achieve a target concentration of 0.05 mg/L total phosphorus. A 46 percent load reduction is needed to meet the TMDL requirements. Table 1-3 shows the predicted average annual total phosphorus concentrations if a 46 percent reduction is achieved.

Table 1-3. Average Total Phosphorus Concentration in Georgetown Lake with 46 Percent Reduction in Loading.

Year	Georgetown Lake TP (mg/L)
1992	0.053
1993	0.050
1994	0.047
1995	0.047
1996	0.065
1997	0.039
1998	0.060
1999	0.048
2000	0.030
2001	0.045
2002	0.067
2003	0.048
Average	0.050

The allocation of loads for the Georgetown Lake TMDL is summarized in Table 1-4. The existing loads are the average annual loads to Georgetown Lake for the period 1992 to 2003. The loading capacity represents the 46 percent reduction from existing loads determined to be necessary from the modeling analysis. The wasteload allocation is the same as the existing estimated load for the Ridge Farm Sewage Treatment Plant. Five percent of the loading capacity is reserved for a margin of safety (as required by the Clean Water Act).

Table 1-4. TMDL Summary for Georgetown Lake.

Category	Phosphorus (lb/yr)	Phosphorus (lb/day)
Existing Load	35,900	98
Loading Capacity	19,390	53
Wasteload Allocation	2,670	7.3
Margin of Safety	970	2.7
Load Allocation	15,750	43

The TMDL report for Georgetown Lake, which has been approved by USEPA, suggests a 46 percent reduction in phosphorus loading to meet the water quality standard in the lake. This report presents an 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).

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2.0 DESCRIPTION OF WATERBODY AND WATERSHED CHARACTERISTICS

The purpose of this section of the report is to provide a brief background of Georgetown Lake and its corresponding watershed. More detailed information on the soils, topography, land use/land cover, climate and population of the Georgetown Lake watershed are available in the Stage One Watershed Characterization Report.

Georgetown Lake, built in 1948, has a surface area of 64 acres and an average depth of approximately four feet. The lake primarily provides recreation opportunities such as fishing and small boating. The drainage area of the lake is approximately 161.4 sq. mi.

Soils in the watershed are primarily IL010 (Flanagan-Drummer-Catlin) and IL014 (Saybrook-Drummer-Parr). Soil erodibility factors for these soils reported in the STATSGO database range from 0.28 to 0.37, indicating moderate soil erodibility. Soils identified by STATSGO as highly erodible generally have slopes greater than 5 percent and represent only 1.28 percent of the total watershed area. Based on an intersection of soils data with 2001 land use data (see below), most of the highly erodible soils are currently farmed (Figure 2-1).

The average depth to water table reported in the STATSGO database for soils in the Georgetown Lake watershed ranges from 2.45 feet to 6 feet. Tile drainage systems are usually placed 3 to 4 feet below the soil surface to lower the depth. Minimum depths occur along the northern margin of the watershed with maximum depths in the headwaters of Baum Branch. The use of tile drains is common in the Georgetown Lake watershed.

Land use/land cover upstream of Georgetown Lake is largely agricultural (46 percent corn and 41 percent soybeans) based on satellite imagery collected around 2001 (INHS, 2003) (Figure 2-2). Additional land use/land cover includes rural grasslands, forest, urban areas, and wetlands. The majority of land around the perimeter of the lake is pasture and forest.

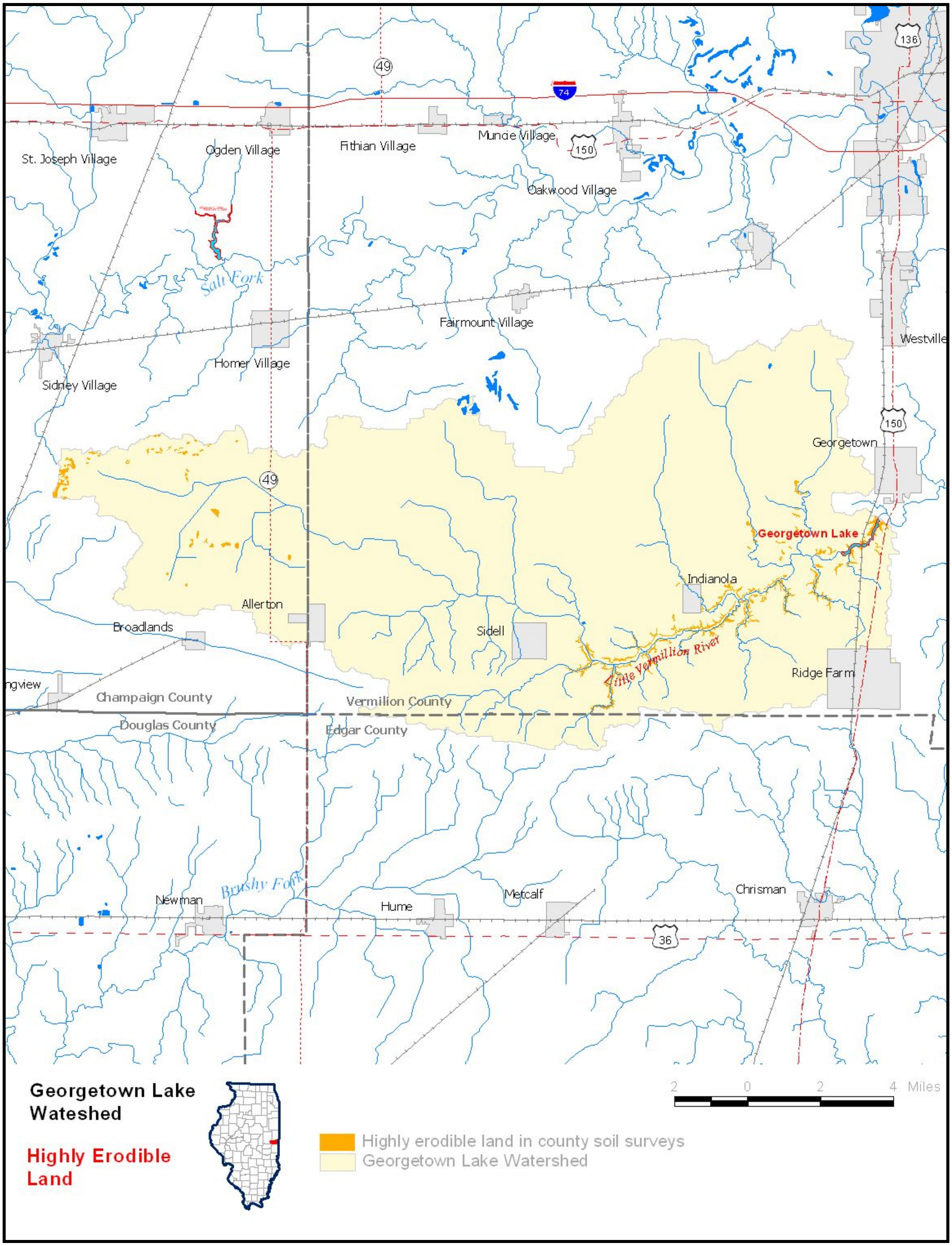

Figure 2-1. Highly Erodible Soils in the Georgetown Lake Watershed.

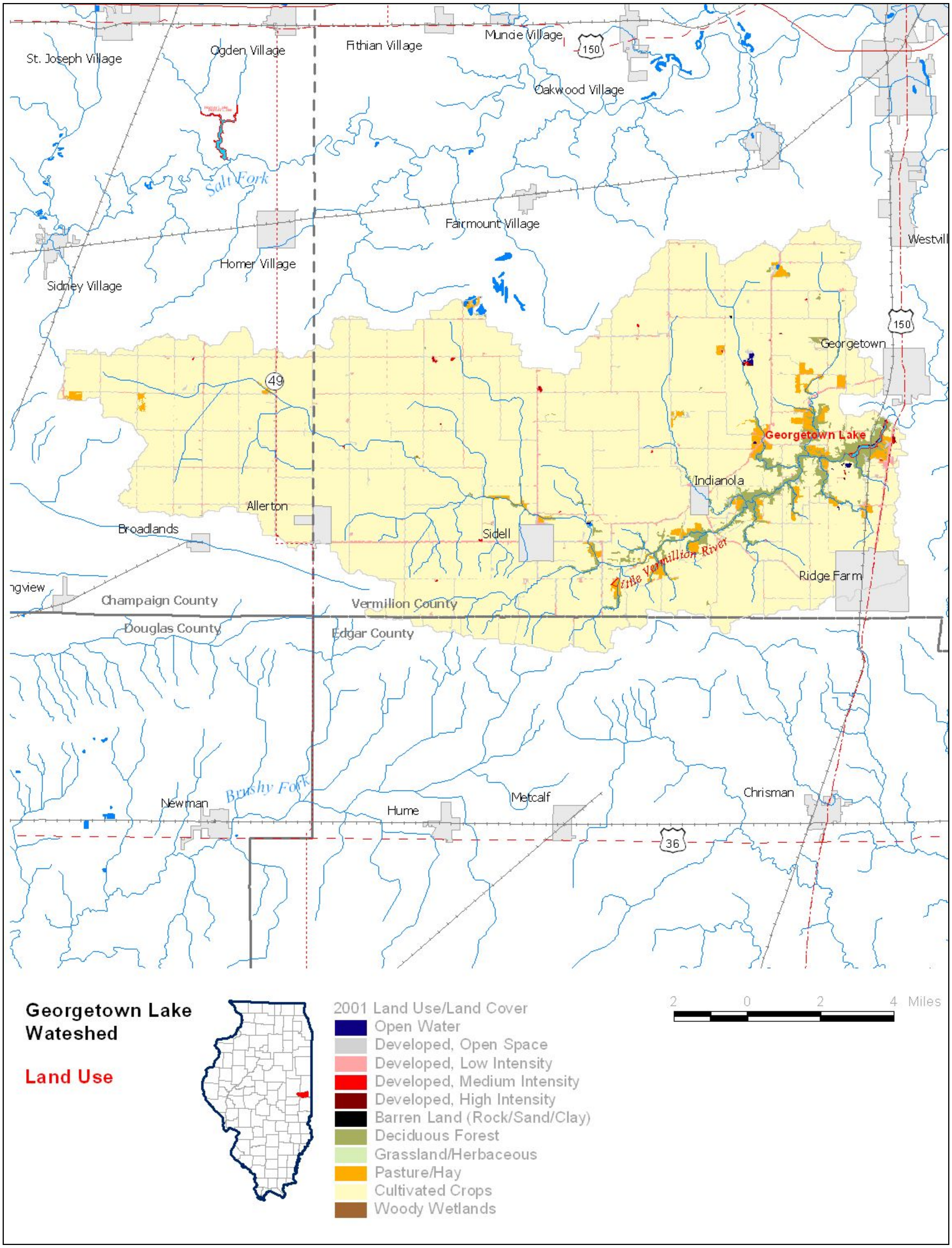

Figure 2-2. Land Use/Land Cover in the Georgetown Lake Watershed (Year 2001 GAP Data).

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3.0 WATER QUALITY STANDARDS AND ASSESSMENT OF WATER QUALITY DATA

This section presents the applicable water quality standards and a summary of the historic water quality data for Georgetown Lake. A more detailed discussion of the available water quality data is located in the Stage One Watershed Characterization 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 Georgetown Lake:

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 Georgetown Lake show that approximately 82 percent of total phosphorus samples exceeded the water quality standard, including 100 percent of recent 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 Georgetown Lake (Chapra, 1997).

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4.0 POLLUTANT SOURCES AND MANAGEMENT ACTIVITIES

As discussed in Section 2.0, the majority of land in the Georgetown Lake watershed (87 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 Georgetown Lake indicates that a reduction in phosphorus load of 46 percent is required to meet the Illinois water quality standard.

4.1 WWTP/NPDES Permittees

There are five National Pollution Discharge Elimination System (NPDES) facilities upstream of Georgetown Lake:

- City of Allerton Water Treatment Plant (ID IL0004511)
- City of Sidell Water Treatment Plant (ID IL0069078)
- Ridge Farm Sewage Treatment Plant (IL0020966)
- Black Beauty Riola Coal Mine (IL0074802)
- Black Beauty Riola Mine, Riola Portal (IL0071021)

The location of each of these facilities is shown in Figure 4-1.

4.1.1 Source Description and Approximate Loading

None of these five facilities are required to monitor for total phosphorus in their effluent so their actual loads are unknown. Reported flow data were also not available for the two coal mines, although effluent load of total phosphorus from these facilities is not considered to be significant. Loads of total phosphorus from the water treatment plants (WTP) and the Ridge Farm sewage treatment plant (STP) were estimated by multiplying their average reported effluent flows by estimates of their total phosphorus concentrations. Ambient Little Vermilion River total phosphorus concentrations in the vicinity of Allerton and Sidell (approximately 0.03 mg/L) were used for the water treatment plant effluent and a literature value of 4 mg/L (Litke, 1999) was used for the Ridge Farm Sewage Treatment Plant effluent. The resulting estimates of total phosphorus loads are shown in Table 4-1.

Table 4-1. Estimated Loads of Total Phosphorus from Point Sources Upstream of Georgetown Lake.

Facility	Average Flow (mgd)	Estimated TP Concentration (mg/L)	Estimated TP Load (lb/yr)
City of Allerton WTP	0.000006	0.03	<1
City of Sidell WTP	0.002	0.03	<1
Ridge Farm STP	0.219	4.0	2,670

The Ridge Farm STP is not currently required to monitor total phosphorus concentrations from the effluent. Because point source discharges comprise a small fraction of the potential load to Georgetown Lake (approximately 1 percent), as will be shown in the following sections, it is not likely that permit changes or plant upgrades will be required to reduce phosphorus loads from this facility.

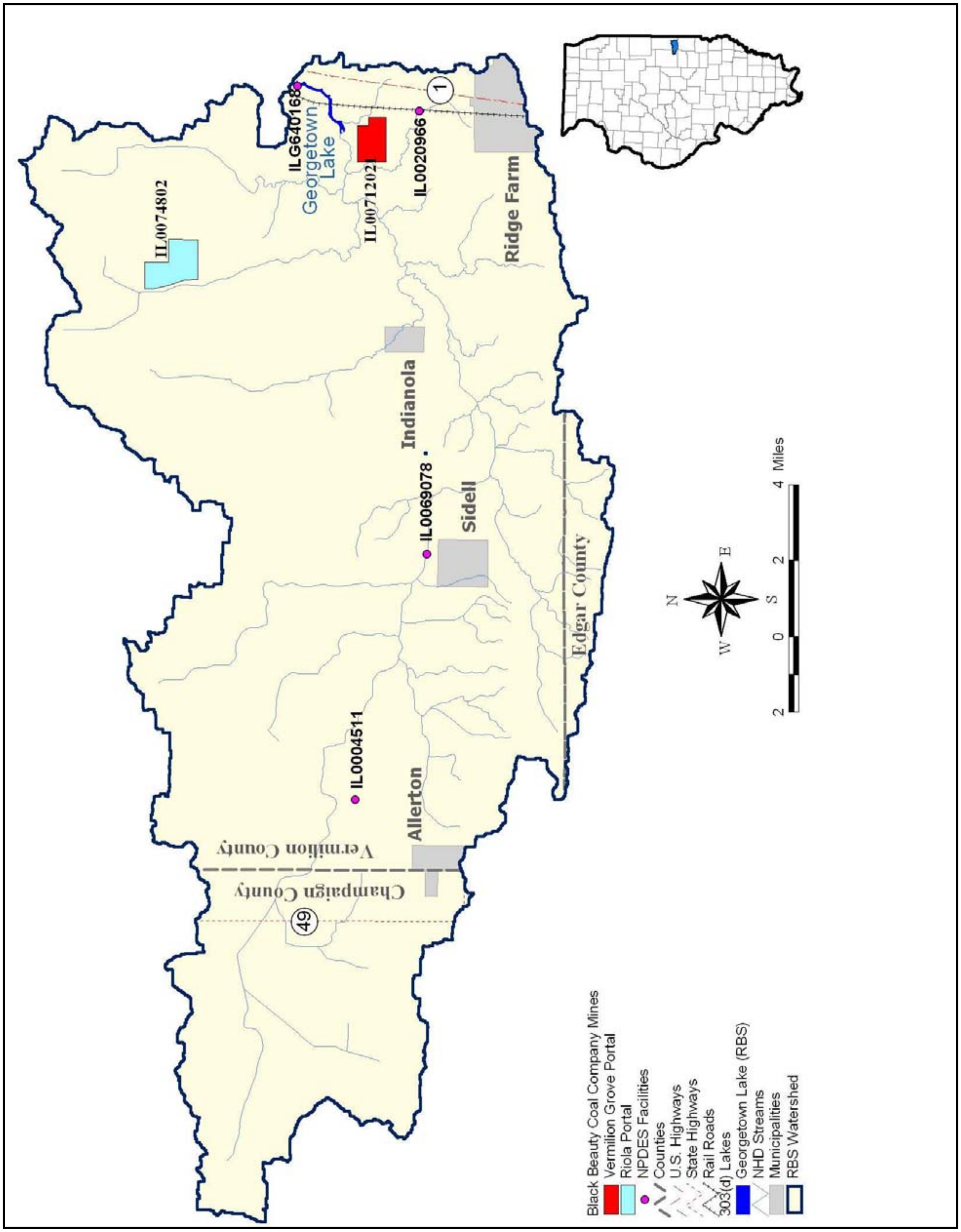


Figure 4-1. Location of Point Sources in the Georgetown Lake Watershed.

4.2 Animal Operations

Total phosphorus loading from animal operations can be a problem in both confined and pasture-based systems. Though the exact location of animal operations in the watershed is not known, countywide statistics indicate that a large number of livestock, swine, and poultry may exist in the watershed. Figure 4-2 shows an example of poorly managed animal wastes that may contaminate nearby surface waters.

(Photo courtesy of USDA NRCS.)

Figure 4-2. Example of Poorly Managed Animal Waste.

4.2.1 Source Description and Approximate Loading

The United States Department of Agriculture distributes agricultural data through the National Agricultural Statistics Service (NASS). Data are available by county and include farm size, market value, crop types, etc., as well as animal counts of cattle, swine, poultry, and sheep. To protect the privacy of the farmers, animal counts are not listed for individual farms. Instead, the numbers are reported on a countywide basis.

Data from the NASS were downloaded for Vermilion, Champaign, and Edgar counties and area weighted to estimate the number of animals in the Georgetown Lake watershed. Table 4-2 lists the estimated animal counts for the watershed.

Table 4-2. Estimated Number of Livestock and Poultry in the Georgetown Lake Watershed.

Animal	Champaign Co.	Edgar Co.	Vermilion Co.	Sum
Broiler Chickens	11	0	35	46
Layer chickens	98	1	73	173
Beef cattle	30	21	442	492
Dairy cattle	2	1	24	27
Other cattle: heifers, bulls, calves, etc.	101	36	758	895
Hogs and pigs	551	0	2,776	3,327
Sheep and lambs	10	2	52	64

Large animals produce more fecal matter per animal compared to smaller animals, so the concept of animal unit is used to normalize the loading from various operations. Table 4-3 lists the number of animals equivalent to one animal unit (IDA, 2001) for each of the livestock and poultry classes likely present in the watershed as well as the total number of animal units in the watershed. In the Georgetown Lake watershed, the majority of animal units are either beef, other cattle, or hogs and pigs.

Table 4-3. Animal Unit Data for the Georgetown Lake Watershed.

Animal	Number of Animals in One Animal Unit	Number of Animal Units in Watershed	Percent of Animal Units in Watershed
Broiler Chickens	50	1	0.04
Layer chickens	50	3	0.1
Beef cattle	1	492	17.8
Dairy cattle	0.71	38	1.4
Other cattle: heifers, bulls, calves, etc.	1	895	32.4
Hogs and pigs	2.5	1,331	48.1
Sheep and lambs	10	6	0.2

Beef and other cattle are likely contained on pastureland in the watershed. Approximately 8,874 ac are classified by the 2001 GAP land use coverage as rural grassland (the only category that might include pasture). Phosphorus export rates for pasture range from 0.12 to 4.4 lb-P/ac/yr (Lin, 2004), yielding approximate loads of 1,065 to 39,045 lb-P/yr from pastured animals in this watershed.

Hogs and swine are typically confined in housing units or feedlots. Assuming a feedlot density ranging from 50 to 200 animals per acre (Barker, 1996) and feedlot export rates of 19 to 709 lb-P/ac/yr (Lin, 2004) yields a phosphorus load from these animals ranging from 315 to 47,120 lb-P/ac/yr.

These loads represent the potential phosphorus load from animals in the watershed and do not account for nutrient assimilation, soil adsorption, manure management practices currently in place, or final disposal outside the watershed.

Agricultural animal operations are a potentially large source of total phosphorus loading if adequate best management practices (BMPs) are not in place to protect surface waters. Livestock operations either consist of confined or pasture-based systems. If a confined operation has greater than 1000 animal units or is determined to threaten water quality, the operation requires a federal Concentrated Animal Feeding Operation (CAFO) permit. CAFOs are required to develop a nutrient management plan (NMP) as part of the CAFO permitting process (USEPA, 2003). The CAFO NMP consists of manure management and disposal strategies that minimize the release of excess nutrients into surface and ground water. The CAFO NMPs are based on NRCS standards and technical expertise.

Illinois EPA is currently reviewing current and expired NPDES permits for CAFOs throughout the state. There are less than 20 of these CAFOs in Illinois at this time. Illinois EPA is in the process of determining which facilities will continue to be permitted and which can be terminated based upon the revised regulations and recent court orders. Many of the facilities previously permitted are no longer in operation and may not need an NPDES permit. Due to the uncertainties associated with these facilities, the TMDL did not identify NPDES permitted CAFO facilities.

4.2.2 Appropriate BMPs

Animal operations typically require a suite of BMPs to protect water quality. BMPs that settle out phosphorus are effective, but the phosphorus will need to be managed following cleanouts and maintenance. BMPs found to effectively reduce the gross phosphorus load are discussed here.

4.2.2.1 Feeding Strategies

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

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

Most feeding strategies work to reduce the phosphorus content of manure such that the end product has a more balanced ratio of nitrogen and phosphorus. The phosphorus content of swine manure may be reduced by approximately 40 percent if the animals are fed low-phytate corn or maize-soybean diets or given a phytase enzyme to increase assimilation by the animal. The phosphorus content of poultry manure can be reduced by 30 to 50 percent by supplementing feed with the phytase enzyme.

4.2.2.2 Animal Management Strategies

Cattle Exclusion from Streams

Cattle manure is a substantial source of nutrient and fecal coliform loading to streams, particularly where direct access is not restricted and/or where cattle feeding structures are located adjacent to riparian areas. Direct deposition of feces into streams may be a primary mechanism of pollutant loading during baseflow periods. During storm events, overbank and overland flow may entrain manure accumulated in riparian areas resulting in pulsed loads of nutrients, total organic carbon (TOC), biological oxygen demand (BOD), and fecal coliform bacteria into streams. In addition, cattle with unrestrained stream access typically cause severe streambank erosion. The impacts of cattle on stream ecosystems are shown in Figure 4-3 and Figure 4-4.

Figure 4-3. Typical Stream Bank Erosion in Pastures with Cattle Access to Stream.

Figure 4-4. Cattle-Induced Streambank Mass Wasting and Deposition of Manure into Stream.

Fencing cattle from streams and riparian areas using vegetative or fencing materials will reduce streambank trampling and direct deposition of fecal material in the streams. Phosphorus reductions of 15 to 49 percent are reported (USEPA, 2003). An example of proper exclusion and the positive impacts on the stream channel are shown in Figure 4-5.

(Photo courtesy of USDA NRCS.)

Figure 4-5. Stream Protected from Sheep by Fencing.

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

Allowing limited or no animal access to streams will provide the greatest water quality protection. On properties where cattle need to cross streams to have access to pasture, stream crossings should be built so that cattle can travel across streams without degrading streambanks and contaminating streams with manure. Figure 4-6 shows an example of a reinforced cattle access point to minimize time spent in the stream and mass wasting of streambanks.

(Photo courtesy of USDA NRCS.)

Figure 4-6. Restricted Cattle Access Point with Reinforced Banks.

