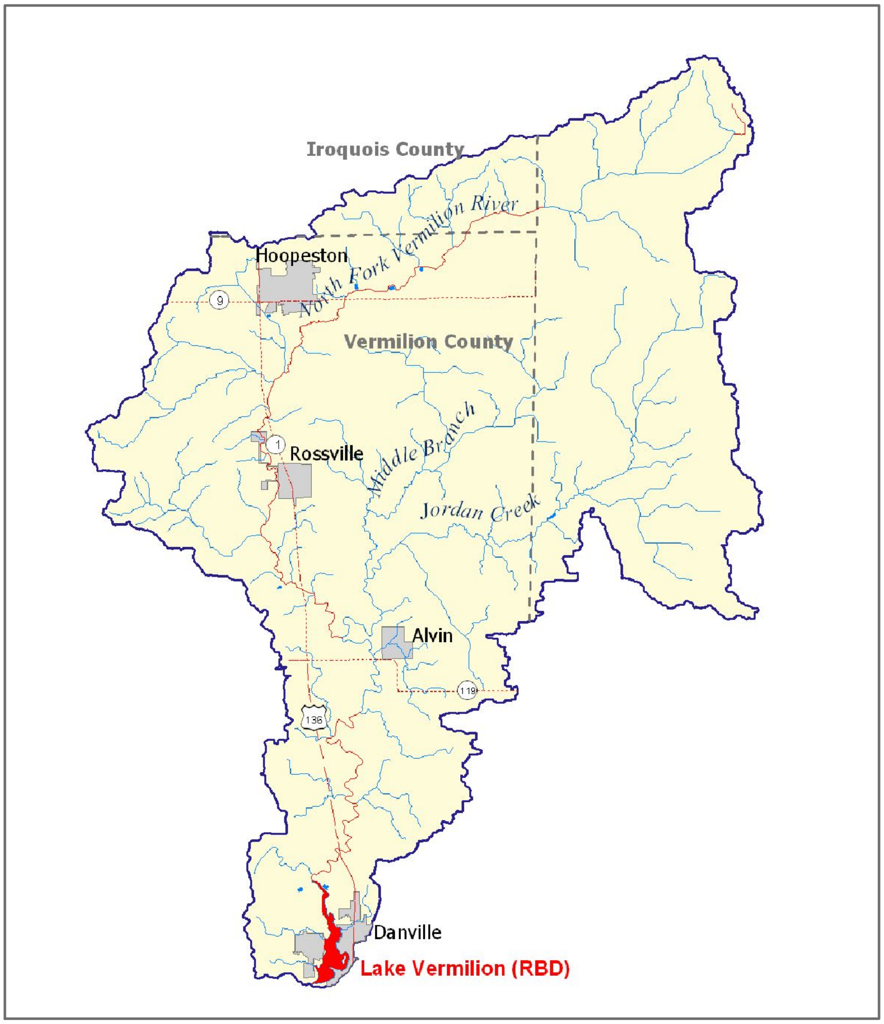
Illinois
Environmental
Protection Agency

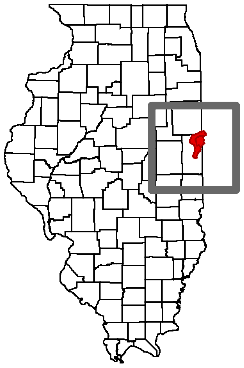
Bureau of Water
P.O. Box 19276
Springfield, IL 62794-9276

June 2008

IEPA/BOW/08-013

NORTH FORK VERMILION RIVER/ LAKE VERMILION WATERSHED TMDL REPORT





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TMDL Development for the North Fork Vermillion and Lake Vermillion, Illinois

This file contains the following documents:

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

2) Stage One Report: Watershed Characterization, Data Analysis, and Methodology Selection

3) Stage Two Report: Water Quality Sampling

4) Stage Three Report: TMDL Development

5) Implementation Plan

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

DEC 29 2006

REPLY TO THE ATTENTION OF:
WW-16J

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BUREAU OF WATER
BUREAU CHIEF'S OFF

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

Dear Ms. Willhite:

The United States Environmental Protection Agency (U.S. EPA) has conducted a complete review of the final Total Maximum Daily Load (TMDL) submittal, including supporting documentation and information, for North Fork Vermilion River segments BPG-05, BPG-09 and Lake Vermilion (RBD), which are located in Vermilion and Iroquois Counties, Illinois. Based on this review, U.S. EPA has determined that Illinois' TMDLs for North Fork Vermilion River segment BPG-05 for nitrate/nitrogen, North Fork Vermilion River segment BPG-09 for fecal coliform; and Lake Vermilion (RBD) for total phosphorus and for nitrate meet the requirements of Section 303(d) of the Clean Water Act (CWA), 33 U.S.C. § 1313(d), and U.S. EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, by this letter, U.S. EPA hereby approves these four TMDLs which address six impairments. The statutory and regulatory requirements, and U.S. EPA's review of Illinois's compliance with each requirement, are described in the enclosed decision document.