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

Alternative Drinking Sources for Cattle

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

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

Alternative watering locations used concurrently with cattle exclusion practices have shown reductions in total phosphorus loading of 15 to 49 percent. Some researchers have studied the impacts of providing alternative watering sites without structural exclusions and found that cattle spend 90 percent less time in the stream when alternative drinking water is furnished (USEPA, 2003). Figure 4-7 shows a centralized watering tank allowing access from rotated grazing plots and a barn area.

(Photo courtesy of USDA NRCS.)

Figure 4-7. Centralized Watering Tank.

The NRCS provides additional information on these alternative watering components:

Spring development:
http://efotg.nrcs.usda.gov/references/public/IL/IL-574.pdf,
Well development:
http://efotg.nrcs.usda.gov/references/public/IL/IL-642.pdf,
Pipeline:
http://efotg.nrcs.usda.gov/references/public/IL/516.pdf,
Watering facilities (trough, barrel, etc.):
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 614

Grazing Land Protection

While erosion rates from pasture areas are generally lower than those from row-crop areas, a poorly managed pasture can approach or exceed a well-managed row-crop area in terms of erosion rates. Grazing land protection is intended to maximize ground cover on pasture, reduce soil compaction resulting from overuse, reduce runoff concentrations of nutrients and fecal coliform, and protect streambanks and riparian areas from erosion and fecal deposition. Figure 4-8 shows an example of a pasture managed for land protection. Cows graze the left lot while the right lot is allowed a resting period to revegetate.

(Photo courtesy of USDA NRCS.)

Figure 4-8. Example of a Well Managed Grazing System.

Maintaining sufficient ground cover on pasture lands requires a proper density of grazing animals and/or a rotational feeding pattern among grazing plots. The EPA nonpoint source guidance for agricultural areas estimates that total phosphorus loading may be reduced by 49 to 60 percent with grazing land protection measures (USEPA, 2003).

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

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

4.2.2.3 Vegetated Controls

Filter Strips

Filter strips are used in agricultural and urban areas to intercept and treat runoff before it leaves the site. For small dairy operations, filter strips may also be used to treat milk house washings and runoff from the open lot (NRCS, 2003). Filter strips will require maintenance, including grading and seeding, to ensure distributed flow across the filter and protection from erosion. Periodic removal of vegetation will encourage plant growth and uptake and remove nutrients stored in the plant material. Filter strips are most effective on sites with mild slopes of generally less than 5 percent, and to prevent concentrated flow, the upstream edge of a filter strip should follow one elevation contour (NCDENR, 2005).

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). A grass filter strip is shown in Figure 4-9.

(Photo courtesy of USDA NRCS.)

Figure 4-9. Grassed Filter Strip.

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

Grass Waterway

Grassed waterways are stormwater conveyances lined with grass that prevent erosion of the transport channel. They are often used to divert clean up-grade runoff around contaminated feedlots and manure storage areas (NRCS, 2003). In addition, the grassed channel reduces runoff velocities, allows for some infiltration, and filters out some particulate pollutants. The effectiveness of grass swales for treating agricultural runoff has not been quantified. In urban settings, reported removal rates for total phosphorus are 30 percent (Winer, 2000). Figure 4-10 shows a grassed waterway draining a corn field.

(Photo courtesy of USDA NRCS.)

Figure 4-10. Grassed Waterway.

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

Riparian Area Improvements

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 73 percent of the land is currently farmed; 17 percent is forested, 5 percent is pasture or hay, 4 percent is developed, and the remaining areas are either grassland, water, or wetland.

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. Figure 4-11 shows a riparian buffer separating agricultural fields from the stream.

(Photo courtesy of USDA NRCS.)

Figure 4-11. Riparian Buffer Protecting the Stream From Adjacent Agricultural Fields.

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

BMPs can be highly efficient in reducing pollutant loading and protecting stream ecosystems, particularly when used in combinations. Table 4-4 summarizes appropriate BMPs for total phosphorus reductions from animal operations.

Table 4-4. Total Phosphorus BMPs for Animal Operations.

BMP	Description and Removal Mechanism	Estimated Total Phosphorus Reduction
Feeding Strategies	Altering the types of feed and quantities of dietary supplements or adding enzymes to feed to increase digestibility.	30 to 50 percent (USEPA, 2002a)
Cattle Exclusion from Streams	Using vegetation or fencing material to prevent stream access by cattle.	These practices used together have a reported reduction in total phosphorus load of 15 to 49 percent (USEPA, 2003)
Alternative Drinking Sources	Providing drinking water for cattle away from the stream.	
Grazing Land Protection	Maintaining vegetation in grazing areas by reducing the number of grazing animals or limiting the number of days each field is grazed.	49 to 60 percent (USEPA, 2003)
Filter Strips	Placement of vegetated strips in the path of field drainage to treat pollutants. May also be used to treat washings from milking parlors in small dairy operations.	65 percent (USEPA, 2003; Kalita, 2000)
Grass waterways	A runoff conveyance lined with vegetative material. Removes total phosphorus by infiltration, sedimentation, and plant uptake. Also used for clean water diversions.	30 percent (Winer, 2000)
Restoration of Riparian Buffers	Conversion of land adjacent to stream channels to vegetated buffer zones. Removes total 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).

4.2.3 Estimated Cost of Implementation

The net costs associated with the animal operation 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.). This section describes how the various costs apply to each BMP, and presents an estimate of the annualized cost spread out over the service life. Incentive plans, 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. Though BMPs implemented at animal operations are not expected to take land out of crop production, the phosphorus BMPs discussed in Section 4.3.2 will need to account for loss of income. 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 animal, not dollars and cents. For prices estimated less than $0.15, values are shown to the nearest penny.

4.2.3.1 Feeding Strategies

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

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

4.2.3.2 Cattle Exclusion from Streams

The cost of excluding cattle from streams depends more on the length of channel that needs to be protected than the number of animals on site. Fencing may also be used in a grazing land protection operation to control cattle access to individual plots. The system life of wire fences is reported as 20 years; the high tensile fence materials have a reported system life of 25 years (Iowa State University, 2005). Fencing materials vary by installation cost, useful life, and annual maintenance cost as presented in Table 4-5.

Table 4-5. Installation and Maintenance Costs of Fencing Material per Foot.

Material	Construction Costs (per ft)	Annual Maintenance Costs (per ft)	Total Annualized Costs (per ft)
Woven Wire	$1.46	$0.25	$0.32
Barbed Wire	$1.19	$0.20	$0.26
High tensile (non-electric) 8-strand	$1.09	$0.14	$0.18
High tensile (electric) 5-strand	$0.68	$0.09	$0.12

NRCS reports that the average operation needs approximately 35 ft of additional fencing per head to protect grazing lands and streams. Table 4-6 presents the capital, maintenance, and annualized costs per head of cattle for four fencing materials based on the NRCS assumptions.

Table 4-6. Installation and Maintenance Costs of Fencing Material per Head.

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

4.2.3.3 Alternative Drinking Water Sources

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

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

Annual operating costs to run the well pump range from $9 to $22 per year for electricity (USEPA, 2003; Marsh, 2001), or up to $0.15 per head. Table 4-7 lists the capital, maintenance, and annualized costs for a well, pump, and storage system assuming a system life of 20 years.

Table 4-7. Costs Calculations for Alternative Watering Facilities.

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

4.2.3.4 Grazing Land Protection

The costs associated with grazing land protection include acquiring additional land if current animal densities are too high (or reducing the number of animals maintained), fencing (Section 4.2.3.1) and seeding costs, and developing alternative water sources (Section 4.2.3.3). Establishment of vegetation for pasture areas costs from $39/ac to $69/ac based on data presented in the EPA nonpoint source guidance for agriculture (USEPA, 2003). Annual costs for maintaining vegetative cover will likely range from $6/ac to $11/ac (USEPA, 2003). If cattle are not allowed to graze plots to the point of requiring revegetation, the cost of grazing land protection may be covered by the fencing and alternative watering strategies discussed above.

4.2.3.5 Vegetative Controls

Filter Strips

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

Filter strips cost approximately $0.30 per sq ft to construct. The system life is typically assumed 20 years (Weiss et al., 2007), and annual maintenance costs are $0.01 per sq ft (USEPA, 2002c). For animal operations, it is not likely that land used for growing crops would be taken out of production for conversion to a filter strip. Table 4-8 summarizes the capital, maintenance, and annualized costs for filter strips.

Table 4-8. Costs Calculations for Filter Strips.

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

Grassed Waterways

Grassed waterways are primarily used in animal operations to divert clean water away from pastures, feedlots, and manure storage areas. Table 4-9 summarizes the capital, maintenance, and annualized costs of this practice per head of cattle as summarized by NRCS (2003).

Table 4-9. Costs Calculations for Grassed Waterways Used in Cattle Operations.

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

Riparian Buffers

Restoration of riparian areas will protect the stream corridor from cattle trampling and reduce the amount of fecal material entering the channel. The cost of this BMP depends more on the length of channel to be protected, rather than the number of animals having channel access. The costs of restoration is approximately $100/ac to construct and $475/ac to maintain over the life of the buffer (Wossink and Osmond, 2001; NCEEP, 2004).

Fecal coliform reductions have been reported for buffers at least 30 ft wide (Wenger, 1999). Large reductions are reported for 200 ft wide buffers. The costs per length of channel for 30 ft and 200 ft wide buffers restored on both sides of a stream channel is listed in Table 4-10. A system life of 30 years is assumed.

Table 4-10. Costs Calculations for Riparian Buffers Per Foot of Channel.

Width	Capital Costs per ft	Annual Operation and Maintenance Costs per ft	Total Annualized Costs per ft
30 ft on both sides of channel	$0.14	$0.02	$0.03
200 ft on both sides of channel	$0.92	$0.14	$0.17

4.2.4 Effectiveness and Estimated Load Reductions

Several BMPs are available to control total phosphorus loads from animal operations in the Georgetown Lake watershed. Selecting a BMP will depend on estimated removal efficiencies, construction and maintenance costs, and individual preferences. Table 4-11 summarizes the annualized costs (construction, maintenance, and operation) for each BMP per head of cattle, poultry, or swine. The removal efficiencies reported in the literature are included as well.

Table 4-11. Cost and Removal Efficiencies for Animal Operation BMPs.

BMP	Total Phosphorus Reduction	Annualized Cost per Head
Feeding Strategies	30 to 50 percent (USEPA, 2002a)	Minimal cost after accounting for reduced phosphorus supplementation and final disposal costs
Cattle Exclusion from Streams with Alternative Drinking Sources	These practices used together have a reported reduction in load of 15 to 49 percent (USEPA, 2003)	Beef cattle: $5.50 to $9
Grazing Land Protection	49 to 60 percent (USEPA, 2003; Government of Alberta, 2007)	Beef cattle: cost varies depending on density of animals and vegetation type
Filter Strips	65 percent (USEPA, 2003; Kalita, 2000)	Beef cattle: $6 to $11 Dairy cattle: $4 to $6
Grass waterways	30 percent (Winer, 2000)	Beef cattle: $0.05 to $0.12
Restoration of Riparian Buffers	80 percent (Wenger, 1999)	30 ft on both sides: $0.03 200 ft on both sides: $0.17

4.3 Agricultural Land Uses

Because the majority of land in the Georgetown Lake watershed (87 percent) is used for agricultural production, agriculture is likely a primary source of phosphorus loading to Georgetown 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 BMPs. Only cost-effective practices with demonstrated phosphorus removal capabilities are included.

4.3.1 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.

4.3.1.1 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 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).

Results of soil phosphorus tests from agricultural fields in Vermilion County, which contains the majority of the drainage area to Georgetown Lake, typically range from 16 to 85 ppm (32 to 170 lb/ac) (Franke, 2006). Similar measurements are reported for Champaign County, which contains a small portion of the drainage area, with typical measurements of 30 to 35 ppm (60 to 70 lb/ac) (Stikkers, 2007). Figure 4-12 shows the range of values typically observed in the Georgetown 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.

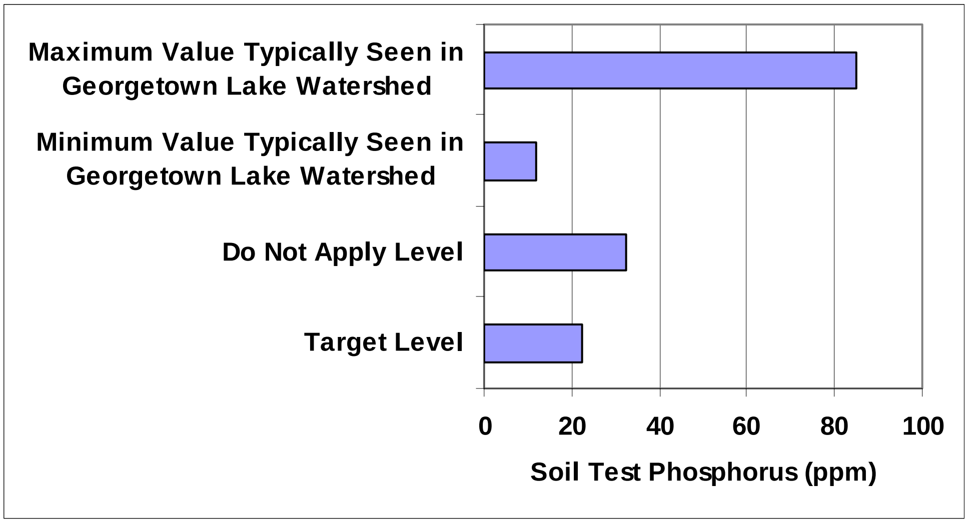


Figure 4-12. Soil Test Phosphorus Levels Measured in the Georgetown Lake Watershed.

4.3.1.2 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). Given that soils in Champaign and Vermilion counties typically test at 16 to 85 ppm, it is not likely that the tile drain dissolved phosphorus concentrations are excessively high, though the potential for moderately elevated concentrations does exist.

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 Georgetown Lake watershed when the tile lines are running to determine the total and dissolved phosphorus concentrations.

4.3.1.3 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).

4.3.2 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 Georgetown Lake watershed is not known.

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.

4.3.2.1 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 Illinois Agronomy Handbook (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). The Georgetown Lake watershed is located in the medium zone for inherent availability (IAH, 2002), and typical Bray P-1 soil test concentrations range from 16 to 85 ppm (Franke, 2006). 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), as with the majority of soils in the Georgetown Lake watershed, 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 4-12 and Table 4-13 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 4-12. Suggested Buildup and Maintenance Application Rates of P2O5 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 4-13. 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 4-13 shows the deep placement attachment used by the CCSWCD.

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

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

(Photo Courtesy of CCSWCD)

Figure 4-13. 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. 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 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).

4.3.2.2 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 the Georgetown Lake watershed; however, county-wide tillage system surveys have been undertaken by the Illinois Department of Agriculture (2002; 2006). It is assumed that the general tillage practice trends evidenced throughout Champaign and Vermilion counties are applicable to the Georgetown Lake watershed and the results of these surveys are presented in Table 4-14. Mulch till and no-till are considered conservation tillage practices. From year 2002 to 2006, the percent of corn fields managed with conservation tillage remained at 6 percent in Champaign County but decreased from 3 to 0 percent in Vermilion County. The percent of soybean fields operating with conservation tillage increased significantly in Champaign County from 45 to 64 percent and in Vermilion County from 45 to 55 percent.

Table 4-14. Percentage of Agricultural Fields Surveyed with Indicated Tillage System in Champaign and Vermilion Counties, Illinois, in 2002 and 2006.

Champaign County 2002 Transect Survey				
Crop Field Type	Tillage Practice			
	Conventional	Reduced-till	Mulch-till	No-till
Corn	74	20	4	2
Soybean	14	41	23	22
Small Grain	0	0	100	0
Champaign County 2006 Transect Survey				
Crop Field Type	Tillage Practice			
	Conventional	Reduced-till	Mulch-till	No-till
Corn	73	21	3	3
Soybean	5	31	32	32
Small Grain	0	0	0	100
Vermilion County 2002 Transect Survey				
Crop Field Type	Tillage Practice			
	Conventional	Reduced-till	Mulch-till	No-till
Corn	91	6	1	2
Soybean	31	24	9	36
Small Grain	50	0	0	50
Vermilion County 2006 Transect Survey				
Crop Field Type	Tillage Practice			
	Conventional	Reduced-till	Mulch-till	No-till
Corn	98	2	0	0
Soybean	30	15	6	49
Small Grain	100	0	0	0

Source: Illinois Department of Agriculture, 2002; 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 4-14 shows a comparison of ground cover under conventional and conservation tillage practices.

Figure 4-14. 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).

4.3.2.3 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 4-15.

(Photo Courtesy of NRCS)

Figure 4-15. Use of Cover Crops.

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

4.3.2.4 Vegetative Controls

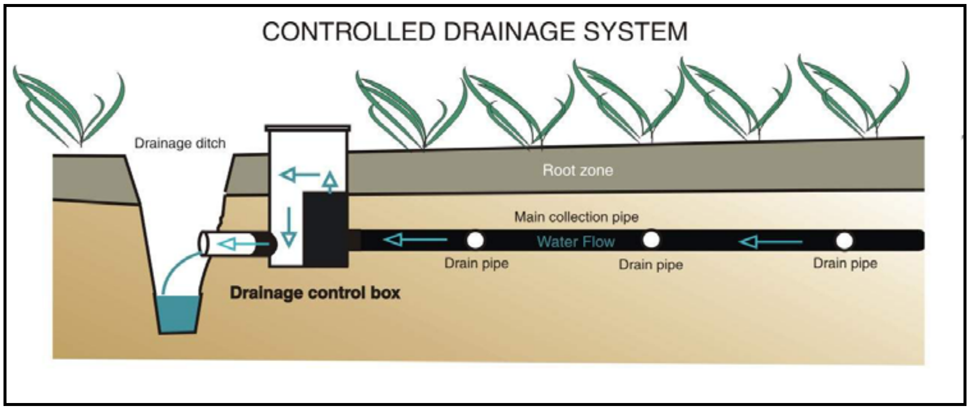
Other phosphorus control measures for agricultural land use include vegetated filter strips, grassed waterways, and riparian buffers. The USDA (2003) does not advocate using these practices solely to control phosphorus loading, but rather as supplemental management measures following operational strategies.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

Vegetated controls were discussed in Section 4.2.2 as BMPs for animal operations. The background information and pollutant reduction effectiveness will not be repeated in this section. Cost estimates as they relate to acreages of crop production are included in Section 4.3.3.4.

4.3.2.5 Drainage Control Structures for Tile Drain Outlets

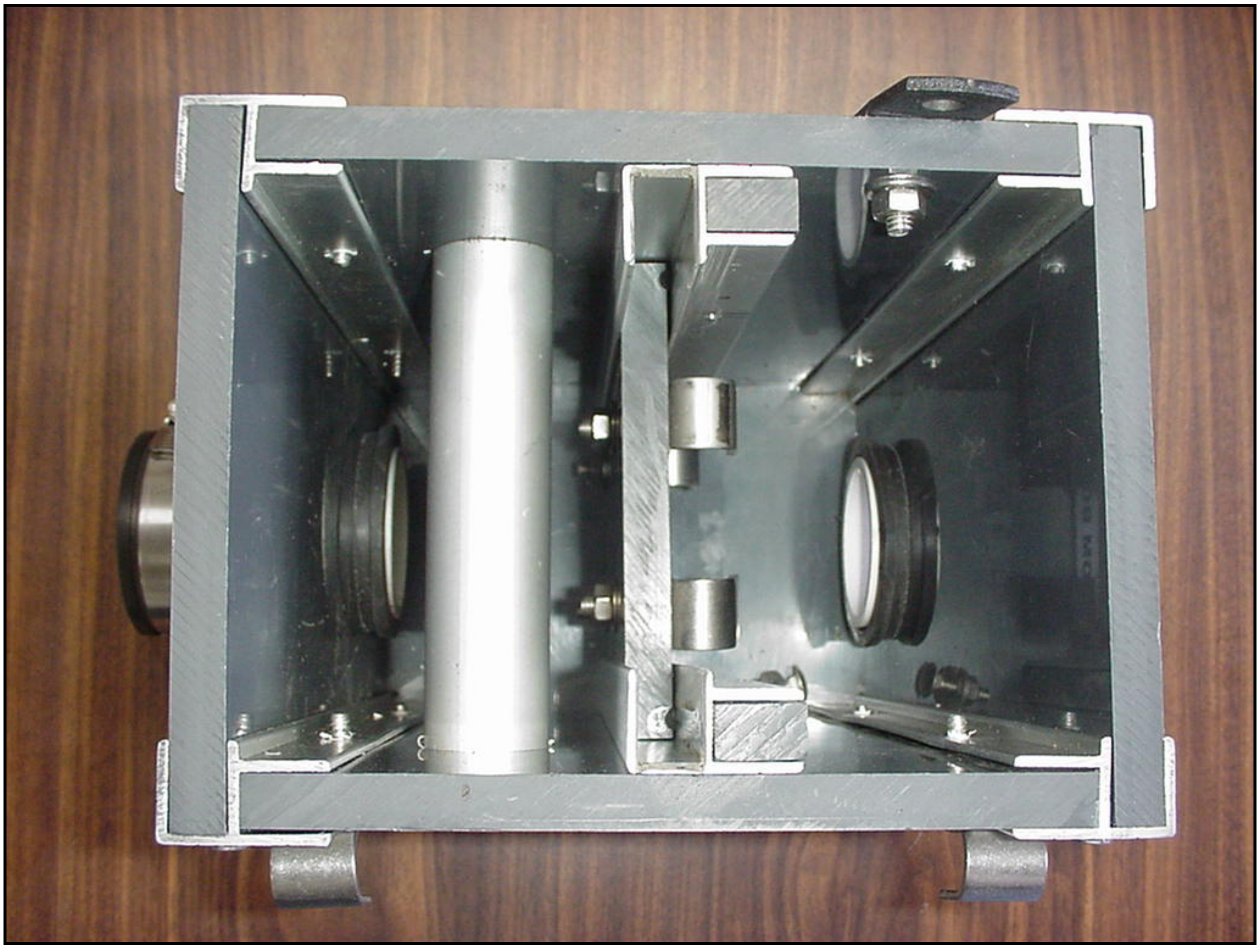
A conventional tile drain system collects infiltrated water below the root zone and transports the water quickly to a down-gradient surface outlet. Placement of a water-level control structure at the outlet (Figure 4-16 and Figure 4-17) allows for storage of the collected water to a predefined elevation. 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 4-16. Controlled Drainage Structure for a Tile Drain System.



(Photo Courtesy of CCSWCD)

Figure 4-17. 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.

To summarize the information presented in Section 4.3.2, Table 4-15 gives a brief description of each BMP as well as the reported reductions in phosphorus loading.

Table 4-15. 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).

4.3.3 Estimated Cost of Implementation

The net costs associated with the agricultural BMPs described in Section 4.3.2 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.

4.3.3.1 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). The Champaign County Soil and Water Conservation District (CCSWCD, 2003) estimates savings of approximately $10/ac during each plan cycle (4 years) by applying fertilizer at recommended rates. Actual savings (or costs) depend on the reduction (or increase) in fertilizer application rates required by the nutrient management plan as well as other farm management recommendations.

Placing the fertilizer below and to the side of the seed bed (referred to as banding) reduces the required application by one third to one half to achieve the same crop yields. In Champaign County, phosphorus application rates were reduced by approximately 13 lb/ac with this method. The equipment needed for deep placement costs up to $113,000 (Stikkers, 2007). Alternatively the equipment can be rented or the entire process 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 4-16 summarizes the assumptions used to develop the annualized cost for this BMP.

Table 4-16. 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**

4.3.3.2 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 4-17 summarizes the available information for determining average annual cost for this BMP.

Table 4-17. 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**

4.3.3.3 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 4-18 summarizes the costs and savings associated with ryegrass and hairy vetch.

Table 4-18. 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		

4.3.3.4 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 cost approximately $0.30 per sq ft to construct. Assuming that the required filter strip area is 2 percent of the area drained (Section 4.3.2.4) 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. At an assumed system life of 20 years (Weiss et al., 2007), the annualized construction costs are $13/ac/yr. Annual maintenance of filter strips is estimated at $0.01 per sq ft (USEPA, 2002c) for an additional cost of $8.70/ac/yr of agricultural land treated. In addition, the area converted from agricultural production to filter strip will result in a net annual income loss of $3.50. Table 4-19 summarizes the costs assumptions used to estimate the annualized cost to treat one acre of agricultural drainage using a filter strip.

Table 4-19. Costs Calculations for Filter Strips.

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

Grassed Waterways

Grassed waterways costs approximately $0.50 per sq ft to construct (USEPA, 2002c). These stormwater conveyances are best constructed where existing bare ditches transport stormwater, so no income loss from land conversion is expected with this practice. It is assumed that the average area required for a grassed waterway is approximately 0.1 to 0.3 percent of the drainage area, or between 44 and 131 sq ft per acre. The range is based on examples in the Illinois Drainage Guide, information from the NRCS Engineering Field Handbook, and a range of waterway lengths (100 to 300 feet). Waterways are assumed to remove phosphorus effectively for 20 years before soil, vegetation, and drainage material need to be replaced (Weiss et al., 2007). The construction 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 4-20 summarizes the annual costs assumptions for grassed waterways.

Table 4-20. 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 4-21).

Table 4-21. 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**

4.3.3.5 Drainage Control Structures for Tile Drain Outlets

The Champaign County Soil and Water Conservation District currently offers tile mapping services for approximately $2.25/ac using color infrared photography to assist farmers in identifying the exact location of their tile drain lines. 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 4-22.

Table 4-22. 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 4-23 for each of the agricultural BMPs discussed in this plan. Costs were adjusted to reflect year 2004 prices for the Champaign, 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 4-23. Estimated 2004 Costs of Agricultural BMPs for Champaign, 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	$25/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

4.3.4 BMP Effectiveness and Estimated Load Reductions

Several BMPs are available for use in the Georgetown Lake watershed to reduce phosphorus loading from crop-production areas. Selecting a BMP will depend on estimated removal efficiencies, construction and maintenance costs, and individual preferences. Table 4-24 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 4-24. 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	65	\$25/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).

4.4 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 Georgetown Lake watershed, so it is difficult to estimate levels of performance.

4.4.1 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 of the counties, 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 Champaign, Vermilion, and Edgar counties indicate that the rural population in the watershed is approximately 5,331 people and the urban population residing in the unsewered communities of Allerton, Indianola, and Sidell is 1,113. Based on the average household size listed for each county, the number of onsite wastewater treatment systems in the watershed is 2,657.

Though a watershed model was not developed for the Georgetown Lake 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 August 9, 2006 TMDL public meeting for the Little Vermilion River, failure rates in the Georgetown Lake 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 4-25 shows the phosphorus load if 7, 15, 30, and 60 percent of systems in the watershed are failing.

Table 4-25. Failure Rate Scenarios and Resulting Phosphorus Loads to Georgetown Lake.

Failure Rate[1] (%)	Average Annual Phosphorus Load (lb/yr)
7[2]	880
15	1,900
30	3,790
60	7,590

[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 Georgetown Lake watershed.

4.4.2 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.

At this time, there is not a formal inspection and maintenance program in Vermilion County. The County Health Department does issue permits for new onsite systems and major repairs. In addition, the Health Department investigates complaints concerning illegal sewage discharges and does limited surveys to locate illegal discharges (Riggle, 2007).

4.4.3 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 Georgetown Lake watershed depends on the number of systems that need to be inspected. Based on Census data collected in 2000, there are approximately 2,657 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 4-26).

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

Table 4-26. 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

4.4.4 Effectiveness and Estimated Load Reductions

It is difficult to estimate the phosphorus loading rate from septic systems in the Georgetown Lake watershed because local estimates of failure rates are not available. Based on information reported at stakeholder meetings in the watershed, some farmers reported finding raw sewage and toilet paper in the tile drain lines when they worked on them.

Depending on the level of failure, septic systems in the Georgetown Lake watershed could contribute between 1,900 lb-P/yr and 7,590 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.

4.5 Lake Bottom Sediments

Phosphorus release from sediments occurs during lake stratification when the soil water interface becomes anoxic (depleted of oxygen). Relative to watershed loading, internal cycling is not considered a significant source of phosphorus to the water column. During development of the Georgetown Lake phosphorus TMDL, the Nürnberg method (1984) was chosen to approximate the internal phosphorus load. This method uses mean depth, flushing rate, average inflow, and average outflow concentrations to estimate internal load. For Georgetown Lake, the internal load is estimated to be less than one percent, primarily due to the shallowness of the lake which would make bottom anoxia less likely to occur due to wind mixing.

4.6 Precipitation and Atmospheric Deposition

Phosphorus loading from atmospheric deposition is not considered a significant fraction of the loading to Georgetown Lake. 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 64 ac, the phosphorus load due to atmospheric deposition to Georgetown Lake is estimated to be 12 lb-P/yr. This is small fraction of the load estimated from watershed sources.

4.7 Shoreline Erosion

No information is currently available to assess the impacts of shoreline erosion to the water quality of Georgetown Lake but it is not expected to be significant based on the wooded corridor surrounding the lake.

4.8 Stream Channel Erosion

An aerial assessment of the Little Vermillion River from the Illinois/Indiana state line to above the confluence with Goodall Branch was prepared by the Illinois Department of Agriculture (Kinney, 2005). Copies of this report are available at the county soil and water conservation districts, the Illinois Department of Agriculture, and the Illinois EPA. The following observations were made during the assessment:

- Stream channels are not actively downcutting at this time. Channels have access to the floodplain and show no evidence of active incision.
- Approximately $1,250,000 is needed to control erosion due to channel widening. For the portion above Georgetown Lake, approximately $390,000 of restoration is recommended.

The extent of stream channel erosion above Goodall Branch and along the tributaries to the Little Vermillion River is not known. Inspection of these streambanks is needed to accurately quantify the loading from this source. However, based on the findings of the aerial assessment which focused on the larger streams with greater erosion potential, it is not likely that streambank erosion is contributing significant pollutant loading to Georgetown Lake.

4.8.1 Source Description and Approximate Loading

Without field inspections of the streambanks in the Georgetown 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.

4.8.2 Appropriate BMPs

Streambanks in the Georgetown 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.

4.8.3 Estimated Cost of Implementation

The aerial assessment of the watershed shows the extent of streambank erosion in the mainstem Lower Vermillion River. However, because the extent of streambank erosion along tributaries in the watershed is not known, specialized BMPs, such as engineering controls, are not suggested. Rather, the agricultural BMPs discussed in Section 4.3.2 that also address streambank stability are recommended (Table 4-27).

Table 4-27. 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.	Filter strips cost $25/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

4.8.4 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.

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5.0 PRIORITIZATION OF IMPLEMENTATION

The phosphorus TMDL for Georgetown Lake requires a 46 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 Georgetown Lake

There are several potential sources of phosphorus loading in the Georgetown Lake watershed but there are limited data with which to quantify any of them. The best available information was used to estimate the most likely range of loads, but there is a great deal of uncertainty associated with the results.

Potential loads from animal operations were estimated to range from 1,380 to 86,160 lb-P/yr. Potential loads from crop production were estimated to contribute 45,130 to 135,390 lb/yr based on phosphorus loading rate data presented by Gentry et al. (2007). Onsite wastewater systems were estimated to have a potential load of 1,900 to 7,590 lb/yr of phosphorus, and the Ridge Farm STP potentially contributes 2,670 lb/yr of phosphorus. The resulting potential load may therefore range from 51,080 to 231,815 lb-P/yr. These values represent the potential loads from each source category and do not account for plant uptake, soil adsorption, instream processes, or management measures currently in place in the watershed. In comparison, the BATHTUB modeling conducted for the TMDL estimated that the phosphorus load reaching the lake ranges from 11,900 to 70,990 lb-P/yr with an average load of 36,530 lb-P/yr. The loads that reach the lake could be lower than the upstream loads due to instream losses, or because the upstream loads were over-estimated.

Figure 5-1 shows the acres of cropland in the watershed that currently use nutrient management plans, EQIP eligible conservation practices (see Section 7.1), or both to manage pollutant loading. There are currently 14,687 acres in the Georgetown Lake watershed that use nutrient management plans, 636 acres enrolled in the EQIP program, and 164 acres that may employ an additional EQIP practice in addition to the nutrient management plans. In addition, 7.61 miles of the mainstem above Georgetown Lake are buffered by either forest or wetland areas.

Even with these practices in place, the TMDL modeling indicates than an additional reduction of 46 percent is required to bring Georgetown Lake into compliance. This equates to an average reduction of 16,804 lb-P/yr.

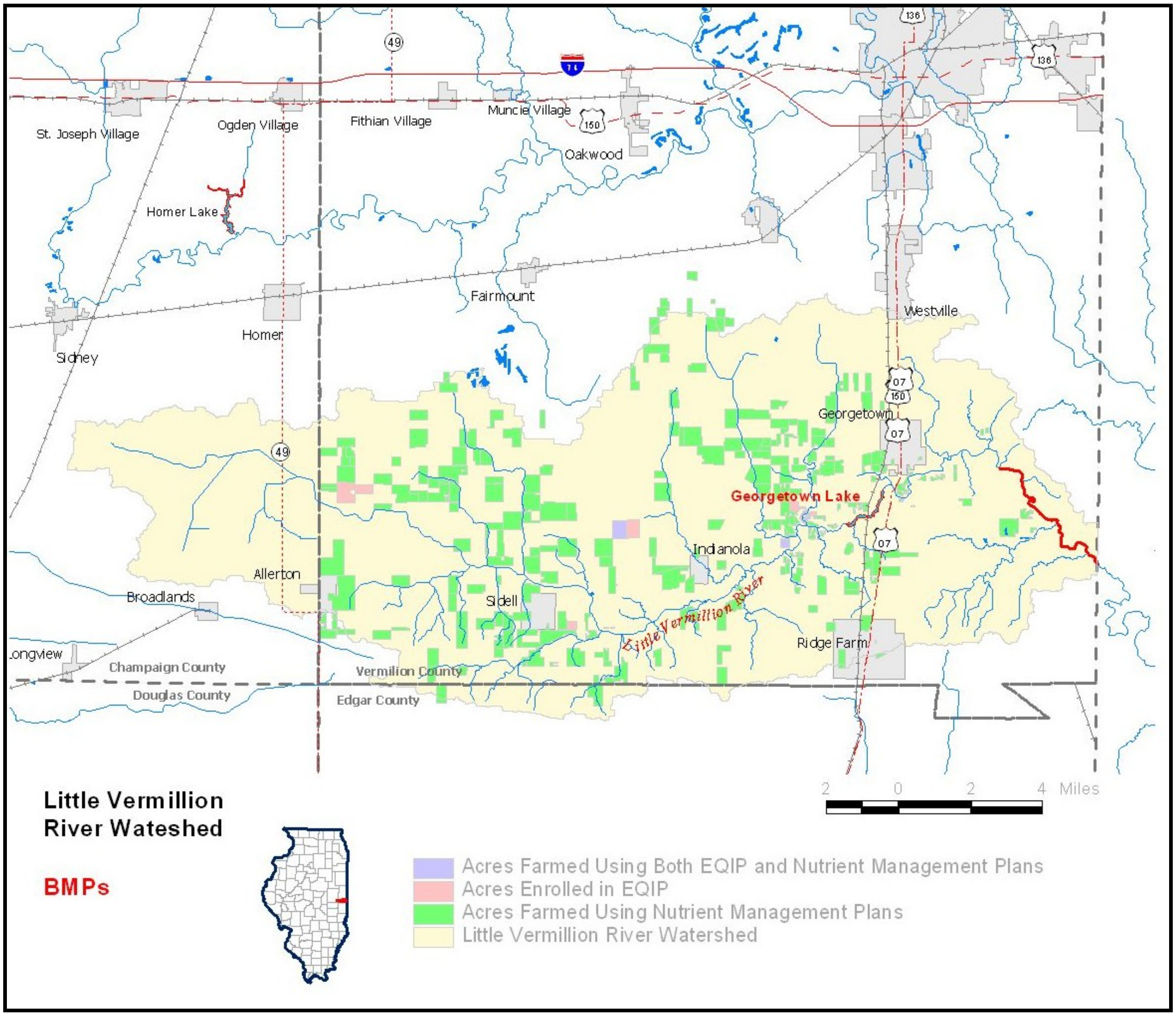

Figure 5-1. Active BMPs in the Georgetown Lake/Little Vermillion River Watershed.

5.2 Use of Phosphorus BMPs to Meet Water Quality Goals

Managing phosphorus loads to Georgetown Lake will primarily involve the use of agricultural BMPs for animal operations and lands used for crop production. Continuing to monitor water quality in the lake will determine whether or not managing the other sources of phosphorus, which likely comprise only two percent of the load, is a necessary to bring the lake into compliance.

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 costs 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 length of the Little Vermillion River upstream of Georgetown Lake where additional riparian buffers could be constructed is 18.65 miles. Thus, the area that could be converted to a buffer is approximately 406 acres and the area treated by this amount of buffer is 1,356 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 (1,762 ac) is approximately 881 to 2,643 lb/yr. The other agricultural BMPs are applicable to all 90,260 ac of farmland in the watershed and are not restricted by the presence of a stream channel.

Crop production areas comprise 60 to 93 percent of the phosphorus load to Georgetown Lake. The use of BMPs on corn and soybean farms in the watershed will likely result in significant reductions in phosphorus loading. Nutrient management plans with deep phosphorus placement, grassed waterways, and retrofitting tile drain systems with outlet control devices are all relatively inexpensive BMPs with potential phosphorus reductions ranging from 9,030 to 67,690 lb/yr. Conservation tillage costs about the same as these BMPs with a potential load reduction of 30,690 to 102,900 lb/yr. These load reductions are comparable to the more expensive BMPs at less than one-fourth of the cost.

Based on the loading rates reported in the literature, animal operations may comprise 3 to 38 percent of the phosphorus load to Georgetown Lake. Controlling these loads with altered feed, exclusion practices, filter strips, and grassed waterways may reduce loads by 160 to 43,080 lb/yr at relatively low costs.

Achieving a zero percent failure rate of septic systems in the Georgetown Lake watershed would likely reduce potential loads by 1,900 to 7,590 lb/yr, assuming that the current failure rate is somewhere between 15 and 60 percent. Though management of this source is likely not required to achieve the phosphorus goals in the Lake, meeting the fecal coliform standard in the Little Vermilion River will require that all systems are functioning as designed.

Table 5-1. Comparison of Phosphorus BMPs.

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 90,260 Acres of Farmland in the Watershed				
Nutrient Management Plan with Deep Phosphorus Placement	20 to 50	45,130 to 135,390	9,030 to 67,690	$67,690 to $338,480
Conservation Tillage	68 to 76	45,130 to 135,390	30,690 to 102,900	$112,820 to $203,090
Cover Crops	70 to 85	45,130 to 135,390	31,590 to 115,080	$1,737,500
Filter Strips	65	45,130 to 135,390	29,330 to 88,000	$2,256,500
Grassed Waterways	30	45,130 to 135,390	13,540 to 40,620	$180,520 to $541,560
Restoration of Riparian Buffers	80 for treated area and 90 for converted area	880 to 2,640	700 to 2,380	$781,020
Retrofit Controlled Drainage	35	45,130 to 135,390	15,790 to 47,390	$67,690 to $135,390
Animal Operations				
Feeding Strategies	30 to 50	1,380 to 86,160	410 to 43,080	May lead to net savings
Cattle Exclusion from Streams with Alternative Drinking Sources	15 to 49	1,060 to 39,040	160 to 19,130	$7,840 to $12,350
Grazing Land Protection	49 to 60	1,060 to 39,040	520 to 23,430	variable
Filter Strips	65	1,060 to 39,040	690 to 25,380	$8,330 to $15,270
Grass Waterways	30	1,060 to 39,040	320 to 11,710	$70 to $170
Onsite Wastewater Treatment BMPs Assuming 2,657 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	1,520 to 6,090	1,520 to 6,090	$186,010 to $225,860 to pump each system once every three to five years
Inspection				Up to $85,040 if each system has to be inspected once every five years.
Replacement				$178,020 to $884,750 assuming each system is replaced once every 30 years
Education				$2,660

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. Altering feeding strategies at animal operations could reduce loading by 30 to 50 percent. Excluding cattle from streams and providing altered drinking water sources may reduce loads by 15 to 49 percent. Grassed waterways and filter strips reduce loads by 30 and 65 percent, respectively. Each of the measures can be implemented at a cost of less than $11 per head.

Nutrient management planning to determine appropriate fertilizer application rates along with deep placement technology could reduce phosphorus loading to Georgetown Lake by 20 to 50 percent. Conservation tillage practices, particularly on corn fields should also be encouraged. The majority of soybean fields (60 percent) in Vermilion County use some form of conservation tillage, but only 2 percent of corn fields meet the 30 percent residual cover suggested to reduce erosion and phosphorus loading. Extending conservation tillage to the remaining 30 percent of soybean fields and 98 percent of corn fields may reduce phosphorus loading from over 57,760 acres by 68 to 76 percent, assuming that half of the fields are planted in soybean or corn during any given year.

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.

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, continued water quality monitoring 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.

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6.0 MEASURING AND DOCUMENTING PROGRESS

Water quality in Georgetown Lake is currently measured at three locations at least once per month from April through October during sampling years. Monitoring at Georgetown Lake should continue at this frequency for at least two monitoring cycles to document progress and direct future management strategies.

Georgetown Lake is not currently operating under the Volunteer Lake Monitoring Program (VLMP), but is encouraged to do so. The VLMP includes the following three levels of:

- 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.

Tracking the implementation of additional BMPs while continuing to monitor total phosphorus and other water quality parameters in Georgetown Lake will assist in determining the effectiveness of the BMPs. If concentrations remain above the water quality standard, further 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 on crop production areas 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 who voluntarily implement resource conservation practices in the Georgetown Lake 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.
- Sixty percent of the costs for fencing, controlled access points, spring and well development, pipeline, and watering facilities are covered by the program.

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 Georgetown Lake 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 one-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 funding 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 for carbon credits 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 Georgetown Lake watershed.

Table 7-1. Summary of Assistance Programs Available for Farmers in the Georgetown Lake Watershed.

Assistance Program/Agency	Program Description	Contact Information
NSMP	Provides grant funding for educational programs and implementation of nonpoint source pollution controls.	Illinois Environmental Protection Agency Bureau of Water Watershed Management Section, Nonpoint Source Unit P.O. Box 19276 Springfield, IL 62794-9276 Phone: (217) 782-3362
Agricultural Loan Program	Provides low-interest loans for the construction and implementation of agricultural BMPs. Loans apply to equipment purchase as well.	Office of State Treasurer Agricultural Loan Program 300 West Jefferson Springfield, Illinois 62702 Phone: (217) 782-2072 Fax: (217) 522-1217
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 composting facilities, cattle exclusion, alternative watering locations, waste storage and treatment facilities, filter strips, grassed waterways, and riparian buffers.	Vermilion County USDA Service Center 1905-A U.S. Route 150 Danville, IL 61832-5396 Phone: (217) 442-8511, Ext. 3 Fax: (217) 442-6998 Champaign County USDA Service Center 2110 West Park Court, Suite C Champaign, IL 61821 Phone: (217) 352-3536, Ext. 3 Fax: (217) 352- 4781
FSA CRP	Offsets income losses due to land conversion by rental agreements. Targets highly erodible land or land near sensitive waters. Provides up to 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years for converted land.	
Conservation 2000 CPP	Provides up to 60 percent cost share for several agricultural fecal coliform BMPs: pasture planting, filter strips, grassed waterways.	
Conservation 2000 Streambank Stabilization Restoration Program	Provides 75 percent cost share for establishment of riparian corridors along severely eroding streambanks. Also provides technical assistance and educational information for interested parties.	
SARE	Funds educational programs for farmers concerning sustainable agricultural practices.	
ICCI	Allows farmers to earn carbon trading credits for use of conservation tillage, grass, and tree plantings.	

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 VCSWCD
Nutrient Management Plan	EQIP: $10/ac, 400 ac. max. VCSWCD: 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 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 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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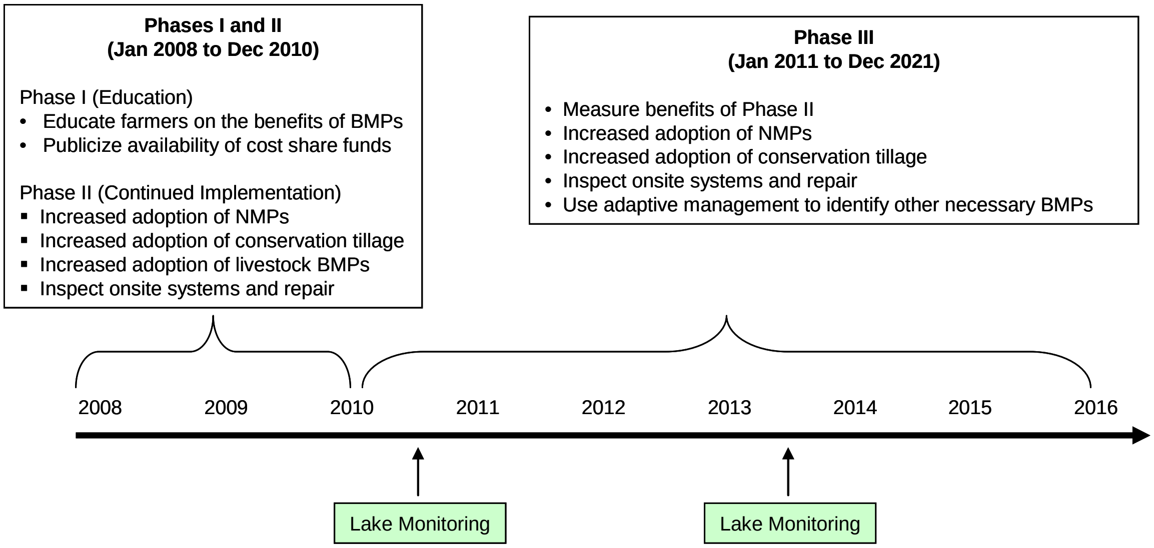
8.0 IMPLEMENTATION TIME LINE

This implementation plan for Georgetown Lake defines a phased approach for achieving the phosphorus standard in the lake (Figure 8-1). Ideally, implementing phosphorus control measures in the Georgetown 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, the Illinois Environmental Protection Agency, and the Vermilion County Soil and Water Conservation District (VCSWCD).

Phase II of the implementation schedule will involve voluntary participation of farmers in 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 Georgetown Lake could occur at the three Illinois EPA monitoring stations. 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 unprotected areas of the lake shore will provide maximized benefits. If required, this phase may last five to ten years.



Phases I and II
(Jan 2008 to Dec 2010)

Phase I (Education)
- Educate farmers on the benefits of BMPs
- Publicize availability of cost share funds

Phase II (Continued Implementation)
- Increased adoption of NMPs
- Increased adoption of conservation tillage
- Increased adoption of livestock BMPs
- Inspect onsite systems and repair

Phase III
(Jan 2011 to Dec 2021)

- Measure benefits of Phase II
- Increased adoption of NMPs
- Increased adoption of conservation tillage
- Inspect onsite systems and repair
- Use adaptive management to identify other necessary BMPs

Figure 8-1. Timeline for the Georgetown Lake Phosphorus TMDL Implementation Plan.

9.0 CONCLUSIONS

Total phosphorus concentrations collected in Georgetown Lake frequently exceed the Illinois water quality standard of 0.05 mg/L, with a long-term average of 0.09 mg/L. IEPA has included Georgetown Lake on the Illinois 303(d) list of impaired waters, and the phosphorus TMDL was approved in September 2005. The total phosphorus TMDL for Georgetown Lake indicates that a reduction in loading of 46 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 source of phosphorus to Georgetown Lake is agriculture. There are approximately 90,260 acres of row crop agriculture in the Georgetown Lake watershed, and phosphorus losses are estimated to range from 45,130 to 135,390 lb-P/yr depending on climate conditions (Gentry et al., 2007). 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 in the watershed. Water quality monitoring (likely occurring in 2010 and 2013) 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.