We appreciate your hard work in this area and the submittal of the TMDLs as required. If you have any questions, please contact Mr. Kevin Pierard, Chief of the Watersheds and Wetlands Branch at 312-886-4448.

Sincerely yours,

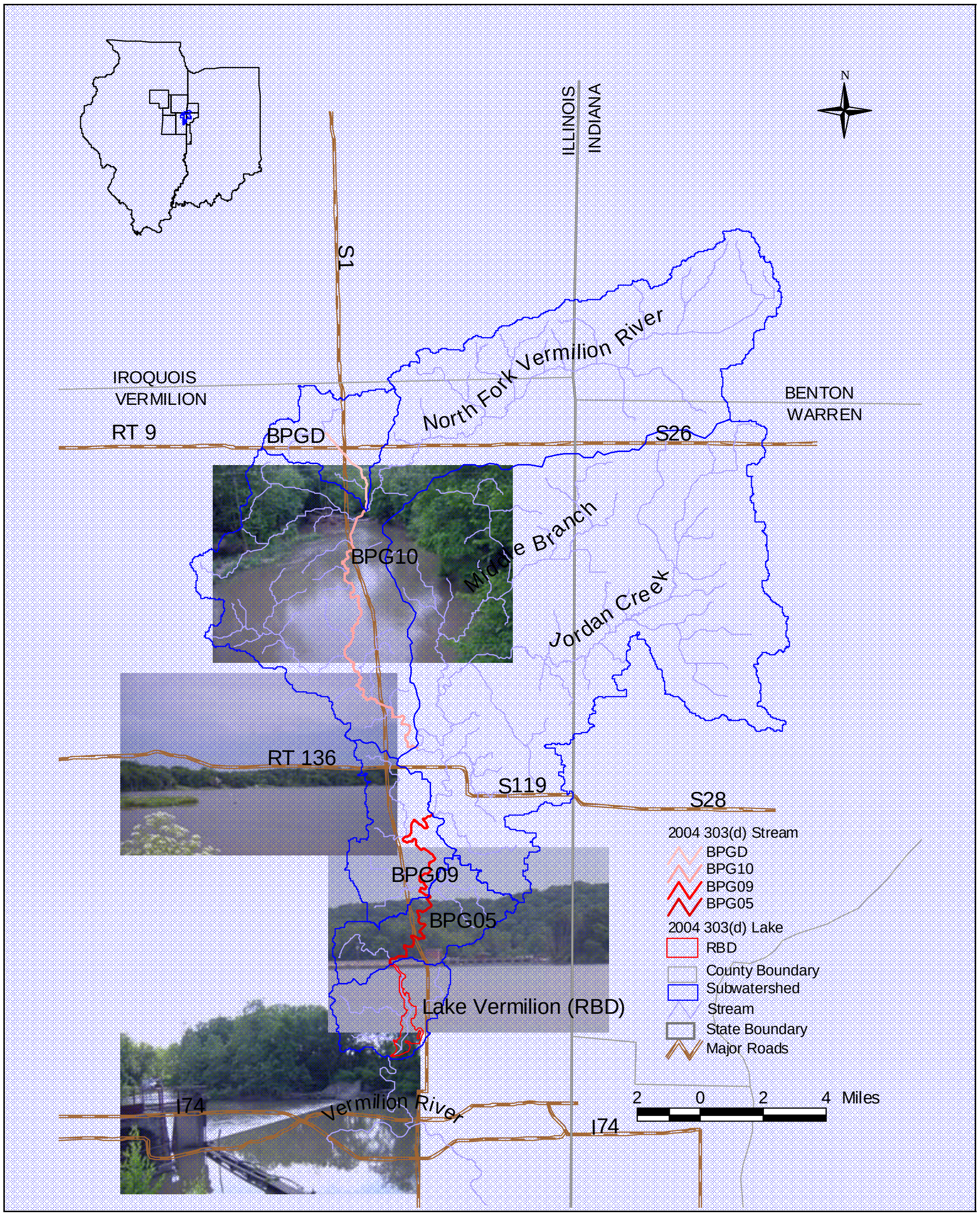
Jo Lynn Traub
Director, Water Division

Enclosure

North Fork Vermilion River and Lake Vermilion TMDL

Stage 1 Report: Watershed Characterization, Data Analysis, and Methodology selection