As agricultural BMPs are implemented, water quality in Georgetown Lake should improve accordingly. Measuring the effectiveness of these BMPs will require continued sampling of water quality in Georgetown Lake and its tributaries 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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Little Vermilion River Fecal Coliform TMDL Implementation Plan

FINAL REPORT

March 11, 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 (IEPA) has identified a reach of the Little Vermilion River (segment BO-07) as impaired for fecal coliform. Illinois general use water quality standards for primary contact recreation require that fecal coliform concentrations not exceed 400 per 100 mL in more than 10 percent of samples taken within a 30-day period or that the geometric mean of five samples taken in a 30-day period not exceed 200 per 100 mL from May through October. Sampling within the river indicates that both parts of the water quality standard have not been met.

The fecal coliform TMDL for the Little Vermilion River was approved by USEPA in October 2006. A load duration analysis was used to estimate required reductions of fecal coliform loading for five flow zones. The analysis indicated that load reductions of 49 to 90 percent are required, depending on hydrologic conditions.

Excursions of the fecal coliform standard occur during the complete range of flows. Because loading from nonpoint sources occurs throughout the watershed, and fecal coliform dieoff and regeneration are complex to predict, it is difficult to pinpoint the most significant sources of loading to the river. Moreover, it is likely that all potential sources in the watershed are contributing to the loading during various hydrologic conditions. Management of all sources will likely be required to meet the water quality standards during all flow zones.

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1.0 INTRODUCTION

1.1 Fecal Coliform (General Information)

Fecal coliform is a commonly used indicator to test for the presence of fecal matter and pathogenic organisms. Because so many disease-causing organisms exist in the environment, it is less expensive to test for an indicator organism, such as fecal coliform bacteria, than it is to test for each individual pathogen. For this reason, most water quality regulations and water quality standards are written in terms of fecal coliform counts or other indicators such as *Escherichia coli*.

Unlike other water quality parameters which report concentration as mass per volume (e.g., mg/L or ppm), fecal coliform is usually reported as the number of bacterial colonies, or colony forming units, observed in 100 milliliters of sample. The abbreviated units for this measurement are cfu/100 mL; in some cases the cfu is omitted.

In general, total maximum daily loads (TMDLs) are reported as a load per day of pollutant (e.g., lb/d), rather than as a concentration (e.g., mg/L). This allows for comparison of the contribution from each source, which depends not only on the pollutant concentration, but also on the volume of water. TMDLs for fecal coliform must also be reported as a daily load (or in this case a count), rather than concentration. The daily loads are often on the order of billions and trillions of counts per day. In this report, loads are expressed in millions of cfu, so the value listed multiplied by 1,000,000 represents the actual value.

1.2 Technical Approach for the Little Vermilion River Fecal Coliform TMDL

The Clean Water Act and USEPA regulations require that states develop TMDLs for waters identified as impaired on Section 303(d) lists. The Little Vermilion River is listed on Illinois' 2006 303(d) list as described in Table 1-1.

Table 1-1. 2006 303(d) List Information for Little Vermilion River.

Segment (Area)	Name	Designated Uses and Support Status	Causes of Impairment	Potential Sources of Impairment
BO07 (5.11 mi)	Little Vermilion River	Aquatic Life Support (Full), Primary Contact/Swimming (Not Supporting)	Fecal Coliform	Source Unknown

IEPA is currently developing TMDLs for pollutants that have numeric water quality standards. The Little Vermilion River project is being initiated in three stages. Stage One involved the characterization of the watershed, an assessment of the available water quality data, and identification of potential technical approaches. Stage Two involved additional fecal coliform data collection for the Little Vermilion River. The first part of Stage Three was completed and approved by USEPA in the fall of 2006 and involved a modeling and TMDL analysis for the Little Vermilion River fecal coliform impairment. The final component of Stage Three is this implementation plan, outlining how the TMDL reductions will be achieved.

A load duration approach was used to estimate existing and allowable fecal coliform loading to the Little Vermilion River. The allowable load is the greatest amount of a pollutant that a water can receive without violating water quality standards. Both the geometric mean (200 cfu/100 mL) and the not-to-exceed (400 cfu/100 mL) components of Illinois' water quality standard were evaluated as part of this study. The TMDL is based on meeting the geometric mean component of the standard because it is more restrictive and ensures both standards will be met. The stream flows displayed on a load duration curve may be grouped into various flow zones to aid with interpretation of the load duration curves. The flow zones are typically divided into 10 groups, which can be further categorized into the following five "hydrologic zones" (Cleland, 2005):

- High flow zone: stream flows that plot in the 0 to 10-percentile range, related to flood flows.
- Moist zone: flows in the 10 to 40-percentile range, related to wet weather conditions.
- Mid-range zone: flows in the 40 to 50-percentile range, median stream flow conditions;
- Dry zone: flows in the 60 to 90-percentile range, related to dry weather flows.
- Low flow zone: flows in the 90 to 100-percentile range, related to drought conditions.

The load duration approach helps to identify the issues surrounding the impairment and to roughly differentiate between sources. Table 1-2 summarizes the relationship between the five hydrologic zones and potentially contributing source areas.

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

Table 1-2. Relationship Between Load Duration Curve Zones and Contributing Sources.

	Duration Curve Zone				
Contributing Source Area	**High**	**Moist**	**Mid-Range**	**Dry**	**Low**
Point source				M	H
Livestock direct access to streams				M	H
Onsite wastewater systems	M	M-H	H	H	H
Riparian areas		H	H	M	
Stormwater: Impervious		H	H	H	
Combined sewer overflow (CSO)	H	H	H		
Stormwater: Upland	H	H	M		
Field drainage: Natural condition	H	M			
Field drainage: Tile system	H	H	M-H	L-M	
Bank erosion	H	M			
Note: Potential relative importance of source area to contribute loads under given hydrologic condition (H: High; M: Medium; L: Low)					

1.3 Development of the Little Vermilion River Fecal Coliform TMDL

The Little Vermilion River watershed (ILBO07) is located in east-central Illinois and drains approximately 200 square miles (Figure 1-1). Approximately 85 percent of the total watershed area is in eastern Vermilion County with smaller portions of the watershed in Champaign (13 percent) and Edgar (2 percent) counties.

Fecal coliform has been measured on the Little Vermilion River below the confluence with Yankee Branch since 1980. Figure 1-2 shows the listed segment of the river along with two monitoring stations. A total of 215 fecal coliform samples have been collected at station BO07 between March 7, 1980 and August 3, 2005 (including samples collected outside the primary contact recreation season of May to October). Station BO06 was sampled 10 times during summer of 2005. The fecal coliform counts observed at this location are similar but somewhat lower than those observed during 2005 at the downstream station BO07. This suggests that there are additional sources of fecal coliform downstream of station BO06.

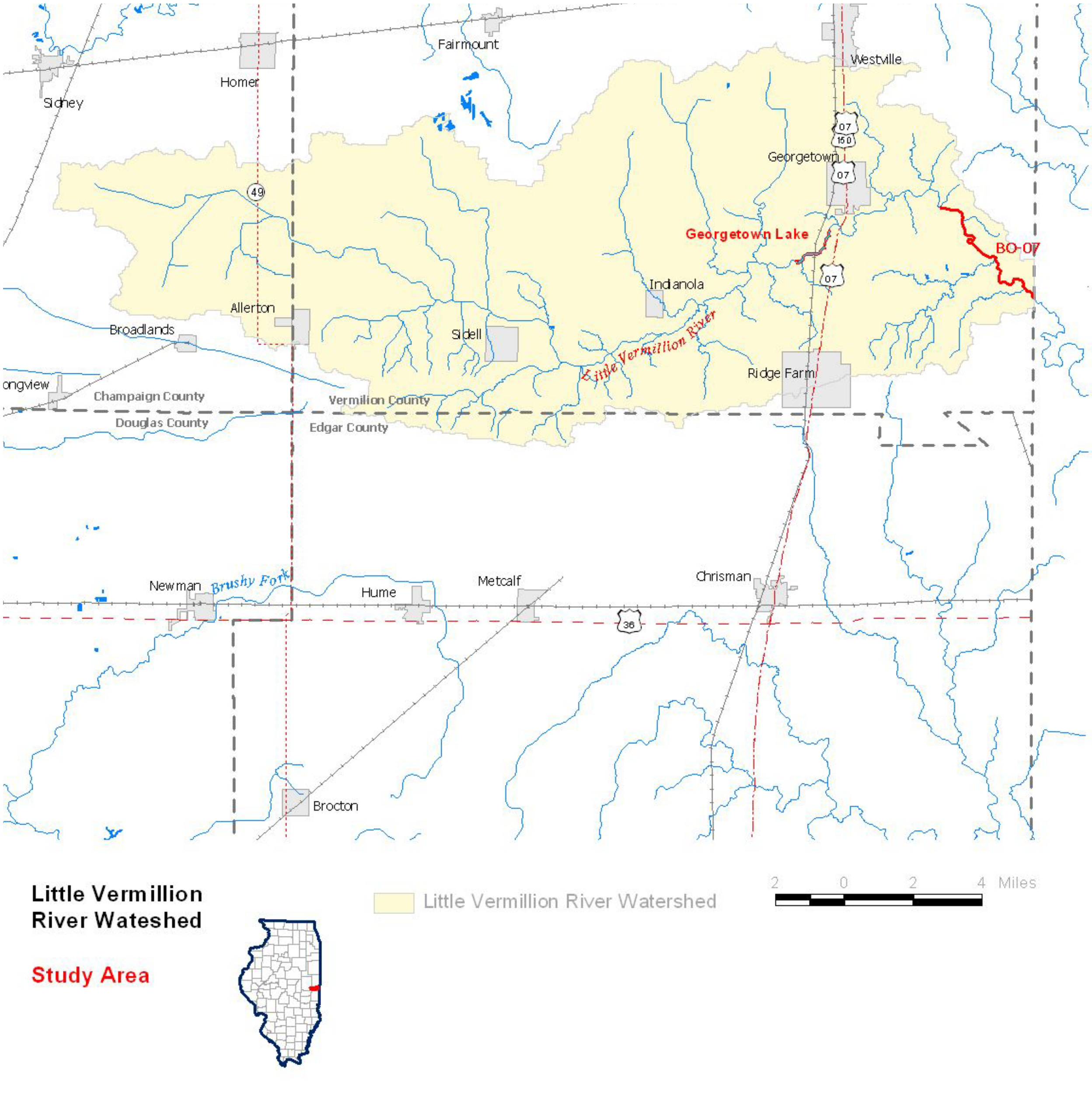

Figure 1-1. Location of the Little Vermilion River Watershed.

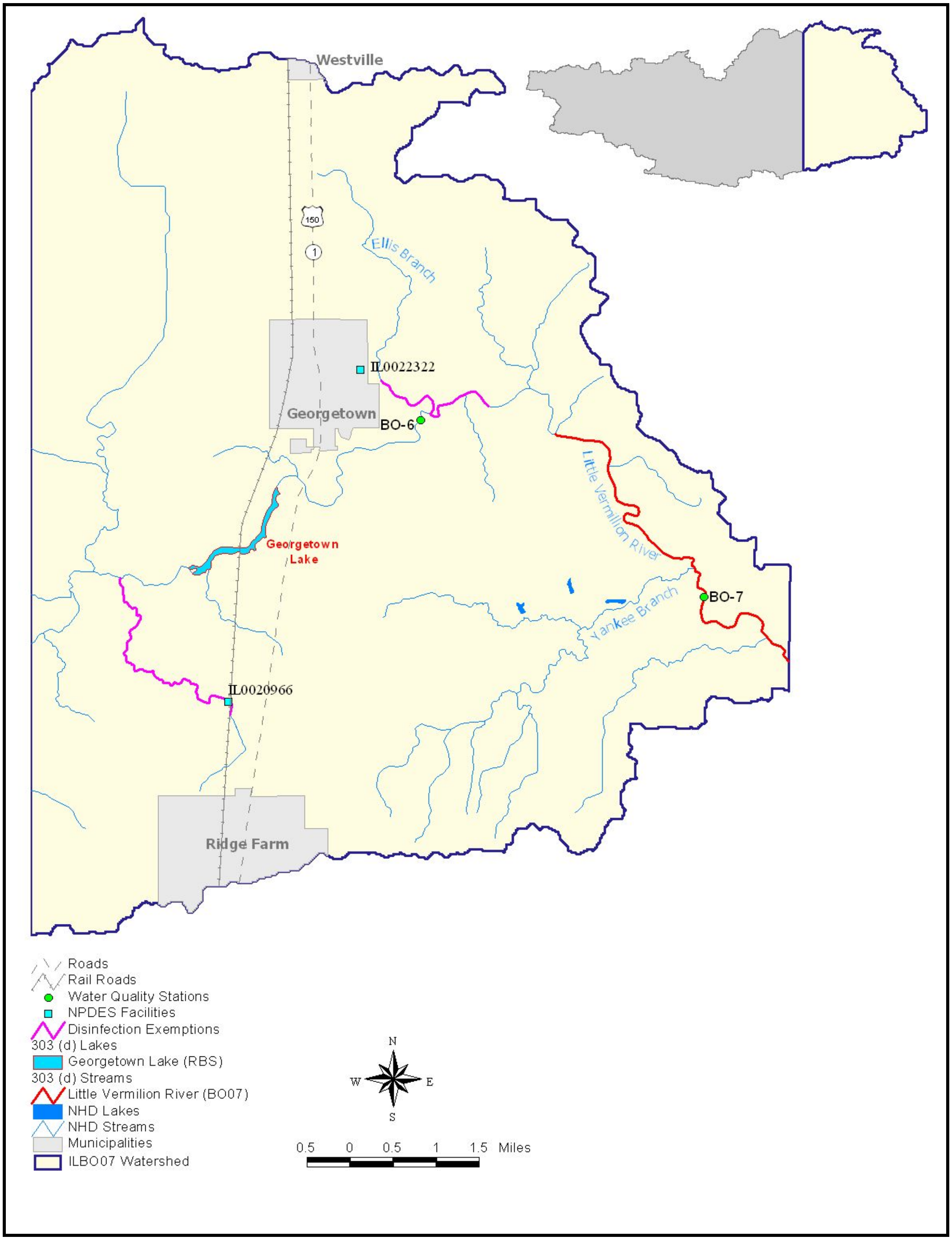

Figure 1-2. Location of IEPA Monitoring Sites BO06 and BO07, Segment BO07, and the Cities of Georgetown and Ridge Farm Disinfection Exemptions.

Figure 1-3 shows the results of the load duration analysis as presented in the Stage Three report and indicates that fecal coliform observations exceed the loading limit consistently across all flow zones. Sources during dry conditions likely include a persistent source such as the Georgetown and Ridge Farm Sewage Treatment Plants, failing onsite wastewater systems, onsite wastewater systems directly connected to agricultural tile drains, or livestock with direct access to streams. Sources of fecal coliform during wet periods likely include the washoff of fecal matter from land surfaces in the watershed, loads from the Georgetown combined sewer overflow (CSO), the point source discharges operating under disinfection exemptions, and the re-suspension of fecal material stored in the stream sediment. No large-scale confined animal feeding operations or Municipal Separate Storm Sewer Systems (MS4s) are located in the watershed.

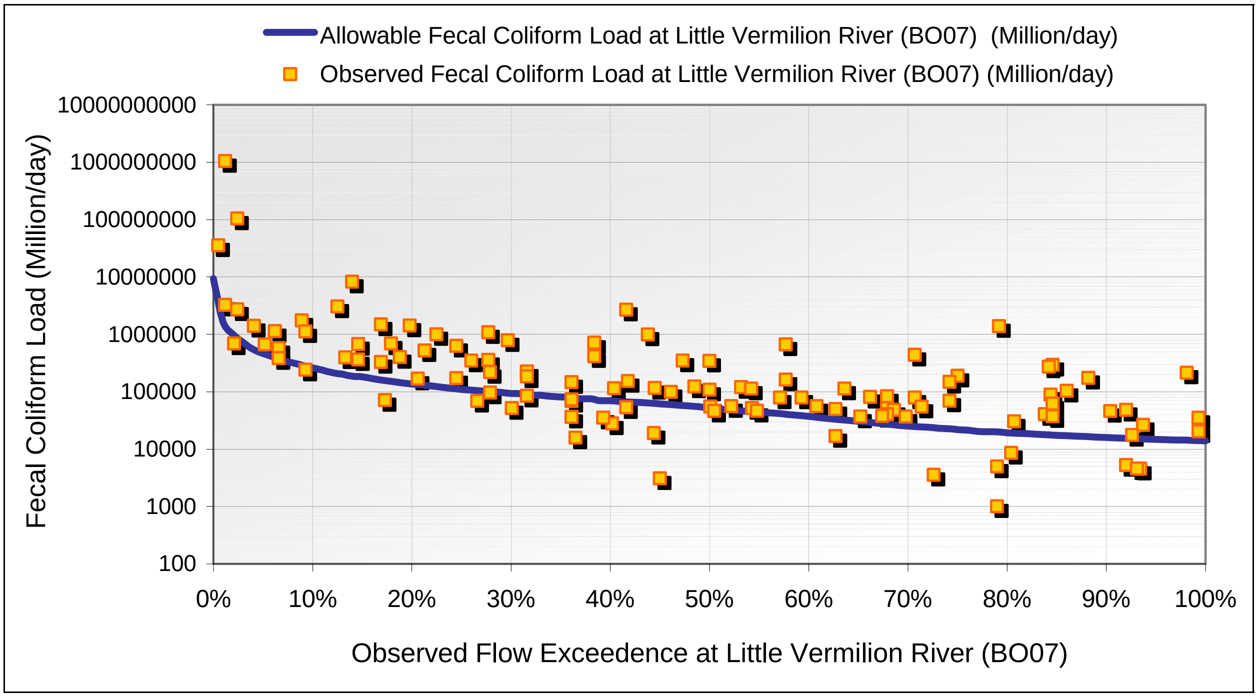

Figure 1-3. Existing Fecal Coliform Loading and Loading Capacity For Load Duration Site BO07. Loading capacity calculated based on geometric mean standard of 200 cfu/100 mL.

The calculated allowable and existing loads displayed in Figure 1-3 were grouped based on hydrologic zones and are summarized in Table 1-3. The existing loads exceed the allowable loads during all flow conditions. Reductions for each flow zone are given in Table 1-4.

This report presents an Implementation Plan that identifies feasible and cost-effective management measures capable of reducing fecal coliform 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) that may reduce the total fecal coliform levels in the Little Vermilion River segment BO-07 to below the water quality standard.

Table 1-3. Fecal Coliform TMDL Summary for the Little Vermilion River.

Zone	Flow Exceedance Ranges	115-Sample Distribution[1]	Median Observed Flow (cfs)	Allowable Load (cfu/day)	Existing Load (cfu/day)	Georgetown Outfall 001 WLA (cfu/day)	Georgetown Outfall 002 WLA (CSO) (cfu/day)	LA (cfu/day)
High Flows	0-10	14	95.32	466,425	1,268,502	11,355	18,168	436,902
Moist Conditions	10-20	12	37.08	181,438	536,326	11,355	0	170,083
	20-30	12	22.23	108,794	352,102	11,355	0	97,439
	30-40	12	16.52	80,854	78,949	11,355	0	69,499
Mid-Range Flows	40-50	14	12.55	61,397	115,274	11,355	0	50,042
	50-60	10	8.99	43,974	79,010	11,355	0	32,619
Dry Conditions	60-70	12	6.25	30,563	49,003	11,355	0	19,208
	70-80	10	4.49	21,969	74,013	11,355	0	10,614
	80-90	10	3.56	17,431	75,062	11,355	0	6,076
Low Flows	90-100	10	3.02	14,791	23,446	11,355	0	3,436

[1] Only samples collected within the recreation season were used for the load duration analysis.

Table 1-4. Load reductions needed for Little Vermilion River Fecal Coliform TMDL.

		Existing Loads			TMDL Loads			Percent Reductions		
Zone	Flow Exceedance Ranges	Outfall 001 (cfu/day)	Outfall 002 (CSO) (cfu/day)	Nonpoint Sources (cfu/day)	Outfall 001 (cfu/day)	Outfall 002 (CSO) (cfu/day)	Nonpoint Sources (cfu/day)	Outfall 001 (%)	Outfall 002 (CSO) (%)	Nonpoint Sources (%)
High Flows	0-10	Unknown	172,596	1,073,196	11,355	18,168	436,902	Unknown	-89%	-60%
Moist Conditions	10-20	Unknown	0	513,616	11,355	0	170,083	Unknown	0%	-68%
	20-30	Unknown	0	329,392	11,355	0	97,439	Unknown	0%	-71%
	30-40	Unknown	0	56,239	11,355	0	69,499	Unknown	0%	0%
Mid-Range Flows	40-50	Unknown	0	92,564	11,355	0	50,042	Unknown	0%	-52%
	50-60	Unknown	0	56,300	11,355	0	32,619	Unknown	0%	-52%
Dry Conditions	60-70	Unknown	0	26,293	11,355	0	19,208	Unknown	0%	-49%
	70-80	Unknown	0	51,303	11,355	0	10,614	Unknown	0%	-83%
	80-90	Unknown	0	52,352	11,355	0	6,076	Unknown	0%	-90%
Low Flows	90-100	Unknown	0	736	11,355	0	3,436	Unknown	0%	-72%

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2.0 DESCRIPTION OF WATERBODY AND WATERSHED CHARACTERISTICS

The purpose of this section of the report is to provide a brief background of Little Vermilion River and its corresponding watershed. More detailed information on the soils, topography, land use/land cover, climate and population of the watershed are available in the Stage One Watershed Characterization Report.

The Little Vermilion River watershed (ILBO07) is located in east-central Illinois and drains approximately 200 square miles. Approximately 85 percent of the total watershed area is in eastern Vermilion County and smaller portions of the watershed are in Champaign (13 percent) and Edgar (2 percent) counties. Based on US Census 2000 data, the estimated population in the Little Vermilion River watershed is 11,000 people. Approximately half of the population live in urban areas. From 1990 to 2000, the watershed experienced a decline in population of 7 percent.

General land cover data for the Little Vermilion River 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 2001 and is the most current detailed land cover data known to be available for the watershed. The listed segment BO07 drains the entire Little Vermilion River watershed and corn and soybean are the dominant crop types, accounting for 44 percent and 39 percent of total watershed area, respectively. Rural grasslands account for slightly more than 10 percent of the watershed area, while forested and urban land uses account for approximately 3.2 percent and 2.2 percent of the watershed area. Land use for the watershed is shown in Figure 2-1.

Soils in the Little Vermilion River watershed are primarily IL010 (Flanagan-Drummer-Catlin) and IL014 (Saybrook-Drummer-Parr). Hydrologic soil group B composes soils throughout the majority of the basin, including soils adjacent to segments RBS and BO07. Hydrologic group C composes soils along the Little Vermilion River from Sidell downstream to Georgetown Lake. The average depth to water table reported in the STATSGO database for soils in the Little Vermilion River watershed ranges from 2.4 to 6 feet. Tile drainage systems are usually placed 3 to 4 feet below the soil surface. The use of tile drains is common in the Little Vermilion River watershed.

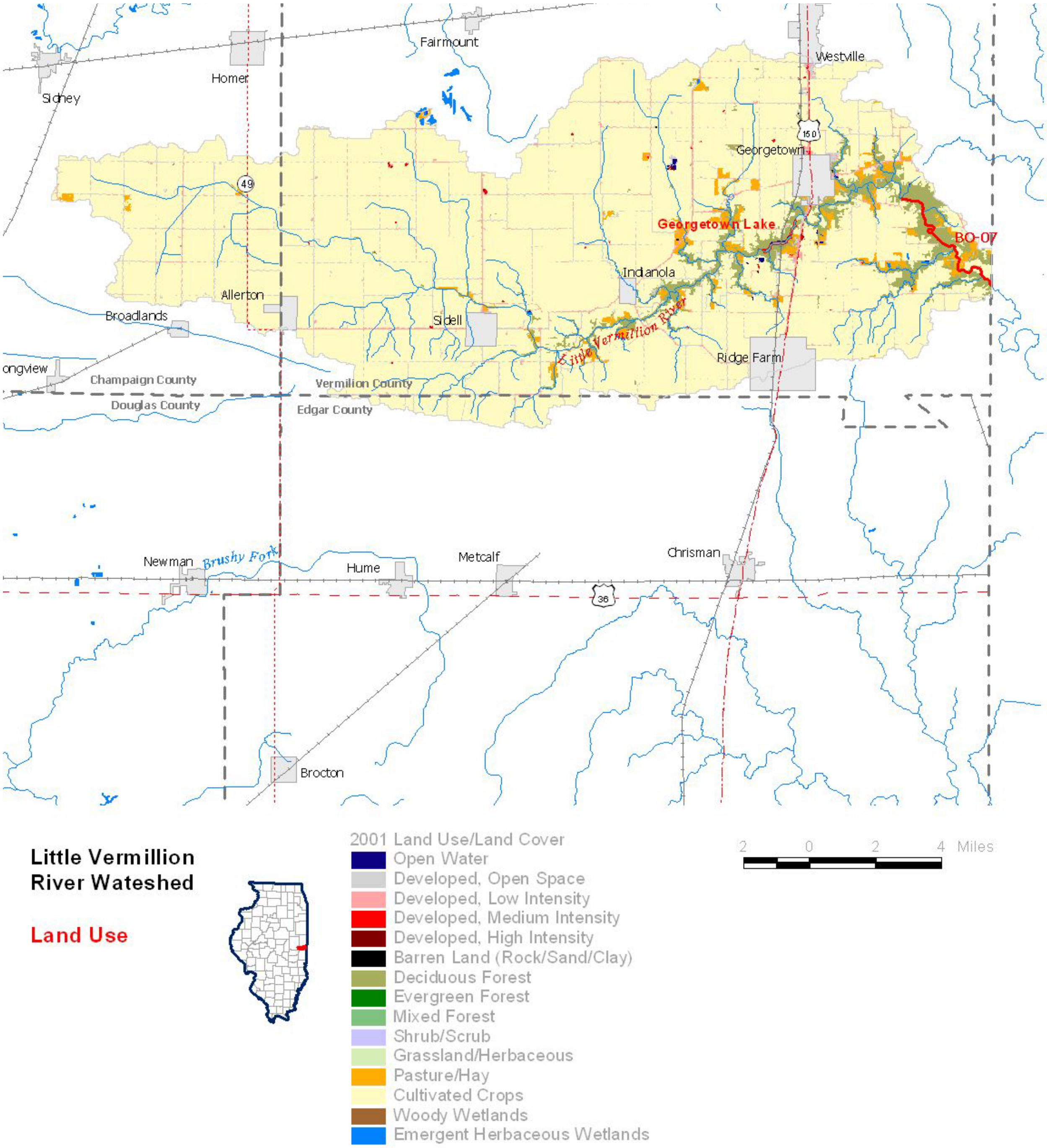

Figure 2-1. Land Use/Land Cover in the Little Vermilion River Watershed (Year 2001 GAP Data).

3.0 WATER QUALITY STANDARDS AND ASSESSMENT OF WATER QUALITY DATA

This section presents the applicable water quality standards and a summary of the historic water quality data for the Little Vermilion River. A more detailed discussion of the available water quality data is available in the Stage One Watershed Characterization 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 that apply to waterbodies in the Little Vermilion River watershed:

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

The following numeric criteria have been adopted to protect the general use fecal coliform standard:

> *"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)*

3.2 Water Quality Assessment

A total of 215 fecal coliform samples collected between March 7, 1980 and August 3, 2005 are available at station BO-07 located on the Little Vermilion River. Table 3-1 summarizes the period of record, number of observations, and geometric mean, minimum and maximum values for each sampling time period, and also presents descriptive statistics for the entire data set.

Table 3-1. Summary of Available Fecal Coliform Data for Station BO-07.

Period of Record	Count	Geometric Mean (cfu/100 mL)	Minimum (cfu/100 mL)	Maximum (cfu/100 mL)
5-19-2005 to 6-14-2005	5	315	160	640
7-6-2005 to 8-03-2005	5	263	230	330
3-07-1980 to 8-03-2005	115	473	10	140,000

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4.0 POLLUTION SOURCES AND MANAGEMENT ACTIVITIES

As discussed in Section 0, the majority of land in the Little Vermilion River watershed (83 percent) is used for agricultural production. Other land uses include grasslands, forest, and urban areas. Wastewater is treated by onsite treatment systems as well as a few small municipal plants. This section describes typical pollutant loading rates from each source category in the watershed along with appropriate best management practices (BMP) to achieve a reduction in fecal coliform loading. The TMDL allocation for Little Vermilion River segment BO-07 indicates that reductions of fecal coliform of 49 to 90 percent are required to meet the Illinois water quality standard depending on flow zone.

4.1 WWTP/NPDES Permittees

There are five permittees with National Pollution Discharge Elimination System (NPDES) permits in the Little Vermilion River watershed. The cities of Georgetown and Ridge Farm each operate a sewage treatment plant. The Ridge Farm facility discharges upstream of Georgetown Lake; the Georgetown facility discharges below the lake. Both facilities are exempt from disinfection of the final treated effluent based on the use classification of the receiving stream. Disinfection of excessive overflows at Ridge Farm and combined sewer overflows at Georgetown is required. These two sewage treatment plants are likely the only point source inputs of fecal coliform in the watershed. Two of the other three permittees are coal mines and the third is a water treatment plant.

4.1.1 Source Description and Approximate Loading

4.1.1.1 Georgetown Sewage Treatment Plant

The only NPDES permitted facility that discharges to the Little Vermilion River downstream of Georgetown Lake is the wastewater treatment facility operated by the City of Georgetown (NPDES ID IL0022322). The design average flow for the facility is 0.6 million gallons per day (MGD) and the design maximum flow for the facility's main outfall (001) is 1.5 MGD. Treatment consists of screening, grit removal, CSO sedimentation and chlorination, primary clarification, trickling filtration, packed bed reactor, final clarification, intermittent sand filtration, anaerobic digestion, drying beds, and land application of sludge. Because the receiving stream (Ellis Branch) and the Little Vermilion River segments BO-06 and BO-02 have been determined to be unsuited to support primary contact activities (swimming) due to physical, hydrologic or geographic configuration, the facility has a disinfection exemption that allows the discharge of treated wastewater from its wastewater treatment plant without first disinfecting the treated effluent. Because of the disinfection exemption, no fecal coliform limit applies to Outfall 001 and the city does not routinely monitor fecal coliform from this outfall. Recent sampling performed in support of this TMDL suggests that average fecal coliform counts fluctuate considerably and are occasionally well above water quality standards as shown in Table 4-1. The City of Georgetown also has two CSO outfalls (Outfalls 002 and 003) and is required to treat and monitor fecal coliform from these outfalls. Table 4-2 lists the volumes and observed fecal coliform concentrations from Outfall 002. No water quality measurements for Outfall 003 were provided for use in this implementation plan.

Table 4-1. Fecal Coliform Counts from City of Georgetown Outfall 001.

Date	Outfall 001	
	Total Fecal Coliform (cfu/100ml)	MGD
5/9/2006	66	0.939
5/17/2006	26,000	1.191
5/24/2006	280	1.057
6/1/2006	89,000	0.463

Table 4-2. Fecal Coliform Counts from City of Georgetown Outfall 002.

Month	Overflow Flow (million gallons)	Overflow Count (cfu/100 mL)	Recreation Season
June-96	0.184	150,000	Yes
July-96	0.581	59,000	Yes
January-97	0.2	800	No
February-97	0.28	25,000	No
March-97	0.28	570	No
December-97	0.28	1,600	No
January-98	0.28	390	No
March-98	7.2	4,600	No
April-98	0.644	3,800	No
May-98	19.953	19,000	Yes
June-98	6.312	3,300	Yes
July-98	4.714	2,100	Yes
January-99	4.481	4,400	No
February-99	9.089	1,000	No
March-99	1.426	230	No
June-99	1.557	3,800	Yes
July-99	1.528	90	Yes
June-00	1.116	250	Yes
July-00	0.974	300	Yes
February-01	5.188	20	No
March-01	1.044	0	No
October-01	4.253	10	Yes
February-02	3.28	0	No
April-02	14.04	2,200	No
May-02	13.44	600	Yes
June-02	2.8	60	Yes
September-03	0.9	8,000	Yes
November-03	1.8	11,000	No
December-03	1.35	60	No
January-04	3.6	5,600	No
March-04	4.05	1,400	No
April-04	0.45	340	No
May-04	0.45	600	Yes
June-04	1.35	3,000	Yes
November-04	1.35	35,000	No
December-04	2.7	1,300	No
January-05	6.75	1,600	No
February-05	2.7	1,000	No

Note that total overflow volumes are reported for an entire month and the duration of the overflow(s) (e.g., 10 hours) are not available. For the purposes of estimating existing loads in the TMDL, it was assumed that each month's overflow volume occurred within a 24-hour period.

Separate wasteload allocations for Outfalls 001 and 002 were presented in the Stage Three TMDL report. The WLA for Outfall 001 is based on the design maximum flow of 1.5 MGD multiplied by the geometric mean water quality standard of 200 cfu/100 mL (11,355 million cfu/d) and applies for each day in the recreation season. The reductions needed from this outfall are unknown due to the lack of historic data (i.e., existing loads are unknown). However, based on the limited data shown in Table 4-1, daily fecal coliform loads have been observed at 1,559,685 million cfu, and it appears that reductions are needed.

The WLA for the CSO (Outfall 002) is based on the historic median flow rate of approximately 1.5 MGD for overflows that occur during the recreation season multiplied by the permit limit of 400 cfu/100 mL (22,700 million cfu). The WLA for the CSO only applies to the high flow zone because the CSO is assumed to only discharge during very wet periods. Approximately a 90 percent reduction in loads is needed from the CSO to meet water quality standards because monitoring data suggest a median CSO effluent of approximately 1,200 cfu/100 mL for overflows that occur during the recreation season (Table 4-2).

Table 4-3 summarizes the range of loading observed for the primary and CSO outfalls for this plant.

Table 4-3. Observed Fecal Coliform Loading from the Georgetown STP.

Outfall	Range of Observed Loading (million cfu/d)	TMDL Allocation (million cfu/d)
Primary (001)	2,346 to 1,559,685	11,355
CSO (002)	1,610 to 14,349,200	22,700

4.1.1.2 Ridge Farm Sewage Treatment Plant

The Ridge Farm Sewage Treatment Plant (NPDES ID IL0020966) discharges to an unnamed tributary above Georgetown Lake. The design average flow for the facility is 0.201 MGD and the design maximum flow for the facility’s main outfall (001) is 0.449 MGD. Treatment consists of a grit chamber, barscreen, comminutor, Imhoff tanks, trickling filter, secondary clarifier, intermittent sand filtration, anaerobic digestion, and vacuum-assisted drying beds. No wasteload allocation was assigned for this plant in the TMDL process.

This facility discharges secondary effluent under a disinfection exemption but is required to disinfect excessive flows. Because of the disinfection exemption, no fecal coliform limit applies to Outfall 001 and the facility does not monitor fecal coliform from this outfall. The STP does have an excess flow outfall (A01) and is required to treat and monitor fecal coliform from this outfall. The fecal coliform permit limit for the excess flow is 400 cfu/100 mL. Point source query data obtained from the EPA PCS website only lists one excess flow event between May 2005 and November 2006. The event occurred sometime in March 2006 with a reported fecal coliform count of 10 cfu/100 mL.

Table 4-4 summarizes the range of loading seen from the primary and excess flow outfalls for this plant. No fecal coliform counts have been collected from the primary outfall, and only one data point was available to estimate the load from excess flows.

Table 4-4. Observed Fecal Coliform Loading from the Ridge Farm STP.

Outfall	Range of Observed Loading (million cfu/d)
Primary (001)	No data
Excess Flow (A01)	227

4.1.2 Appropriate BMPs

4.1.2.1 Disinfection of Primary Effluent (Outfall 001)

Sewage from treatment plants treating domestic and/or municipal waste contains fecal coliform bacteria, which is indigenous to sanitary sewage. In Illinois, a number of these treatment plants have applied for and received disinfection exemptions, which allow a facility to discharge wastewater without disinfection. All of these treatment facilities are required to comply with the geometric mean fecal coliform water quality standard of 200 cfu/100 mL at the closest point downstream where recreational use occurs in the receiving water or where the water flows into a fecal-impaired segment. Facilities with year-round disinfection exemptions may be required to provide the Agency with updated information to demonstrate compliance with these requirements. Facilities directly discharging into a fecal-impaired segment may have their year-round disinfection exemption revoked through future NPDES permitting actions.

Reducing the fecal coliform concentrations from a primary outfall of an exempt facility to 200 cfu/100 mL will require a permit change and disinfection of the effluent prior to discharge. Common disinfection techniques include chlorination, ozonation, and UV disinfection. In most cases, chlorination is the most cost-effective alternative, though residuals and oxidized compounds are toxic to aquatic life; subsequent dechlorination may be necessary prior to discharge which will increase costs similar to the other two options (USEPA, 1999a). The options most frequently employed are discussed below.

Chlorination

Chlorine compounds used for disinfection are usually either chlorine gas or hypochlorite solutions though other liquid and solid forms are available. Oxidation of cellular material destroys pathogenic organisms. The remaining chlorine residuals provide additional disinfection, but may also react with organic material to form harmful byproducts. To reduce the impacts on aquatic life from chlorine residuals and byproducts, a dechlorination step is often included in the treatment process (USEPA, 1999a).

The advantages of chlorine disinfection are

- Generally more cost-effective relative to UV disinfection or ozonation if dechlorination is not required.
- Residuals continue to provide disinfection after discharge
- Effective against a wide array of pathogens
- Capable of oxidizing some organic and inorganic compounds
- Provides some odor control
- Allows for flexible dosing

There are several disadvantages as well:

- Chlorine residuals are toxic to aquatic life and may require dechlorination, which may increase costs by 30 to 50 percent
- Highly corrosive and toxic with expensive shipping and handling costs

- Meeting Uniform Fire Code requirements can increase costs by 25 percent
- Oxidation of some organic compounds can produce toxic byproducts
- Effluent has increased concentrations of dissolved solids and chloride

More information about disinfection with chlorine is available online at
http://www.consolidatedtreatment.com/manuals/Fact_sheet_chlorine_disinfection.pdf

Ozonation

Ozone is generated onsite by passing a high voltage current through air or pure oxygen (USEPA, 1999b). The resulting gas (O_3) provides disinfection by destroying the cell wall, damaging DNA, and breaking carbon bonds. The advantages of ozonation include

- Ozone is more effective than chlorine and has no harmful residuals
- Ozone is generated onsite so there are no hazardous transport issues
- Short contact time of 10 to 30 minutes
- Elevates the DO of the effluent

Disadvantages are

- More complex technology than UV light or chlorine disinfection
- Highly reactive and corrosive
- Not economical for wastewater with high concentrations of BOD, TSS, COD, or TOC
- Initial capital, maintenance, and operating costs are typically higher than for UV light or chlorine disinfection

More information about ozonation is available online at
http://www.epa.gov/owmitnet/mtb/ozon.pdf

Ultraviolet Disinfection

UV radiation is generated by passing an electrical current through a lamp containing mercury vapor. The radiation attacks the genetic material of the organisms, destroying reproductive capabilities (NSFC, 1998).

The advantages of UV disinfection are

- Highly effective
- Destruction of pathogens occurs by physical process, so no chemicals must be transported or stored
- No harmful residuals
- Easy to operate
- Short contact time (20 to 30 min)
- Requires less space than chlorination or ozonation

Disadvantages of UV disinfection are

- Organisms can sometimes regenerate
- Turbidity and TSS can interfere with disinfection at high concentrations
- Not as cost effective compared to chlorination alone, but when fire code regulations and dechlorination are considered, costs are comparable.

More information about disinfection with UV radiation is available online at http://www.nsfc.wvu.edu/nsfc/pdf/eti/UV_Dis_tech.pdf

4.1.2.2 Control of Combined Sewer Overflows and Excess Flows

Combined sewer systems transport both wastewater and stormwater/snowmelt to the treatment plant. During extremely wet weather, if the capacity of the system is exceeded, the plants are designed to overflow to surface waterbodies such as streams or lakes. In 1994, EPA issued a list of nine minimum control measures that will reduce the frequency and volume of overflows without requiring significant engineering or construction to implement. The nine controls are listed below (USEPA, 1994):

- Proper operating and maintenance procedures should be followed for the sewer system, treatment plant, and CSO outfalls. Periodic inspections are necessary to identify problem areas.
- Maximize use of the collection system for storage:
  - Remove obstructions and repair valves and flow devices
  - Adjust storage levels in the sewer system
  - Restrict the rate of stormwater flows:
    - Disconnect impervious surfaces
    - Use localized detention
  - Upgrade or adjust the rate of lift stations
  - Remove obstructions in the conveyance system
- Review and modification of pretreatment requirements to ensure that CSO impacts are minimized:
  - Minimize impacts of discharges from industrial and commercial facilities
  - May need to require more onsite storage of process wastewater or stormwater runoff
- Maximize flow to the POTW for treatment:
  - Assess the capacity of the pumping stations, major interceptors, and individual process units
  - Identify locations of additional available capacity
  - Identify unused units or storage facilities onsite that may be used to store excess flows
- Elimination of CSOs during dry weather:
  - Initiate an inspection program to identify dry weather overflows
  - Adjust or repair flow regulators
  - Fix gates stuck in the open position

  - Remove blockages that prevent the wastewater from entering the interceptor
  - Cleanout interceptors
  - Repair sewer lines that are infiltrated by groundwater
- Control of solid and floatable materials in CSOs:
  - Use of baffles, screens, and racks to reduce solids
  - Street sweeping
- Pollution prevention programs to reduce contaminants in CSOs:
  - Education, street sweeping, solid waste and recycling collection programs
- Public notification to ensure that the public receives adequate notification of CSO occurrences and CSO impacts:
  - Notifying the public of the locations, health concerns, impacts on the environment
- Monitoring to effectively characterize CSO impacts and the efficacy of CSO controls:
  - Record the flow and duration of each CSO event as well as the total daily rainfall
  - Quality monitoring for permit requirements or modeling exercises

The USEPA Guidance for Nine Minimum Controls for Combined Sewer Overflows is available online at http://www.epa.gov/npdes/pubs/owm0030.pdf

The Water Environment Research Foundation suggests a decentralized approach to minimizing the frequency and volumes of CSO events (WERF, 2005). This approach utilizes individual site BMPs that encourage evapotranspiration and infiltration to reduce the volume of runoff, rather than storing large volumes of stormwater from larger land areas in the conventional, centralized controls. Practices that reduce CSOs include

- routing gutter downspouts to pervious surfaces,
- collecting rainwater in barrels and cisterns,
- using vegetative controls such as vegetated roofs, filter strips, grass swales, pocket wetlands, or rain gardens,
- porous pavement,
- infiltration ditches,
- soil amendments that improve vegetative growth and/or increase water retention,
- and tree box filters.

Excessive stormwater volumes contributing to CSOs typically occur in urban areas with large amounts of impervious surface, overly compacted soil, and little pervious or open space. Because decentralized controls treat a smaller volume of stormwater runoff, they require a smaller footprint and are easier to incorporate into a pre-existing landscape compared to the larger, more conventional practices such as stormwater detention ponds. However, retrofitting a previously developed area with BMPs does present challenges which must be considered during design: potential damage to roadway and building foundations, issues with standing water and mosquito breeding, and perceptions of private property owners. All of these may be overcome with proper planning and education.

If the nine minimum controls, including decentralized BMPs, do not reduce the frequency and impacts of CSOs from the two sewage treatment plants (STPs), then long-term measures may be required. These are listed below and described in more detail in the Combined Sewer Overflows Guidance for Long-term Control Plan (USEPA, 1995):

- Characterization, monitoring, and modeling activities as the basis for selection and design of effective CSO controls
- A public participation process that actively involves the affected public in the decision making to select long-term CSO controls
- Consideration of sensitive areas as the highest priority for controlling overflows
- Evaluation of alternatives that will enable the permittee, in consultation with the NPDES permitting authority, water quality standards (WQS) authority, and the public, to select CSO controls that will meet Clean Water Act (CWA) requirements
- Cost/performance considerations to demonstrate the relationships among a comprehensive set of reasonable control alternatives
- Operational plan revisions to include agreed-upon long-term CSO controls
- Maximization of treatment at the existing publicly owned treatment works (POTW) treatment plant for wet weather flows
- An implementation schedule for CSO controls
- A post-construction compliance monitoring program adequate to verify compliance with water quality-based CWA requirements and ascertain the effectiveness of CSO controls

The USEPA Guidance for Long-term Controls for Combined Sewer Overflows is available online at http://www.epa.gov/npdes/pubs/owm0272.pdf

4.1.3 Estimated Cost of Implementation

4.1.3.1 Disinfection of Primary Effluent

Upgrading the existing STPs to include disinfection prior to discharge can be achieved with either chlorination, ozonation, or UV radiation processes. The costs associated with these three techniques include upfront capital costs to construct additional process units, operating and maintenance costs for chemicals, electricity, labor, etc., as well as chemical storage and fire code requirements associated with the chlorination option. The USEPA compares costs of chlorination, ozonation, and UV disinfection in a series of fact sheets available online. This information is summarized below as well as in Table 4-5. Prices in the fact sheets were listed in either 1995 or 1998 dollars. Prices have been converted to year 2004 dollars, assuming a 3 percent per year inflation rate, for comparison with the other BMPs discussed in this plan that must be described in year 2004 dollars.

Chlorine dosage usually ranges from 5 mg/L to 20 mg/L depending on the wastewater characteristics and desired level of disinfection. The cost of adding a chlorination/dechlorination system meeting fire code requirements and treating 1 MGD of wastewater with a chlorine dosage of 10 mg/L costs approximately $1,260,000 in 1995 with annual operation and maintenance costs of $59,200 (USEPA, 1999a). If a 3 percent per year inflation rate is assumed, these costs in 2004 dollars are $1,640,000 and $77,200, respectively.

Costs for ozonation were given by USEPA (1999b) in 1998 dollars. The capital costs in 1998 for treating 1 MGD of secondary wastewater with BOD and TSS concentrations each less than 30 mg/L was $300,000. The operating and maintenance costs were listed at $18,500 plus the costs of electricity. In 2004 dollars, these costs are $358,200 and $22,000, respectively.

Ultraviolet radiation costs were listed in 1995 dollars by USEPA (1995) relative to the cost per bulb. Based on vendor information available online, approximately 40 bulbs would be required to treat 1 MGD of secondary wastewater. Based on the information presented, the capital costs in 2004 for a 1 MGD facility would be approximately $750,000 and the annual operating and maintenance costs would range from $4,500 to $5,100.

Table 4-5 compares the costs for these three disinfection technologies. Annualized costs are calculated assuming a 20-year system life for each technology before major repairs or replacement would be required.

Table 4-5. Comparison of Disinfection Costs (2004) per 1 MGD of Sewage Treatment Plant Effluent.

Technology	Capital Costs	Annual Operating and Maintenance Costs	Annualized Costs
Chlorination (10 mg/L dosage), dechlorination, fire code regulations	$1,640,000	$77,200	$159,200
Ozonation	$358,200	$22,000	$39,900, plus cost of electricity
UV Disinfection	$750,000	$4,500 to $5,100	$42,000 to $42,600

4.1.3.2 CSO Controls

Relative to the cost of upgrading the sewage treatment plants to include a disinfection process, instituting the nine minimum controls for CSOs should be a minimal cost to each facility. Plant operators and inspection personnel are likely already on hand to perform most of these functions. If the nine minimum controls are not effective in reducing the fecal coliform loading from the CSOs, the more costly long-term measures may be needed. These may include additional monitoring, modeling, and plant upgrades to provide adequate storage during wet weather events.

4.1.4 Effectiveness and Estimated Load Reductions

It is difficult to estimate the current fecal coliform load from these two facilities because fecal coliform is not currently monitored on a routine basis. Based on the four fecal coliform samples collected in May and June of 2006, the load from the Georgetown STP likely ranges from 2,346 to 1,559,685 million cfu/day. A load allocation of 11,355 million cfu/d would require a reduction in fecal coliform loading ranging from zero to 99.3 percent. No data are available to estimate existing loading or required reductions from the Ridge Farm STP.

The combined sewer overflow at the Georgetown STP has reported loads ranging from 1,610 to 14,349,200 million cfu/day during high flow events. With a load allocation of 22,700 million cfu/d, reductions in loading from the CSO range from zero to 99.9 percent. No permit violations of the excess flow at the Ridge Farm facility were reported.