Submitted to:
Illinois Environmental Protection Agency



Tetra Tech, EM Inc

February 27, 2006

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EXECUTIVE SUMMARY

The Illinois 2004 303(d) list identifies following segments for impairment of designated uses:

- Hoopeston Branch (BPGD)
- North Fork Vermilion River (BPG10)
- North Fork Vermilion River (BPG09)
- North Fork Vermilion River (BPG05)
- Lake Vermilion (RBD)

This report documents the analysis and findings in Stage 1 of the TMDL development for these five water segments – watershed characterization, data analysis, and methodology selection. The focus of this report is on the portion of the North Fork Vermilion River watershed that drains into Lake Vermilion.

The North Fork Vermillion River Watershed is located in central Illinois along the Illinois-Indiana border. Most of the watershed is located in Vermilion County, Illinois, with portions extending to Iroquois County in Illinois, and to Warren and Benton Counties in Indiana. The watershed drains about 295 square miles, with about 200 square miles in Illinois and 95 square miles in Indiana. The North Fork Vermilion River flows about 62 miles from its headwaters in Benton County, Indiana, to Lake Vermilion in Danville, Illinois, then into the Vermilion River. Lake Vermilion is a drinking water reservoir located northwest of Danville, Illinois. The land use in the North Fork Vermilion River watershed is predominantly agriculture cropland. The soil has medium potential for runoff and erosion.

Water quality data are gathered from IEPA, USGS NWIS and USEPA STORET database. The data analysis is performed for the listed segments. A review of the available water quality data confirms the causes of impairments in BPGD, BPG09, BPG05, and RBD. DO concentration has violated the minimum 5 mg/l Illinois standard in BPGD. It was found that average monthly fecal coliform concentrations (indicator for pathogen) in BPG09 have exceeded the Illinois not-to-exceed standard of 400 cfu/100mL although the existing one-sample-per-month approach does not support the calculation of 5-samples-per-month geometric mean required in Illinois water quality standard. The average fecal coliform concentration exceeded the standards in both low flow and high flow condition, resulting from overland runoff as well as possible steady low flow sources. BPG10 is listed for a pollutant without a water quality standard and no TDML will be developed.

The data verified that the total phosphorus is a limiting nutrient in Lake Vermilion (RBD) and frequently exceeded the 0.05 mg/L water quality standard. The average annual concentrations exceeded the lake phosphorus standard in almost every year. Therefore, a TMDL will be developed for phosphorus. The elevated phosphorus concentration results in excessive algae growth and organic enrichment. Nitrate nitrogen is listed as a cause for impairment in Lake Vermilion. Because nitrite nitrogen seldom appears in concentration greater than 1 mg/L and tends to transforms to nitrate, the nitrate and nitrite nitrogen concentration data is used to verify the exceedance. The maximum observed nitrite and nitrate concentration exceeded the standard of 10 mg/L in Lake Vermilion. As a result of the 2004 assessment update for Lake Vermilion, dissolved oxygen, sedimentation/siltation, and total nitrogen no longer apply as a potential causes of impairment because Aquatic Life Use is not impaired. A TMDL will not be developed for these pollutants.

Both point sources and nonpoint sources may potentially contribute to impairments in Hoopeston Branch, North Fork Vermilion River, and Lake Vermilion. Potential nonpoint sources include agricultural runoff, urban runoff, wildlife, animal feedlots, and possible manure applications. Private septic systems are prevalent in Vermilion County and the estimated number of unpermitted septic systems is relatively high. The septic system failure is a potential source of nutrient, and pathogen loads. Septic systems can potentially leach nutrients into the shallow groundwater and eventually reach surface water. In addition, subsurface tile drainage is common in the watershed. The tile drain increases the possibility for soluble nitrogen to reach the surface water. In addition, some private septic systems may be connected with the drain tile and provides a direct load to the streams, especially under low flow conditions. There are six significant point source dischargers in the watershed. Hoopeston Sewage Treatment Plant discharges the largest flow of 1.65 million gallons per day to the North Fork Vermilion River. This issue will be explored further in Stages 2 and 3. The point sources may not be dominant sources in the watershed.