4.2 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems are a potential source of fecal coliform loading to the Little Vermilion River. Approximately 6,830 people in the watershed are served by onsite wastewater treatment systems. Properly functioning systems typically achieve fecal coliform concentrations around 1,000 cfu/100 mL within the tank, but a malfunctioning system may have concentrations of 1,000,000 to

100,000,000 cfu/100 mL (Siegrist et al., 2000). Malfunctioning systems that backup into homes, onto yards, or short-circuit the drainfield and discharge quickly to groundwater may expose humans and other animals to pathogenic organisms.

4.2.1 Source Description

Even properly functioning onsite wastewater systems contribute fecal coliform loading to the surrounding environment. Typically, by the time effluent reaches the groundwater zone, concentrations have been reduced by 99.99 percent by natural processes. However, if systems are placed on unsuitable soils, not maintained properly, or are connected to subsurface drainage systems such as tile drains, loading rates to receiving waterbodies may be relatively high. In order to accurately quantify the loading to the Little Vermilion River, an inspection of each system in the watershed would be needed. Systems older than 20 years and those located near the river and its tributaries should be inspected first.

During the Watershed Characterization and Water Quality Analysis for this watershed (Tetra Tech, 2005), it was estimated from year 2000 US Census data that approximately 11,005 people reside in the watershed. Urban areas such as Ridge Farm and Georgetown provide sewer service for approximately 4,178 people. Therefore, approximately 6,827 people are served by onsite wastewater treatment systems.

In a properly functioning septic system, wastewater effluent leaves the septic tank and percolates through the system drainfield. Fecal coliform concentrations are typically reduced by 99.99 percent (Siegrist et al., 2000). Failing systems that short circuit the soil adsorption field, result in ponding on the ground surface, or backup into homes will have concentrations typical of raw (untreated) sewage. Direct discharge systems that intentionally bypass the drainfield by connecting the septic tank directly to a waterbody or other transport line (such as an agricultural tile drain) will also have concentrations similar to raw sewage.

A properly functioning onsite wastewater treatment system typically achieves fecal coliform concentrations of 100 to 10,000 cfu/100 mL (Siegrist et al., 2000), or an average reduction in loading of 99.99 percent. A malfunctioning system, however, does not provide adequate soil-zone treatment, and concentrations of 1,000,000 to 100,000,000 cfu/100 mL are typical (Siegrist et al., 2000). Translating these concentrations to daily loads from the population served is achieved by assuming a wastewater generation rate. Rates reported in the literature are typically 100 gpd (gallons per person per day). In addition, assumptions regarding the rate of failure are needed. Unfortunately, estimates of failure are difficult to ascertain unless a formal inspection program exists, and few communities have such programs in place. In tile-drained agricultural watersheds such as this one, loading rates are often high due to direct connection of septic tank effluent to the tile drain lines (without treatment in the soil drain field) (Bird, 2006).

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 in other heavily tiled watersheds in east-central Illinois, failure rates in the Little Vermilion River watershed are likely higher than the national average. Systems closest to Segment BO-07 will have more impact on the impaired reach though those systems located upstream may cause localized impacts detrimental to water quality or human health.

4.2.2 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 (i.e., 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 (USEPA, 2002b). 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.

At this time, there is not a formal inspection and maintenance program in Vermilion County. The County Health Department does issue permits for new onsite systems and major repairs. In addition, the Health Department investigates complaints concerning illegal sewage discharges and does limited surveys to locate them (Riggle, 2007).

4.2.3 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 backups.

The cost to pump a septic tank ranges from $250 to $350 depending on how many gallons are pumped out and the disposal fee for the area. If a system is pumped once every three to five years, this expense averages out to less than $100 per year. Septic systems 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 Little Vermilion River watershed depends on the number of systems that need to be inspected. Based on Census data collected in 2000, there are approximately 2,837 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. 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 costs associated with inspecting and maintaining onsite wastewater treatment systems and educating owners of their responsibilities is summarized in Table 4-6.

Table 4-6. 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

4.2.4 Effectiveness and Estimated Load Reductions

There is a high degree of uncertainty associated with onsite wastewater system fecal coliform loads to the Little Vermilion River. The Champaign County Health Department (Bird, 2006) has identified several systems in the county that were directly connected to a subsurface drainage system. Bacterial counts from the discharge water were over 90,000/100 mL, indicating a poor level of treatment. Pollutant loads from similar systems pose a threat to the water quality in the river as well as a public health hazard. Ideally, all systems in the watershed would be maintained, repaired, and replaced frequently enough to ensure proper treatment of wastewater. The reductions required range from 99.8 to over 99.9 depending on the current rate of failure in the watershed.

4.3 Animal Operations

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

(Photo courtesy of USDA NRCS.)

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

4.3.1 Source Description and Approximate Loading

The United States Department of Agriculture distributes agricultural data through the National Agricultural Statistics Service (NASS). Data are available by county and include farm size, market value, crop types, etc., as well as animal counts of cattle, swine, poultry, and sheep. To protect the privacy of the farmers, animal counts are not listed for individual farms. Instead, the numbers are reported on a countywide basis.

Data from the NASS were downloaded for Vermilion, Champaign, and Edgar Counties and area weighted to estimate the number of animals in the Little Vermilion River watershed. Table 4-7 lists the estimated animal counts for the watershed.

Table 4-7. Estimated Number of Livestock and Poultry in the Little Vermilion Watershed.

Animal	Champaign Co.	Edgar Co.	Vermilion Co.	Sum
Broiler Chickens	11	0	45	56
Layer chickens	98	1	95	194
Beef cattle	30	21	571	622
Dairy cattle	2	1	31	34
Other cattle: heifers, bulls, calves, etc.	101	36	981	1,118
Hogs and pigs	551	0	3591	4,143
Sheep and lambs	10	2	67	80

Large animals produce more fecal matter per animal compared to smaller animals, so the concept of animal unit is used to normalize loading from various operations. Fecal coliform loading rates are usually given as the bacterial count per animal unit per day. Table 4-8 lists the number of animals equivalent to one animal unit (IDA, 2001) for each of the livestock and poultry classes likely present in the watershed (USEPA, 2002a). In addition, the table lists the total number of animal units in the watershed. Animals that deposit fecal material directly into a stream channel near Segment BO-07 will contribute more loading to the impaired reach than animals who deposit material on land in the headwaters of the watershed.

Table 4-8. Animal Unit Data and Fecal Coliform Loading Rates for the Little Vermilion River Watershed.

Animal	Number of Animals in One Animal Unit	Number of Animal Units in Watershed
Broiler Chickens	50	1.1
Layer chickens	50	3.9
Beef cattle	1	622
Dairy cattle	0.71	47.6
Other cattle: heifers, bulls, calves, etc.	1	1,118
Hogs and pigs	2.5	1,657.2
Sheep and lambs	10	8

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

4.3.2 Appropriate BMPs

Animal operations typically require a suite of BMPs to protect water quality. BMPs recommended by the NRCS and USEPA are discussed in the following sections.

4.3.2.1 Manure Handling, Storage, and Treatment

Animal operations are typically either pasture-based or confined, or sometimes a combination of the two. The operation type dictates the practices needed to manage manure from the facility. A pasture or open lot system with a relatively low density of animals (1 to 2 head of cattle per acre (USEPA, 2002a)) may not produce manure in quantities that require management for the protection of water quality. If excess manure is produced, then the manure will typically be scraped with a tractor to a storage bin constructed on a concrete surface. Stored manure can then be land applied when the ground is not frozen and precipitation forecasts are low. Rainfall runoff should be diverted around the storage facility with berms or grassed waterways. Runoff from the feedlot area is considered contaminated and is typically treated in a lagoon.

Confined facilities (typically dairy cattle, swine, and poultry operations) often collect manure in storage pits located under slatted floors. Wash water used to clean the floors and remove manure buildup combines with the solid manure to form a liquid or slurry in the pit. The mixture is usually land applied or transported offsite.

Final disposal of waste usually involves land application on the farm or transportation to another site. Manure is typically applied to the land once or twice per year. To maximize the amount of nutrients and organic material retained in the soil, application should not occur on frozen ground or when precipitation is forecast during the next several days.

Storage of manure for at least 30 days prior to land application may reduce fecal coliform concentrations in runoff by 97 percent (Meals and Braun, 2006). Use of waste storage structures, ponds, and lagoons (Figure 4-2) reduce fecal coliform loading by 90 percent (USEPA, 2003). Anaerobic treatment in a lagoon or digester may reduce pathogen concentrations to 100 cfu per 100 mL in less than 15 days if temperatures are maintained at 35 ºC (Roos, 1999).

(Photo courtesy of USDA NRCS.)

Figure 4-2. Waste Storage Lagoon.

The NRCS provides additional information on waste storage facilities and cover at
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 313 and 367

and on anaerobic lagoons at
http://efotg.nrcs.usda.gov/references/public/IL/IL-365_2004_09.pdf
http://efotg.nrcs.usda.gov/references/public/IL/IL-366_2004_09.pdf

4.3.2.2 Manure Composting

Composting is the biological decomposition and stabilization of organic material. The process produces heat that, in turn, produces a final product that is stable, free of pathogens and viable plant seeds, and can be beneficially applied to the land. Like manure storage areas, composting facilities should be located on dry, flat, elevated land at least 100 feet from streams. The landowner should coordinate with local NRCS staff to determine the appropriate design for a composting facility based on the amount of manure generated. Extension agents can also help landowners achieve the ideal nutrient ratios, oxygen levels, and moisture conditions for composting on their site.

Composting can be accomplished by simply constructing a heap of the material, forming composting windrows, or by constructing one or more bins to hold the material. Heaps should be 3 feet wide and 5 feet high with the length depending on the amount of manure being composted. Compost does not have to be turned, but turning will facilitate the composting process (University of Missouri, 1993; PSU, 2005). Machinery required for composting includes a tractor, manure spreader, and front-end loader (Davis and

Swinker, 2004). Heat produced during the process has been found to reduce fecal coliform concentrations by 99 percent (Larney et. al., 2003). Figure 4-3 shows a poultry litter composting facility.

(Photo courtesy of USDA NRCS.)

Figure 4-3. Poultry Litter Composting Facility.

The NRCS provides additional information on composting facilities at
http://efotg.nrcs.usda.gov/references/public/IL/IL-317rev9-04.pdf
and
ftp://ftp.wcc.nrcs.usda.gov/downloads/wastemgmt/neh637c2.pdf

4.3.2.3 Animal Management Strategies

Cattle Exclusion from Streams

Cattle manure is a substantial source of nutrient and fecal coliform loading to streams, particularly where direct access is not restricted and/or where cattle feeding structures are located adjacent to riparian areas. Direct deposition of feces into streams may be a primary mechanism of fecal coliform loading during baseflow periods. During storm events, overbank and overland flow may entrain manure accumulated in riparian areas resulting in pulsed loads of nutrients, total organic carbon (TOC), biological oxygen demand (BOD), and fecal coliform bacteria into streams. In addition, cattle with unrestrained stream access typically cause severe streambank erosion. The impacts of cattle on stream ecosystems are shown in Figure 4-4 and Figure 4-5.

Figure 4-4. Typical Stream Bank Erosion in Pastures with Cattle Access to Stream.

Figure 4-5. Cattle-induced Streambank Mass Wasting and Deposition of Manure into Stream.

Stream channel morphology and floodplain quality are also believed to play an important role in high fecal coliform densities observed in many agricultural watersheds. It is well established (Thomann and Mueller, 1987) that coliform bacteria may be stored in stream sediment, where they experience a lower die off rate, and diffuse back into the water column, resulting in a slower recovery of stream concentrations to baseflow levels after washoff events. High TSS concentrations have also been correlated to high fecal coliform counts as have low habitat scores (OEPA, 2006).

Fencing cattle from streams and riparian areas using vegetative or fencing materials will reduce streambank trampling and direct deposition of fecal material in the streams. A reduction of 29 to 46 percent of fecal coliform concentrations is reported (USEPA, 2003). An example of proper exclusion and the positive impacts on the stream channel are shown in Figure 4-6.

(Photo courtesy of USDA NRCS.)

Figure 4-6. Stream Protected from Sheep by Fencing.

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

Allowing limited or no animal access to streams will provide the greatest water quality protection. On properties where cattle need to cross streams to have access to pasture, stream crossings should be built so that cattle can travel across streams without degrading streambanks and contaminating streams with manure. Figure 4-7 shows an example of a reinforced cattle access point to minimize time spent in the stream and mass wasting of streambanks.

(Photo courtesy of USDA NRCS.)

Figure 4-7. Restricted Cattle Access Point with Reinforced Banks.

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

Alternative Drinking Sources for Cattle

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

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

Alternative watering locations used concurrently with cattle exclusion practices have shown reductions in fecal coliform loading of 29 to 46 percent. Some researchers have studied the impacts of providing alternative watering sites without structural exclusions and found that cattle spend 90 percent less time in the stream when alternative drinking water is furnished (USEPA, 2003). Figure 4-8 shows a centralized watering tank allowing access from rotated grazing plots and a barn area.

(Photo courtesy of USDA NRCS.)

Figure 4-8. Centralized Watering Tank.

The NRCS provides additional information on these alternative watering components:

Spring development
http://efotg.nrcs.usda.gov/references/public/IL/IL-574.pdf,
Well development
http://efotg.nrcs.usda.gov/references/public/IL/IL-642.pdf,
Pipeline
http://efotg.nrcs.usda.gov/references/public/IL/516.pdf,
Watering facilities (trough, barrel, etc.)
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 614

Grazing Land Protection

While erosion rates from pasture areas are generally lower than those from row-crop areas, a poorly managed pasture can approach or exceed a well-managed row-crop area in terms of erosion rates. Grazing land protection is intended to maximize ground cover on pasture, reduce soil compaction resulting from overuse, reduce runoff concentrations of nutrients and fecal coliform, and protect streambanks and riparian areas from erosion and fecal deposition. Figure 4-9 shows an example of a pasture managed for land protection. Cows graze the left lot while the right lot is allowed a resting period to revegetate.

(Photo courtesy of USDA NRCS.)

Figure 4-9. Example of a Well Managed Grazing System.

Maintaining sufficient ground cover on pasture lands requires a proper density of grazing animals and/or a rotational feeding pattern among grazing plots. The EPA nonpoint source guidance for agricultural areas estimates that fecal coliform loading may be reduced by 40 percent with grazing land protection measures (USEPA, 2003). Researchers in Alberta, Canada saw a load reduction of 90 percent with rotational grazing (Government of Alberta, 2007).

The NRCS provides additional information on prescribed grazing at
http://efotg.nrcs.usda.gov/treemenuFS.aspx
in Section IV B. Conservation Practices Number 528A
and on grazing practices in general at
http://www.glti.nrcs.usda.gov/technical/publications/nrph.html

4.3.2.4 Vegetated Controls

Filter Strips

Filter strips are used in agricultural and urban areas to intercept and treat runoff before it leaves the site. For small dairy operations, filter strips may also be used to treat milk house washings and runoff from the open lot (NRCS, 2003). Filter strips will require maintenance, including grading and seeding, to ensure distributed flow across the filter and protection from erosion. Periodic removal of vegetation will encourage plant growth and uptake and remove nutrients stored in the plant material. Filter strips are most effective on sites with mild slopes of generally less than 5 percent, and to prevent concentrated flow, the upstream edge of a filter strip should follow one elevation contour (NCDENR, 2005).

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

Filter strips have been found to effectively remove pollutants from agricultural runoff. Reductions in fecal coliform loading of 55 to 87 percent are reported (USEPA, 2003; Kalita, 2000; Woerner et al., 2006). A grass filter strip is shown in Figure 4-10.

(Photo courtesy of USDA NRCS.)

Figure 4-10. Grassed Filter Strip.

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

Grass Waterway

Grassed waterways are stormwater conveyances lined with grass that prevent erosion of the transport channel. They are often used to divert clean up-grade runoff around contaminated feedlots and manure storage areas (NRCS, 2003). In addition, the grassed channel reduces runoff velocities, allows for some infiltration, and filters out some particulate pollutants. The effectiveness of grass swales for treating agricultural runoff has not been quantified. In urban settings, reported removal rates of fecal coliform are 5 percent (Winer, 2000).

Riparian Area Improvements

Converting land adjacent to streams for the creation of riparian buffers will provide streambank stabilization, stream shading, nutrient uptake, and pollutant trapping from adjacent treated areas. Riparian buffers also prevent cattle access to streams, reducing streambank trampling and defecation in the stream. Minimum buffer widths of 25 feet are required for water quality benefits and higher removal rates are provided with greater buffer widths. Wenger (1999) report that fecal coliform reductions in 30 ft buffers treating poultry litter ranged from 34 to 74 percent in two test plots, and that 200 ft buffers may achieve reductions of 87 percent. Buffer widths based on slope measurements and recommended plant species should conform to NRCS Field Office Technical Guidelines.

Figure 4-11 shows a riparian buffer separating agricultural fields from the stream.

(Photo courtesy of USDA NRCS.)

Figure 4-11. Riparian Buffer Protecting the Stream from Adjacent Agricultural Fields.

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

Constructed Wetlands

Constructed wetlands used to treat animal wastes are typically surface flowing systems comprised of cattails, bulrush, and reed plants. Wetland environments treat wastewater through sedimentation, filtration, plant uptake, biochemical transformations, and volatilization. Constructed wetlands typically reduce fecal coliform concentrations in animal waste streams by 92 percent (USEPA, 2002a).

Prior to treating animal waste in a constructed wetland, storage in a lagoon or pond is required to protect the wetland from high pollutant loads that may kill the vegetation or clog pore spaces. After treatment in the wetland, the effluent is typically held in another storage lagoon and then land applied (USEPA, 2002a). Alternatively, the stored effluent can be used to supplement flows to the wetland during dry periods. Constructed wetlands that ultimately discharge to a surface waterbody will require a permit, and the receiving stream must be capable of assimilating the effluent during low flow conditions (NRCS, 2002b). Figure 4-12 shows an example of a lagoon-wetland system.

(Photo courtesy of USDA NRCS.)

Figure 4-12. Constructed Wetland System for Animal Waste Treatment.

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

BMPs can be highly efficient in reducing pollutant loading and protecting stream ecosystems, particularly when used in combinations. Table 4-9 summarizes appropriate BMPs for fecal coliform reductions from animal operations.

Table 4-9. Fecal Coliform BMPs for Animal Operations.

BMP	Description and Removal Mechanism	Estimated Fecal Coliform Reduction
Manure Handling, Storage, and Treatment	Storing manure in centralized locations away from streams and wells. Location should be covered by a permanent structure or plastic barrier for protection from rain and snow. Clean water should be diverted away from storage facilities.	90 to 97 percent (Meals and Braun, 2006)
Manure Composting	Biological decomposition and stabilization that generates heat and raises the temperature of the compost to levels that are detrimental to pathogen survival.	99 percent (Larney et. al., 2003)
Cattle Exclusion from Streams	Using vegetation or fencing material to prevent stream access by cattle.	These practices used together have a reported reduction in fecal coliform load of 29 to 46 percent (USEPA, 2003)
Alternative Drinking Sources	Providing drinking water for cattle away from the stream.	
Grazing Land Protection	Maintaining vegetation in grazing areas by reducing the number of grazing animals or limiting the number of days each field is grazed.	40 to 90 percent (USEPA, 2003; Government of Alberta, 2007)
Filter Strips	Placement of vegetated strips in the path of field drainage to treat pollutants. May also be used to treat washings from milking parlors in small dairy operations.	55 to 87 percent (USEPA, 2003; Kalita, 2000; Woerner and Lorimer, 2006)
Grass Waterways	A runoff conveyance lined with vegetative material. Removes fecal coliform by infiltration and sedimentation. Also used for clean water diversions.	5 percent (Winer, 2000)
Restoration of Riparian Buffers	Conversion of land adjacent to stream channels to vegetated buffer zones. Removes fecal coliform by sedimentation and infiltration. Provides streambank stability, stream shading, and aesthetic enhancement.	34 to 87 percent (Wenger, 1999)
Constructed Wetlands	Areas constructed to simulate natural wetland processes. Removes fecal coliform by sedimentation; filtration; and exposure to sunlight, low pH, and protozoa.	92 percent (USEPA, 2002a)

4.3.3 Estimated Cost of Implementation

The net costs associated with the agricultural BMPs described in Section 4.3.2 depend on the cost of construction (for structural BMPs), maintenance costs (seeding, grading, etc.), and operating costs (electricity, fuel, labor, etc). This section describes how the various costs apply to each BMP, and presents an estimate of the annualized cost spread out over the service life. Incentive plans, 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. Though BMPs implemented at animal operations are not expected to take land out of crop production, the phosphorus BMPs discussed in the Georgetown Lake implementation plan will need to account for loss of income. Market prices fluctuate 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. For prices estimated less than $0.15, values are shown to the nearest penny.

Gross 2004 income estimates for corn and soybean 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, respectively (USDA-ERS, 2005). The average net annual income of $178/ac was used to estimate the annual loss from BMPs that take a portion of land out of farm production. The average value is appropriate since most farms operate on a 2-year crop rotation.

4.3.3.1 Manure Handling, Storage, and Treatment

Depending on whether or not the production facility is pasture-based or confined, manure is typically deposited in feedlots, around watering facilities, and within confined spaces such as housing units and milking parlors. Except for feedlots serving a low density of animals, each location will require the collection and transport of manure to a storage structure, holding pond, storage pit, or lagoon prior to final disposal.

Manure collected from open lots and watering areas is typically collected by a tractor equipped with a scraper. This manure is in solid form and is typically stored on a concrete pad surrounded by three walls that allow for stacking of contents. Depending on the climate, a roof may be required to protect the manure from frequent rainfall. Clean water from rooftops or up-grade areas should be diverted around waste stockpiles and heavy use areas with berms, grassed channels, or other means of conveyance (USEPA, 2003). Waste storage lagoons, pits, and above ground tanks are good options for large facilities. Methane gas recovered from anaerobic treatment processes can be used to generate electricity.

The NRCS (2003) has developed cost estimates for the various tasks and facilities typically used to transport, store, and dispose of manure. Table 4-10 summarizes the information contained in the NRCS report and lists the capital and operating/maintenance costs reported per head of animal. Annual maintenance costs were assumed 3 percent of capital costs except for gutter downspouts (assumed 10 percent to account for animals trampling the downspouts) and collection and transfer (assumed 15 percent to account for costs associated with additional fuel and labor). The costs presented as a range were given for various sizes of operations. The lower values reflect the costs per head for the larger operations which are able to spread out costs over more animals.

The full NRCS document can be viewed at
http://www.nrcs.usda.gov/Technical/land/pubs/cnmp1.html

The useful life for practices requiring construction are assumed 20 years. The total annualized costs were calculated by dividing the capital costs by 20 and adding the annual operation and maintenance costs. Prices are converted to year 2004 dollars.

Table 4-10. Costs Calculations for Manure Handling, Storage, and Treatment Per Head.

Item	Application	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Collection and Transfer of Solid Manure, Liquid/Slurry Manure, and Contaminated Runoff				
Collection and transfer of manure solids (assuming a tractor must be purchased)	All operations with outside access and solid collection systems for layer houses	$130.50 - dairy cattle $92.50 - beef cattle $0 - layer[1] $37.00 - swine	$19.50 - dairy cattle $13.75 - beef cattle $0.04 - layer $5.50 - swine	$26.00 - dairy cattle $18.25 - beef cattle $0.04 - layer $7.25 - swine
Collection and transfer of liquid/slurry manure	Dairy, swine, and layer operations using a flush system	$160 to $200 - dairy cattle $.50 - layer $5.75 to $4.50 - swine	$12.25 - dairy cattle $0.03 - layer $0.25 - swine	$20.25 to 22.25 - dairy cattle $0.05 - layer $0.50 - swine
Collection and transfer of contaminated runoff using a berm with pipe outlet	Fattened cattle and confined heifers	$4 to $9 - cattle	$0.12 to 0.25 - cattle	$0.25 to $0.75 - cattle
Feedlot Upgrades for Cattle Operations Using Concentrated Feeding Areas				
Grading and installation of a concrete pad	Cattle on feed (fattened cattle and confined heifers)	$35 - cattle	$1 - cattle	$2.75 - cattle
Clean Water Diversions				
Roof runoff management: gutters and downspouts	Dairy and swine operations that allow outside access	$16 - dairy cattle $2.25 - swine	$1.60 - dairy cattle $0.25 - swine	$2.50 - dairy cattle $0.50 - swine
Earthen berm with underground pipe outlet	Fattened cattle and dairy operations	$25.25 to $34.50 - cattle	$0.75 to $1.00 - cattle	$2 to $2.75 - cattle
Earthen berm with surface outlet	Swine operations that allow outside access	$1 - swine	$0.03 - swine	$0.08 - swine
Grassed waterway	Fattened cattle and confined heifer operations: scrape and stack system	$0.50 to $1.50 - cattle	$0.02 to $0.04 - cattle	$0.05 to $0.12 - cattle

[1] Costs presented by NRCS (2003) as operating and maintenance only.

Table 4-11. Costs Calculations for Manure Handling, Storage, and Treatment Per Head (continued).

Item	Application	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Storage				
Liquid storage (contaminated runoff and wastewater)	Swine, dairy, and layer operations using flush systems (costs assume manure primarily managed as liquid)	$245 to $267 - dairy cattle $2 - layer $78.50 to $80 - swine	$7.25 - dairy cattle $0.06 - layer $2.50 - swine	$19.50 to $20.50 - dairy cattle $0.16 - layer $6.50 - swine
Slurry storage	Swine and dairy operations storing manure in pits beneath slatted floors (costs assume manure primarily managed as slurry)	$104 to $127 - dairy cattle $15.50 to $19.50 - swine	$3.25 to $3.75 - dairy cattle $0.50 - swine	$8.25 to $10.25 - dairy cattle $1.25 to $1.50 - swine
Runoff storage ponds (contaminated runoff)	All operations with outside access	$125.50 - dairy cattle $140 - beef cattle $23 - swine	$3.75 - dairy cattle $4.25 - beef cattle $0.75 - swine	$10 - dairy cattle $11.25 - beef cattle $2 - swine
Solid storage	All animal operations managing solid wastes (costs assume 100% of manure handled as solid)	$196 - dairy cattle $129 - beef cattle $1 - layer $14.25 - swine	$5.75 - dairy cattle $3.75 - beef cattle $0.03 - layer $0.50 - swine	$15.50 - dairy cattle $10.25 - beef cattle $0.25 - layer $1.25 - swine

Table 4-11. Costs Calculations for Manure Handling, Storage, and Treatment Per Head (continued).

Item	Application	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
Final Disposal				
Pumping and land application of liquid/slurry	Operations handling manure primarily as liquid or slurry.	Land application costs are listed as capital plus operating for final disposal and are listed as dollars per acre for the application system. The required number of acres per head was calculated for each animal type based on the phosphorus content of manure at the time of application. Pumping costs were added to the land application costs as described in the document.		$19.50 - dairy cattle $0.25 - layer $2.75 - swine
Pumping and land application of contaminated runoff	Operations with outside feedlots and manure handled primarily as solid	Pumping costs and land application costs based on information in NRCS, 2003. Assuming a typical phosphorus concentration in contaminated runoff of 80 mg/L to determine acres of land required for agronomic application (Kizil and Lindley, 2000). Costs for beef cattle listed as range representing variations in number of animals and manure handling systems (NRCS, 2003). Only one type and size of dairy and swine operation were included in the NRCS document.		$4 - dairy cattle $3.75 - beef cattle $4.50 - swine
Land application of solid manure	Operations handling manure primarily as solid	Land application costs are listed as capital plus operating for final disposal and are given as dollars per acre for the application system. The required number of acres per head was calculated for each animal type based on the phosphorus content of manure at the time of application. No pumping costs are required for solid manure.		$11 - dairy cattle $0.25 - layer $1.50 - swine $10.25 - fattened cattle

4.3.3.2 Manure Composting

The costs for developing a composting system include site development costs (storage sheds, concrete pads, runoff diversions, etc.), purchasing windrow turners if that system is chosen, and labor and fuel required to form and turn the piles. Cost estimates for composting systems have not been well documented and show a wide variation even for the same type of system. The NRCS is in the process of developing cost estimates for composting and other alternative manure applications in Part II of the document discussed in Section 4.3.3.1. Once published, these estimates should provide a good comparison with the costs summarized for the Midwest region in Table 4-10. For now, costs are presented in Table 4-11 based on studies conducted in Wisconsin, Canada, and Indiana.

Researchers in Wisconsin estimated the costs of a windrow composting system using four combinations of machinery and labor (CIAS, 1996). These costs include collection and transfer of excreted material, formation of the windrow pile, turning the pile, and reloading the compost for final disposal. The Wisconsin study was based on a small dairy operation (60 head). Costs for beef cattle, swine, and layer hens were calculated based on animal units and handling weights of solid manure (NRCS, 2003). Equipment life is assumed 20 years. The costs presented in the Wisconsin study are much higher than those presented in Table 4-10 for collection, transfer, and storage of solid manure. However, the

Wisconsin study presented a cost comparison of the windrow system to stacking on a remote concrete slab, and these estimates were approximately four and half times higher than the values summarized by NRCS. It is likely that the single data set used for the Wisconsin study is not representative of typical costs.

The University of Alberta summarized the per ton costs of windrow composting with a front end load compared to a windrow turner (University of Alberta, 2000).

The Alberta Government presented a per ton estimate for a windrow system with turner: this estimate is quite different than the University of Alberta study. These per ton costs were converted to costs per head of dairy cattle, beef cattle, swine, and layer hens based on the manure generation and handling weights presented by NRCS (2003).

In 2001, the USEPA released a draft report titled “Alternative Technologies/Uses for Manure.” This report summarizes results from a Purdue University research farm operating a 400-cow dairy operation. This farm also utilizes a windrow system with turner.

Table 4-11 summarizes the cost estimates presented in each of the studies for the various composting systems. None of these estimates include the final costs of land application, which should be similar to those listed for disposal of solid manure in Table 4-10 as no phosphorus losses occur during the composting process.

Table 4-11. Costs Calculations for Manure Composting.

Equipment Used	Capital Costs per Head	Annual Operation and Maintenance Costs per Head	Total Annualized Costs per Head
2004 Costs Estimated from CIAS, 1996 – Wisconsin Study			
Windrow composting with front-end loader	$324.25 - dairy cattle $213.50 - beef cattle $1.75 - layer $23.75 - swine	$179.75 - dairy cattle $118.50 - beef cattle $1 - layer $13.25 - swine	$196 - dairy cattle $129.25 - beef cattle $1 - layer $14.25 - swine
Windrow composting with bulldozer	$266 - dairy cattle $175.25 - beef cattle $1.50 - layer $19.50 - swine	$179.75 - dairy cattle $118.50 - beef cattle $1 - layer $13.25 - swine	$193.25 - dairy cattle $127.25 - beef cattle $1 - layer $14.25 - swine
Windrow composting with custom-hire compost turner	$266 - dairy cattle $175.25 - beef cattle $1.50 - layer $19.50 - swine	$215.25 - dairy cattle $141.75 - beef cattle $1.25 - layer $15.75 - swine	$228.75 - dairy cattle $150.50 - beef cattle $1.25 - layer $16.75 - swine
Windrow composting with purchased compost turner	$617 - dairy cattle $406.25 - beef cattle $3.50 - layer $45.25 - swine	$234.25 - dairy cattle $154.25 - beef cattle $1.25 - layer $17.25 - swine	$265.25 - dairy cattle $174.75 - beef cattle $1.50 - layer $19.50 - swine
2004 Costs Estimated from University of Alberta, 2000			
Windrow composting with front-end loader	Study presented annualized costs per ton of manure composted.		$23.75 to $47.50 - dairy cattle $15.75 to $31.25 - beef cattle $0.13 to $0.25 - layer $1.75 to $3.50 - swine
Windrow composting with compost turner	Study presented annualized costs per ton of manure composted.		$71.25 to $142.50 - dairy cattle $47.00 to $94.00 - beef cattle $0.50 to $0.75 - layer $5.25 to $10.50 - swine
2004 Costs Estimated from Alberta Government, 2004			
Windrow composting with compost turner	Study presented annualized costs per ton of manure composted.		$31.50 - dairy cattle $20.75 - beef cattle $0.25 - layer $2.25 - swine
2004 Costs Estimated from USEPA, 2001a Draft			
Windrow composting with compost turner	Study presented annualized costs per dairy cow.		$15.50 - dairy cattle $10.25 - beef cattle $0.09 - layer $1.25 - swine

4.3.3.3 Cattle Exclusion from Streams

The costs of excluding cattle from streams depends more on the length of channel that needs to be protected than the number of animals on site. Fencing may also be used in a grazing land protection operation to control cattle access to individual plots. The system life of wire fences is reported as 20 years; the high tensile fence materials have a reported system life of 25 years (Iowa State University, 2005). Fencing materials vary by installation cost, useful life, and annual maintenance cost as presented in Table 4-12.

Table 4-12. Installation and Maintenance Costs of Fencing Material per Foot

Material	Construction Costs (per ft)	Annual Maintenance Costs (per ft)	Total Annualized Costs (per ft)
Woven Wire	$1.46	$0.25	$0.32
Barbed Wire	$1.19	$0.20	$0.26
High tensile (non-electric) 8-strand	$1.09	$0.14	$0.18
High tensile (electric) 5-strand	$0.68	$0.09	$0.12

NRCS reports that the average operation needs approximately 35 ft of additional fencing per head to protect grazing lands and streams. Table 4-13 presents the capital, maintenance, and annualized costs per head of cattle for four fencing materials based on the NRCS assumptions.

Table 4-13. Installation and Maintenance Costs of Fencing Material per Head.

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

4.3.3.4 Alternative Drinking Water Sources

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

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

Annual operating costs to run the well pump range from $9 to $22 per year for electricity (USEPA, 2003; Marsh, 2001), or up to $0.15 per head. Table 4-14 lists the capital, maintenance, and annualized costs for a well, pump, and storage system assuming a system life of 20 years.

Table 4-14. Costs Calculations for Alternative Watering Facilities.

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

4.3.3.5 Grazing Land Protection

The costs associated with grazing land protection include acquiring additional land if current animal densities are too high (or reducing the number of animals maintained), fencing (Section 4.3.3.3) and seeding costs, and developing alternative water sources (Section 4.3.3.4). Establishment of vegetation for pasture areas costs from $39/ac to $69/ac based on data presented in the EPA nonpoint source guidance for agriculture (USEPA, 2003). Annual costs for maintaining vegetative cover will likely range from $6/ac to $11/ac (USEPA, 2003). If cattle are not allowed to graze plots to the point of requiring revegetation, the cost of grazing land protection may be covered by the fencing and alternative watering strategies discussed above.

4.3.3.6 Vegetative Controls

Filter Strips

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

Filter strips cost approximately $0.30 per sq ft to construct, and the system life is typically assumed 20 years (Weiss et al., 2007). Annual maintenance costs are $0.01 per sq ft (USEPA, 2002b). For animal operations, it is not likely that land used for growing crops would be taken out of production for conversion to a filter strip. Table 4-15 summarizes the capital, maintenance, and annualized costs for filter strips.

Table 4-15. Costs Calculations for Filter Strips.

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

Grassed Waterways

Grassed waterways are primarily used in animal operations to divert clean water away from pastures, feedlots, and manure storage areas. Table 4-16 summarizes the capital, maintenance, and annualized costs of this practice per head of cattle as summarized by NRCS (2003).

Table 4-16. Costs Calculations for Grassed Waterways Used in Cattle Operations.

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

Riparian Buffers

Restoration of riparian areas will protect the stream corridor from cattle trampling and reduce the amount of fecal material entering the channel. The cost of this BMP depends more on the length of channel to be protected, rather than the number of animals having channel access. The costs of restoration is approximately $100/ac to construct and $475/ac to maintain over the life of the buffer (Wossink and Osmond, 2001; NCEEP, 2004).

Fecal coliform reductions have been reported for buffers at least 30 ft wide (Wenger, 1999). Large reductions are reported for 200 ft wide buffers. The costs per length of channel for 30 ft and 200 ft wide buffers restored on both sides of a stream channel are listed in Table 4-17. A system life of 30 years is assumed.

Table 4-17. Costs Calculations for Riparian Buffers Per Foot of Channel.

Width	Capital Costs per ft	Annual Operation and Maintenance Costs per ft	Total Annualized Costs per ft
30 ft on both sides of channel	$0.14	$0.02	$0.03
200 ft on both sides of channel	$0.92	$0.14	$0.17

Constructed Wetlands

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

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

Capital and maintenance costs reported in the literature for dairy and swine operations are summarized per head in Table 4-18. No example studies including costs were available for beef cattle operations, which should generate less liquid waste than the other two operations. It would therefore be expected that constructing a wetland for beef cattle operation would cost less than for a dairy or swine operation.

Table 4-18. Costs Calculations for Constructed Wetlands.

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

4.3.4 Effectiveness and Estimated Load Reductions

Several BMPs are available to control fecal coliform loads from animal operations in the Little Vermilion River watershed. Selecting a BMP will depend on estimated removal efficiencies, construction and maintenance costs, and individual preferences. Table 4-19 summarizes the annualized costs (construction, maintenance, and operation) for each BMP per head of cattle, poultry, or swine. The removal efficiencies reported in the literature are included as well.

Table 4-19. Cost and Removal Efficiencies for Agricultural BMPs

BMP	Fecal Coliform Reduction	Annualized Cost per Head
Manure Handling, Storage, and Treatment	97 percent (Meals and Braun, 2006)	Beef cattle: $41.75 Dairy cattle: $48 to $62 Swine: $5 to $10.25 Poultry: $0.50
Manure Composting	99 percent (Larney et. al., 2003)	Beef cattle: $10.25 to $94 Dairy cattle: $15.50 to $142.50 Swine: $1.25 to $10.50 Poultry: $0.10 to $0.75
Cattle Exclusion from Streams with Alternative Drinking Sources	These practices used together have a reported reduction in fecal coliform load of 29 to 46 percent (USEPA, 2003)	Beef cattle: $5.50 to $9
Grazing Land Protection	40 to 90 percent (USEPA, 2003; Government of Alberta, 2007)	Beef cattle: cost varies depending on density of animals and vegetation type
Filter Strips	55 percent (USEPA, 2003; Kalita, 2000)	Beef cattle: $6 Dairy cattle: $4
Grass Waterways	5 percent (Winer, 2000)	Beef cattle: $0.05 to $0.12
Constructed Wetlands	92 percent (USEPA, 2002a)	Beef cattle: no data Dairy cattle: $2.50 Swine: $4.50 Poultry: no data
BMP	**Fecal Coliform Reduction**	**Annualized Cost per Ft of Stream Channel**
Restoration of Riparian Buffers	34 to 74 percent (Wenger, 1999)	30 ft on both sides: $0.03 200 ft on both sides: $0.17

4.4 Domestic Pets

The domestic pets discussed in this section are primarily dogs and cats, which excrete waste outdoors. Birds, reptiles, and other caged animals are not assumed to contribute to fecal coliform loading in outdoor environments.

4.4.1 Source Description and Approximate Loading

Household pets may reside in both rural areas and urban centers. The Vermilion County Department of Animal Regulation estimates that 10,000 dogs and 5,000 cats reside in Vermilion County. The respective animal densities in this 902 sq mi county are 11 dogs per sq mi and 5.5 cats per sq mi. The total area of the Little Vermilion River watershed is 200 sq mi, so approximately 2,217 dogs and 1,110 cats reside in the watershed.

The American Society for Microbiology (Cox et al., 2005) reports median fecal coliform concentrations per gram of dog and cat feces of 31,000,000 cfu/gram and 2,300,000 cfu/gram, respectively. Assuming average daily excretion rates of 200 grams/dog/day and 100 grams/cat/day yields estimated daily loading rate from dogs in the watershed of 13,745,400 million cfu/day and from cats of 255,300 million cfu/day. However, the load from cats is negligible since these animals typically either bury their feces or are litter box trained.

4.4.2 Appropriate BMPs

BMPs for reducing the fecal coliform loading rate from dogs are primarily education based. Encouraging pet owners to spay and neuter their pets will reduce the feral population and subsequent loading. Education about the importance of picking up pet waste from yards, parks, and impervious surfaces such as sidewalks is imperative. Most owners do not realize that stormwater eventually reaches surface water bodies, and that the cumulative impacts from pet waste can be significant.

Pet waste management systems have been used in concentrated urban settings and dog parks. These stations are structures located in areas where pet owners often walk or exercise their pets. The stations usually provide plastic bags for picking up the pet waste and a garbage can for disposal. In addition, pet waste cleanup services are becoming available for weekly or twice weekly collection from residential areas.

4.4.3 Estimated Cost of Implementation

The Washington State Department of Ecology (WSDE, 2006) found that pet stations can be purchased from anywhere between $60 and several hundred dollars, depending on size, design, and durability. Installation of stations was found to be relatively easy and inexpensive. Pet waste pickup bags can be purchased in bulk and range in price from 5 to 14 cents per bag. Other programs have included local grocery stores by asking for donated produce bags in lieu of having to purchase the plastic bags made available at pet waste stations. The removal of pet waste station garbage, restocking of plastic bags, and basic station maintenance may easily be integrated with pre-existing grounds maintenance.

The cost of an education and outreach program will vary depending on the county or municipality's desire to invest in these programs. Assuming one dollar per year per dog owner to cover mass mailings, television, and radio announcements equates to a cost of approximately $2,220 per year for this watershed.

4.4.4 Effectiveness and Estimated Load Reductions

Education and outreach programs used in conjunction with pet collection stations have been found to be most effective in reducing the fecal coliform loading from pet waste. Surveys of pet owners indicate that education and awareness can result in approximately 40 percent of dog owners picking up pet waste on a consistent basis. The loading associated with pet wastes could therefore be reduced from 13,745,400 million cfu/day to 8,247,240 million cfu/day. Programs should be targeted to neighborhoods closest to the impaired segment since less die-off will occur during overland and instream transport.

4.5 Wildlife

In wet conditions when runoff related sources of fecal coliform loading are more prevalent, wildlife feces can sometimes be an important source of loading. Heavily wooded areas in or near riparian zones are most likely to contribute fecal coliform loading from wildlife. Loads from wildlife are often considered background as they are “natural” and are usually relatively small when compared to loading from human activities (e.g., agricultural activities or leaking septic systems). Only about 6 percent of the LVR watershed is comprised of forest or wetland areas that would be home to dense populations of wildlife.

4.5.1 Source Description and Approximate Loading

The three wildlife species that may play a role in fecal coliform loading in the Little Vermilion River watershed are white-tailed deer, various duck species, and Canadian geese. Smaller animals such as squirrels and rodents also contribute loading, but density estimates for these species are not available.

White-tailed deer (*Odocoileus virginianus*) are known to be prevalent in human disturbed areas throughout the contiguous United Sates. Specifically, these deer are often found in areas where there is an interface of agricultural land use and forested areas. The most recent (2003-2004) Illinois Department of Natural Resources (IDNR) estimate of the deer population within Vermilion County is approximately 9,000 animals (Shelton, 2007). A loading rate used in a previous USEPA Region 4 TMDL report in Tennessee (South Fork Forked Deer River) estimated fecal coliform loading from deer to be approximately 500 million cfu/animal/day (USEPA, 2001b). Scaling the Vermilion County deer population estimates to the Little Vermilion River watershed area results in an estimated fecal coliform load from deer of 998,000 million cfu/day.

IDNR reported that duck population estimates for Vermilion County were unattainable but that there may be a small wood duck population in the forested areas of the county, especially along waterways. It was mentioned that the duck populations of Illinois are found more in the central and northern counties of Illinois located to the west and north of the Little Vermilion River watershed.

The Canadian geese (*Branta Canadensis maxima*) population for the state of Illinois is estimated at around 100,000 animals. Obviously this number will vary depending on season and migrational patterns, but for the loading estimates in this report 100,000 will be used as a conservative Canadian geese resident population. The average loading for a Canadian goose was estimated by the Georgia Department of Natural Resources (GADNR) to be approximately 5,200 million cfu/day/animal (Williams, 2003). Using this estimation, the fecal coliform load in the Little Vermilion river watershed from Canadian geese could be as much as 1,790,000 million cfu/day. However, as with the duck populations, IDNR also mentioned that the geese populations tend to be further west and north of Vermilion County. The sum of approximate loading from wildlife is 2,788,000 million cfu/day.

4.5.2 Effectiveness and Estimated Load Reductions

Even though it can be difficult to control wildlife population levels and movements, it has been an ongoing practice within the natural resources management community for quite some time. Its effectiveness is assumed to be directly proportional to the degree to which wildlife can be restricted from accessing waterbodies (e.g., if access to waterbodies was limited by 50 percent, the fecal coliform loading rate would also decrease by 50 percent).

4.6 Die-off, Resuspension, and Regeneration

The movements and life cycle of fecal coliform bacteria are dynamic, complex, and still not fully understood. Much progress has been made in understanding how to better manage BMPs to maximize the die-off rates of fecal coliform (Fallowfield et al., 1996). However, recent studies have shown that sediment, and in some cases vegetation, can not only store fecal coliform for long periods of time, sometimes in excess of 90 days (Davies et al., 2005), but can actually provide habitat and nutrients for bacterial population recovery, also known as regeneration (Sanders et al., 2005). While Sanders et al. (2005) have pointed out that hydrodynamically active wetlands such as estuaries or streams may still serve as net sinks of fecal coliform, it is their opinion that the estimated potential for bacterial die-off should be tempered by the recent findings concerning regeneration and resuspension. The importance of fecal coliform resuspension as well as regeneration in vegetation and inundated sediments is yet another challenge in understanding fecal coliform dynamics.

4.6.1 Source Description and Approximate Loading

Sediments naturally contain some levels of fecal coliform in areas inhabited by animals. There have been studies that have shown *E. coli* populations growing in forest soils under natural conditions. The concern of watershed managers is primarily with the sediment underlying waterbodies, waterways, and BMPs that transport bacteria to waters designated for drinking water supply, aquatic health, or recreation. As mentioned above, there is much difficulty in approximating a loading rate from the resuspension and/or regeneration of fecal coliform from inundated sediment.

4.6.2 Appropriate BMPs

Research findings such as those by Fallowfield et al. (1996) show that conventional BMPs for fecal coliform removal, such as ponds, are effective. However, with the new knowledge concerning resuspension and regeneration, it is important to maintain and manage BMPs appropriately to ensure the maximum removal (die-off) potential of the practice employed. Fallowfield et al. recommend that ponds should be operated at shallow depths (0.5 ft to 1 ft) to allow for optimal penetration of UV light. The increased irradiation not only destroys the bacteria, but also encourages photosynthesis, which increases the water pH, and increases the rate of bacterial die-off.

4.6.3 Estimated Cost of Implementation

Altering a preexisting management practice for stormwater BMPs may be a low cost option depending on the current management scheme. Management plans for newly constructed BMPs should be created to minimize resuspension and regeneration of fecal coliform bacteria. By building BMPs, or managing existing BMPs, so that the energy of incoming flows is allowed to dissipate before entering the larger, shallower main pool area of a BMP it may minimize the re-suspension of pre-existing bacteria. Also, the decreased turbidity in the shallow main pool section would aid penetration of UV radiation thus maximizing the die-off rates of bacteria within the sediment.

4.6.4 Effectiveness and Estimated Load Reductions

Because the research findings on the rates of resuspension and regeneration are still relatively new, and significant findings on loading rates are not available, it is difficult to estimate the degree of effectiveness and estimated reductions in load for altered BMP management scenarios. In some cases, the management of a BMP may already be optimizing the fecal coliform removal rate.

5.0 PRIORITIZATION OF IMPLEMENTATION

Meeting the water quality standards for fecal coliform in the Little Vermilion River requires reductions in loading of 49 to 90 percent, depending on hydrologic conditions. Section 4.0 provides loading estimates by source category (where possible) 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 fecal coliform loading.

5.1 Current Fecal Coliform Loading to the Little Vermilion River

Fecal coliform loads impact the Little Vermilion River during all flow conditions. The relative importance of a loading source changes as flow conditions vary. The most significant dry weather sources (septic systems, cattle in streams, and point source dischargers) may cause less of an impact following wet weather events that wash fecal coliform from land sources. Table 5-1 summarizes the source categories and potential loads where available without accounting for the natural processes contributing to organism die-off or BMPs that may already be in place. With the exception of the point sources, the other source categories are likely scattered through out the watershed. Loads from the Georgetown STP will not undergo the same amount of die-off as those from the other sources that may be located far from segment BO-07, since it discharges just upstream of the listed segment of the Little Vermilion River.

Table 5-1. Potential Loading of Fecal Coliform in the Little Vermilion River Watershed.

Source	Potential Load (million cfu/day)
Georgetown STP – Primary Effluent[1]	1,560,000
Excessive flows and CSOs[2]	14,300,000
Onsite Wastewater Treatment Systems	Unknown
Animal Operations	Unknown
Domestic Pets	14,000,000
Wildlife	2,790,000

[1] Excludes loads from the Ridge Farm STP due to lack of monitoring data for estimation of existing loads.
[2] Loading is only expected to occur during very high flows.

5.2 Use of Fecal Coliform BMPs to Meet Water Quality Goals

The allowable fecal coliform load to the Little Vermilion River at Site BO-07 ranges from 14,791 to 466,425 million cfu/day depending on the flow conditions (Table 1-3). Each major source in the watershed has the potential to contribute a load greater than allowable (Table 5-1) though die-off during overland and channel flow will reduce these loads proportional to their distance from segment BO-07. Table 5-2 summarizes the BMPs for each major source, the reported reductions and resulting loading to the river, and the total cost to implement the measures over the entire watershed. 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 or die-off in the natural environment. The purpose is to compare the potential load reduction for each BMP as well as the cost associated with achieving that reduction.

The information in Table 5-2 summarizes the impacts of implementing each BMP throughout the watershed (or at an individual STP). The fecal coliform removal rates described in Section 4.0 were multiplied by the potential loads (where available) from each source listed in Table 5-1. The resulting potential load reduction is given in column three of Table 5-2. The difference between the existing load and potential load reduction is the reduced load to the river (column 4).

The last column in Table 5-2 is the cost of full implementation for each BMP. The range of costs listed for adding a disinfection step at each STP is based on the design maximum flow rate for each facility and the three treatment options discussed in Section 4.1.2.1. The costs for maintaining onsite wastewater treatment systems assumes there are 2,837 systems in the watershed that need to be pumped every three to five years, inspected once every five years (if no record of pumping is on file), replaced once every thirty years. It is also assumed that period mailings and announcements will be needed to remind system owners of the importance of maintaining there systems.

The costs of implementing BMPs at animal operations are broken down for each animal type. Costs described in Section 4.3.3 are applied to 1,740 pastured cattle; 34 dairy cattle; 4,143 swine; and 250 chickens.

The costs of restoring riparian buffers along the intermittent and perennial streams in the watershed assumes buffers may vary in width from 30 ft to 200 ft, will be constructed on both sides of the channel, and approximately 171 miles of channel qualify as intermittent or perennial. Again, these costs do not account for streams in the watershed already protected by vegetative buffers.

Table 5-2. Comparison of Fecal Coliform BMPs

BMP	Fecal Coliform Removal Rate (%)	Potential Load Reduction (million cfu/d)	Resulting Load (million cfu/d)	Annualized Costs for Full Management
Upgrades and Controls for Sewage Treatment Plants				
Disinfection of Georgetown STP (1.5 MGD)	Up to 99.27	1,548,000	11,400	$60,000 to $240,000
Disinfection of Ridge Farm STP (0.449 MGD)	unknown	unknown	3,400	$18,000 to $72,000
CSO Controls at Georgetown STP	Up to 99.87	14,280,000	18,200	minimal
Onsite Wastewater Treatment BMPs Assuming 2,837 Systems in the Watershed				
Pumping/ Maintenance	99.99	unknown	unknown	$199,000 to $203,000 to pump each system once every three to five years
Inspection				Up to $91,000 if each system has to be inspected once every five years.
Replacement				$190,000 to $945,000 assuming each system is replaced once every 30 years
Education				$2,840
BMPs for Beef and "Other" Cattle Operations (1,740 head in the watershed)				
Proper Manure Handling, Storage, and Treatment	90 to 97	unknown	unknown	$73,000
Composting	99	unknown	unknown	$18,000 to $164,000
Cattle Exclusion from Stream with Alternative Watering Locations	29 to 46	unknown	unknown	$10,000 to $16,000
Grazing Land Protection	40 to 90	unknown	unknown	Variable
Filter Strips	55 to 87	unknown	unknown	$10,000
Grassed Waterways	5	unknown	unknown	$90 to $200

BMP	Fecal Coliform Removal Rate (%)	Potential Load Reduction (million cfu/d)	Resulting Load (million cfu/d)	Annualized Costs for Full Management
BMPs for Dairy Operations (34 head in the watershed)				
Proper Manure Handling, Storage, and Treatment	90 to 97	unknown	unknown	$1,600 to $2,100
Composting	99	unknown	unknown	$530 to $4,800
Filter Strips	55 to 87	unknown	unknown	$130
Constructed Wetlands	92	unknown	unknown	$85
BMPs for Swine Operations (4,143 head in the watershed)				
Proper Manure Handling, Storage, and Treatment	90 to 97	unknown	unknown	$21,000 to $43,000
Composting	99	unknown	unknown	$5,200 to $44,000
Constructed Wetlands	92	unknown	unknown	$18,644
BMPs for Poultry Operations (250 head in the watershed)				
Proper Manure Handling, Storage, and Treatment	90 to 97	unknown	unknown	$110 to $140
Composting	99	unknown	unknown	$20 to $190
Restoration of Riparian Buffers Along Intermittent and Perennial Streams				
Riparian Buffers	34 to 87	Variable[1]	Variable	$27,000 to $154,000
BMPs for Dog Waste (2,217 dogs)				
Pet Waste Stations	40	5,600,000	8,400,000	Variable
Education of Dog Owners				$2,200

[1] The reduction achieved from restoration of riparian buffers will depend on the type of land and presence of animals adjacent to the buffer.

5.2.1 Implementation Strategy for Agricultural BMPs

Reducing fecal coliform loads to the river will likely require management of all potential sources of loading in the watershed. One exception may be the loading from wildlife, which is relatively low and likely dispersed throughout the watershed, minimizing localized impacts.

Agricultural animal operations are a source of potential loading. Beef and other cattle (i.e., not dairy cattle) should become a priority for implementing BMPs. Encouraging proper collection, transfer, storage, and land application of manure at these operations may reduce their loads by 90 to 97 percent. Implementing a composting step in the process may reduce loading by 99 percent.

Failing onsite wastewater treatment systems are another potential source of fecal coliform loading in the watershed is. Potential loads from this source increase with the number of failing systems, the percent of failing systems cannot be verified unless all systems in the watershed are inspected. Returning all failing systems to proper function may reduce the load from this source by up to 99.99 percent.

The primary outfall and CSO of the Georgetown Sewage Treatment Plant is in close proximity to segment BO-07 which increases the impact of this source. Because the nonpoint sources are dispersed throughout the watershed, the load reaching the listed segment of the Little Vermilion River is likely lower than the potential load due to die-off in the natural environment. The STP, however, occurs as a concentrated point source just upstream of the listed segment of the river. It is likely that loading from this source has a much greater impact than the upland sources, though a watershed loading model or intensive water quality monitoring program would be required to verify that assumption. Requiring the Georgetown STP to disinfect their effluent may reduce the fecal coliform load from this source by 99 percent.

Each of these three main sources has the potential to contribute loads across all flow zones. Septic systems can contribute a continuous load regardless of weather patterns (if they are tied to drainage tiles), though extremely wet events may expedite transport through shallow groundwater systems or carry ponded wastewater directly to waterbodies. Cattle operations that allow animal access to streams also contribute loading during dry conditions. During rain or snow melt events, manure accumulated on land surfaces may be transported to the stream system. Similarly, the sewage treatment plants in the watershed that discharge under a disinfection exemption deliver a constant load to the river, with additional loading occurring during extremely wet events that cause combined sewer overflows. It is therefore important to address each of these sources of fecal coliform loading to ensure that fecal coliform water quality standards are met during all flow zones.

As BMPs are implemented in the watershed, the nonpoint sources closest to the listed segment of the river should be prioritized. Loads from animal operations and septic systems in the headwaters of the drainage area will be much lower by the time they reach segment BO-07 due to natural die-off processes. Those closest to the listed segment may reach the impaired segment before significant reductions in loading have occurred.

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6.0 MEASURING AND DOCUMENTING PROGRESS

Water quality in the Little Vermilion River is currently monitored at IEPA ambient water quality station BO-07 where fecal coliform measurements have been collected approximately every six weeks since 1978. During the summer of 2005, the frequency was increased to allow for comparison to the geometric mean standard. Continuing to sample this location over the next several years will be beneficial in determining the impacts of BMPs as they become implemented. Collecting data during dry weather and wet weather events is important since excessive loading occurs across all flow zones.

It would also be helpful to collect data at other locations in the watershed to determine which areas are contributing the majority of the load:

- Collecting samples above and below the confluence with Ellis Branch would assist in determining the importance of the Georgetown Sewage Treatment Plant on loading. This data would also allow for assessment of the effectiveness of the nine minimal controls for CSOs as well as the disinfection process.
- Collecting samples on the river above and below Georgetown Lake will help determine whether or not die-off processes in the lake mitigate sources from the upper portions of the watershed.
- Collection of samples on the river above and below the receiving stream of the Ridge Farm Sewage Treatment will determine the impacts from that facility.

Continuing to monitor fecal coliform in the watershed will determine how effective voluntary management practices are. If the concentrations continue to be 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 BMPs such as 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, management of all sources of loading, including point and nonpoint sources, will likely be required to reach these goals. Participation of farmers and landowners is essential to reducing nonpoint source pollution and improving water quality, but resistance to change and upfront costs may deter participation. Educational efforts and cost share programs will likely increase participation to levels needed to protect water quality.

Two of the incentive programs discussed below were administered under the 2002 Farm Bill, which expired September 30, 2007. The Conservation Reserve Program will continue to pay out existing contracts, but new enrollments will not be allowed until the bill is reinstated; no official date of reinstatement has been announced. Though the Environmental Quality Incentives Program was also part of the 2002 Farm Bill, it was extended beyond fiscal year 2007 by the Deficit Reduction Act of 2005 (Congressional Research Reports for the People, 2007). New CRP Enrollments are allowed for practices that fall under the continuous signup. A new general signup period has not been announced. At the time of writing, a new Farm Bill is being developed, and the future extent of these programs is unknown.

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 Little Vermilion River 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 75 percent of the construction cost for a composting facility.
- Sixty percent of the fencing, controlled access points, spring and well development, pipeline, and watering facility costs are covered by the program.
- Waste storage facilities and covers for those facilities have a 50 percent cost share for construction.
- The program will also pay 60 percent of the cost to construct grassed waterways and riparian buffers.
- Use of vegetated filter strips will earn the farmer $100/ac/yr for three years (up to 50 acres per farmer).
- Prescribed grazing practices will earn the farmer $10/ac/yr for three years (up to 200 acres per farmer).

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

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

7.2 Conservation Reserve Program (CRP)

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

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

7.3 Conservation 2000

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

7.3.1 Conservation Practices Program (CPP)

The Conservation Practices Cost Share Program provides monetary incentives for conservation practices implemented on land eroding at one and one-half times or more the tolerable soil loss rate. Payments of up to 60 percent of initial costs are paid through the local SWCDs. Of the fecal coliform BMPs discussed in this plan, the program will cost share filter strips, grassed waterways, and pasture planting. 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/

7.3.2 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

7.3.3 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/

7.4 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.

Carbon credits are currently selling at around $3.70 per mt. Current exchange rates are available online at http://chicagoclimatex.com. Administrative fees of $0.14/mt plus 8 percent are subtracted from the sale price.

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

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

Table 7-1 and Table 7-2 summarize the cost share programs available for fecal coliform reduction BMPs in the Little Vermilion River watershed.

Table 7-1. Summary of Assistance Programs Available for Farmers in the Little Vermilion River Watershed.

Assistance Program	Program Description	Contact Information
NSMP	Provides grant funding for educational programs and implementation of nonpoint source pollution controls.	Illinois Environmental Protection Agency Bureau of Water Watershed Management Section, Nonpoint Source Unit P.O. Box 19276 Springfield, IL 62794-9276 Phone: (217) 782-3362
Agricultural Loan Program	Provides low-interest loans for the construction and implementation of agricultural BMPs. Loans apply to equipment purchase as well.	Office of State Treasurer Agricultural Loan Program 300 West Jefferson Springfield, Illinois 62702 Phone: (217) 782-2072 Fax: (217) 522-1217
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 composting facilities, cattle exclusion, alternative watering locations, waste storage and treatment facilities, filter strips, grassed waterways, and riparian buffers.	Vermilion County USDA Service Center 1905-A U.S. Route 150 Danville, IL 61832-5396 Phone: (217) 442-8511, Ext. 3 Fax: (217) 442-6998 Champaign County USDA Service Center 2110 West Park Court, Suite C Champaign, IL 61821 Phone: (217) 352-3536, Ext. 3 Fax: (217) 352- 4781
FSA CRP	Offsets income losses due to land conversion by rental agreements. Targets highly erodible land or land near sensitive waters. Provides up to 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years for converted land.	
Conservation 2000 CPP	Provides up to 60 percent cost share for several agricultural fecal coliform BMPs: pasture planting, filter strips, grassed waterways.	
Conservation 2000 Streambank Stabilization Restoration Program	Provides 75 percent cost share for establishment of riparian corridors along severely eroding stream banks. Also provides technical assistance and educational information for interested parties.	
SARE	Funds educational programs for farmers concerning sustainable agricultural practices.	
VCSWCD	Provides incentives for individual components of resource management.	
ICCI	Allows farmers to earn carbon trading credits for use of conservation tillage, grass, and tree plantings.	

Table 7-2. Assistance Programs Available for Agricultural Fecal coliform BMPs.

BMP	Cost Share Programs and Incentives
Education and Outreach	Conservation 2000 Streambank Stabilization Restoration Program SARE NSMP VCSWCD
Composting Facilities	EQIP: 75 percent of construction of costs
Cattle Exclusion and Alternative Watering Facilities	EQIP: 60 percent of construction of costs
Waste Storage Facilities and Covers	EQIP: 50 percent of construction of costs
Prescribed Grazing	EQIP: $10/ac for three years, 200 ac. max
Filter Strips	EQIP: $100/ac for three years, 50 ac. max. CPP: 60 percent of construction costs CRP: 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years ICCI: earns 0.75 mt/ac/yr of carbon trading credit for each acre planted
Grassed Waterways	EQIP: 60 percent of construction costs CPP: 60 percent of construction costs CRP: 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years ICCI: earns 0.75 mt/ac/yr of carbon trading credit for each acre planted
Land Retirement of Highly Erodible Land or Land Near Sensitive Waters	CRP: 50 percent of the costs of establishing vegetative cover and cash incentive of $185/ac/yr for 15 years ICCI: earn between 0.75 and 5.4 mt/ac/yr of carbon trading credit depending on species planted
Restoration of Riparian Buffers	EQIP: 60 percent of construction of costs CRP: 50 percent of the costs of establishing vegetative cover and cash incentive of $185/ac/yr for 15 years ICCI: earn between 0.75 and 5.4 mt/ac/yr of carbon trading credit depending on species planted

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

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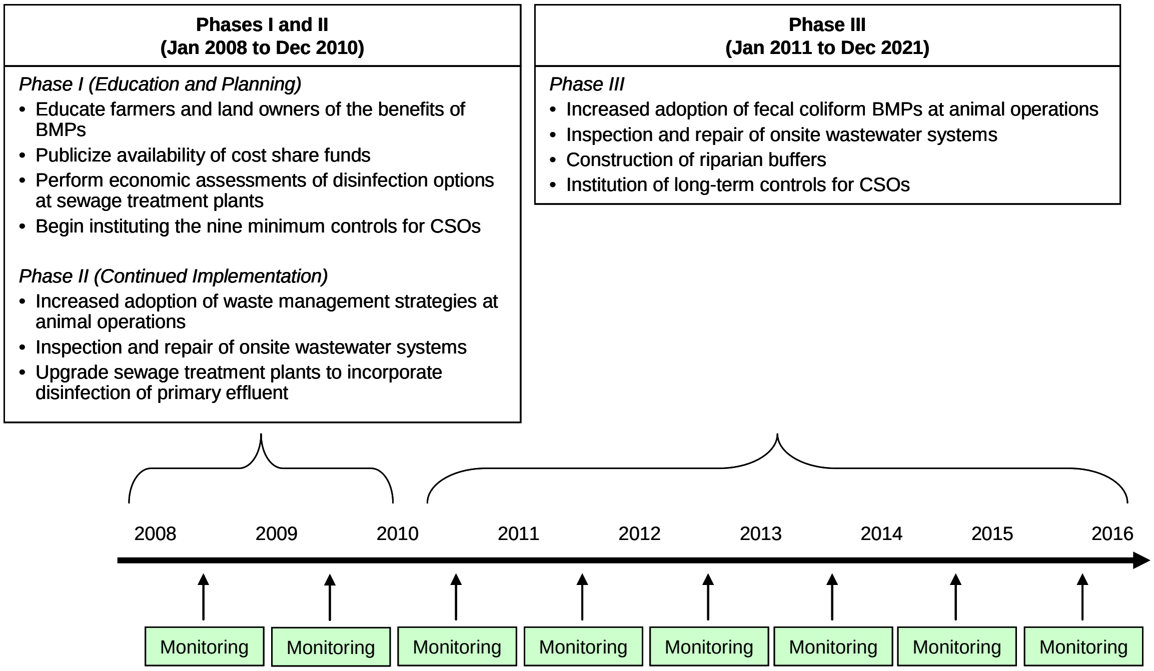
8.0 IMPLEMENTATION TIME LINE

This implementation plan for the Little Vermilion River suggests a phased approach for achieving the fecal coliform standard (Figure 8-1). Ideally, implementing fecal coliform control measures on nonpoint sources of loading will be based on voluntary participation which will depend on 1) the effectiveness of the educational programs for farmers, land owners, and owners of onsite wastewater systems, and 2) the level of participation in the programs. In addition, point source dischargers operating under a disinfection exemption are required to comply with the geometric mean fecal coliform water quality standard of 200 cfu/100 mL at the closest point downstream where recreational use occurs in the receiving water or where the water flows into a fecal-impaired segment. Facilities with year-round disinfection exemptions may be required to provide the Agency with updated information to demonstrate compliance with these requirements. Facilities directly discharging into a fecal-impaired segment may have their year-round disinfection exemption revoked through future NPDES permitting actions. 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 owners of animal operations concerning the benefits of agricultural BMPs on protecting water quality and human health as well as cost share programs available in the watershed. In addition, all owners of onsite wastewater treatment systems should be informed of their responsibilities to maintain and repair their systems. 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 Vermilion County Soil and Water Conservation District (VCSWCD). During this phase, the Georgetown and Ridge Farm sewage treatment plants may be asked to submit fecal coliform data to IEPA to determine if a disinfection exemption is still appropriate. Also, the Georgetown STP should begin to institute the nine minimum controls for mitigating CSOs.

Phase II of the implementation schedule will involve voluntary participation of farmers in BMPs such as proper manure handling and storage, composting facilities, and exclusion of cattle from streams. The local Natural Resources Conservation Service office will be able to provide technical assistance and cost share information for these BMPs. In addition, initial inspections of all onsite wastewater treatment systems and necessary repairs may begin. Plant upgrades to include a disinfection process should also begin during Phase II. Continued monitoring of water quality in the Little Vermilion River could occur at multiple monitoring stations in the watershed. This phase of the plan will likely take one to three years.

If fecal coliform 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 fecal coliform concentrations measured before and after Phase II implementation. If BMPs are resulting in decreased fecal coliform concentrations, and additional areas could be incorporated, further efforts to include more stakeholders in the voluntary program will be needed. If the Phase II BMPs are not having the desired impacts on fecal coliform concentrations, or additional areas of incorporation are not available, supplemental agricultural BMPs will be needed such as restoration of riparian areas. If the nine minimum controls are not mitigating the fecal coliform load from CSOs, the more expensive, long-term measures should be implemented. If required, this phase may last five to ten years.



Phases I and II
(Jan 2008 to Dec 2010)

Phase I (Education and Planning)

- Educate farmers and land owners of the benefits of BMPs
- Publicize availability of cost share funds
- Perform economic assessments of disinfection options at sewage treatment plants
- Begin instituting the nine minimum controls for CSOs

Phase II (Continued Implementation)

- Increased adoption of waste management strategies at animal operations
- Inspection and repair of onsite wastewater systems
- Upgrade sewage treatment plants to incorporate disinfection of primary effluent

Phase III
(Jan 2011 to Dec 2021)

Phase III

- Increased adoption of fecal coliform BMPs at animal operations
- Inspection and repair of onsite wastewater systems
- Construction of riparian buffers
- Institution of long-term controls for CSOs

Figure 8-1. Timeline for the Little Vermilion River Fecal Coliform TMDL Implementation Plan.

9.0 CONCLUSIONS

Illinois water quality standards specify that fecal coliform shall not exceed a geometric mean of 200 cfu per 100 ml based on a minimum of five samples taken over not more than a 30 day period during the months May through October. This standard was exceeded in the Little Vermilion River based on sampling that occurred between May 19, 2005 and June 14, 2005 (geomean of 315 cfu/100 mL) and between July 6, 2005 and August 3, 2005 (geomean of 263 cfu/100 mL). The geometric mean of all fecal coliform samples collected in the Little Vermilion River (377 cfu/100 mL) also exceeds 200 cfu/100 mL. IEPA has therefore included the Little Vermilion River on the Illinois 303(d) list of impaired waters, and the fecal coliform TMDL was approved in October 2006. The fecal coliform TMDL for the Little Vermilion River indicates that reductions in loading ranging from 49 to 90 percent (depending on hydrologic conditions) are required to maintain the fecal coliform standard. This implementation plan has identified the potential sources of fecal coliform loading to the river and suggests a phased approach to achieve the water quality standard.

The major sources of fecal coliform loading to the Little Vermilion River are estimated to be animal operations, failing septic systems, and sewage treatment plants operating under a disinfection exemption. There are approximately 3,460 animal units in the Little Vermilion River watershed, including beef and dairy cattle, other classes of cattle, swine, and poultry. Several cost-effective BMPs have been identified to reduce fecal coliform loading to the river from these operations: proper manure collection, transport, and storage; composting; cattle exclusion from streams with alternative watering locations; and filter strips. In addition to these BMPs, constructed wetlands have been used effectively at swine and dairy operations to reduce loading. These BMPs can each be implemented at a cost ranging from $6 to $60/animal unit/yr (not considering cost share programs).

Failing septic systems are another potential source of fecal coliform loading. Ensuring that all systems are operating as designed would reduce loading by 99.99 percent and would involve periodic inspections of all systems, pumping of tanks every three to five years, and replacement of systems on average every 30 years. The total costs per system for these controls range from $170 to $450 per year.

Other significant sources of fecal coliform loading are the two sewage treatment plants that operate under disinfection exemptions. Data are not available to estimate current loads from the Ridge Farm Plant, but the Georgetown facility has discharged up to 1,560,000 million cfu/day from the primary effluent and 14,300,000 million cfu/day from the CSO based on recent monitoring data. Upgrading these facilities to reduce loading will cost between $40,000 and $160,000 per MGD treated.

Phase I of this implementation plan will provide education and incentives to farmers and land owners in the watershed to encourage the use of BMPs. In addition, economic analyses of disinfection options at each plant will begin as well as institution of the nine minimum controls for CSOs. Phase II will occur during and following Phase I and will involve voluntary participation of farmers and land owners in the watershed. Water quality monitoring will determine whether or not these BMPs are capable of reaching the water quality goals in the watershed.

Whether or not Phase III of the plan 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, then the more expensive BMPs will need to be considered. Also, if the nine minimum controls are not sufficient to ensure compliance with the CSO permit limitations at the Georgetown STP, then implementation of the long-term controls will be necessary.

As BMPs are implemented at animal operations, failing septic systems are corrected, and sewage treatment plants begin disinfecting their effluent, water quality in the Little Vermilion River should improve accordingly. Measuring the effectiveness of these BMPs will require continued sampling of water quality in the river over the next several years.

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