Both a simple and sophisticated modeling approaches are considered for the North Fork Vermilion River TMDL. The final selection will be made after the review of Stage 1 report and follow-up discussion with IEPA. A simple duration curve approach may be used in combination with spreadsheet type watershed model for the development of TMDLs in BPG05 and BPG09, given that the continuous flow and water quality data are available. A simple mass balance BATHTUB model may be used for Lake Vermilion (RBD). A sophisticated modeling approach includes watershed model and water body model. Soil Water Assessment Tool (SWAT) is considered as watershed model to simulate hydrology and loading in the watershed. A Water Quality Analysis Simulation Program (WASP) model may be selected to simulate the water quality in the listed North Fork Vermilion River and Lake Vermilion segments. Both models are frequently used for TMDL development and load allocation throughout the United States. The combination of these two models provides a framework for TMDL development and watershed management evaluation.

Data review shows that available flow and water quality data meet the basic needs for TMDL development of the segments BPG 09 and BPG05 of North Fork Vermilion River and Lake Vermilion. A sampling stage is recommended for BPGD since few data points are available for the segment. In addition, IEPA may also consider collecting flow and current fecal coliform data at a temporal interval of five-samples-per-month (as stated in Illinois Water Quality Standards) in North Fork Vermilion River to verify the exceedance. While data collection may not be exhausted, the identified data gaps are mainly related to the sources assessment. These data gaps include:

- Flow and water quality in Hoopeston Branch
- Septic tank investigation (distribution, upgrade, failure incidents)
- Drain tile data (existing condition, distribution, and density)
- Groundwater discharge and quality data
- Live stock assessment
- Wildlife assessment
- Channel geometry
- Livestock operations and feedlot permits
- Danville Storm and Sanitary Sewer information

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act (CWA) and the U.S. Environmental Protection Agency (USEPA) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to identify water bodies that do not meet water quality standards and to determine the Total Maximum Daily Load (TMDL) for pollutants causing the impairment. A TMDL is the total amount of pollutant load that a water body can receive and still meet the water quality standards. It is the sum of the individual waste load allocation for point sources and load allocations for nonpoint sources and natural background with a margin of safety. The CWA establishes the process for completing TMDLs to provide more stringent, water-quality based controls when technology-based controls are not sufficient to achieve state water quality standards. 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 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.

Under Section 303(d) of the CWA, the State of Illinois prepared a list of waters that are not meeting state water quality standards (hereafter referred to as the “303(d) list”) in each 2-year cycle. The most recent list was reviewed and approved by USEPA in 2004. The 303(d) list identifies five water bodies as impaired:

- North Fork Vermilion River (BPG05)
- North Fork Vermilion River (BPG09)
- North Fork Vermilion River (BPG10)
- Hoopeston Branch (BPGD)
- Lake Vermilion (RBD)

IEPA is currently developing TMDLs for pollutants that have numeric water quality standards. Although BPG10 is discussed in this report, no TMDL will be developed for BPG10 because there is no water quality standard for total nitrogen in streams. North Fork Vermilion River (watershed ID: ILBPG09) flows into Lake Vermilion and discharge to the Vermilion River (Watershed HUC 05120109). The State of Illinois has assigned a high priority to the North Fork Vermilion River watershed for TMDL development.

This report documents the analysis and findings in Stage 1 characterization of overall hydrology and water quality for North Fork Vermilion River watershed. The focus of this TMDL is on the portion of the North Fork Vermilion River watershed that drains into Lake Vermilion. In this report, “North Fork Vermilion River watershed” refers to the watershed area upstream of Lake Vermilion dam, unless otherwise specified. The purposes of the watershed characterization and data analysis report are to (1) confirm impairments in listed water bodies by comparing observed data with water quality standards or appropriate targets; (2) evaluate spatial and temporal water quality variation; (3) evaluate any identifiable relationships between pollutants of concern and other environmental measurements and conditions (for example, water quality and stream flow condition); (4) provide a preliminary assessment of sources contributing to impairments; (5) describe potential TMDL development approaches; and (6) identify data needs and recommendations for additional data collection.

This chapter discusses the rationale for beneficial use designations and impairments for waters of the State of Illinois, and specifically, for the listed North Fork Vermilion River segments and Lake Vermilion in eastern Illinois. Chapter 2 describes the characteristics of the watershed and water bodies, and chapter 3 addresses the climate and hydrology conditions. Chapter 4 describes the water quality standards and water quality assessment. Chapter 5 discusses the potential nonpoint and point sources that may cause the impairment. Chapter 6 describes the methodology selection for the TMDL development. Finally, chapter 7 identifies data gaps and provides recommendations for additional data collection.

All waters of Illinois are assigned one of the following four designations: general use waters, public and food processing water supplies, Lake Michigan, and secondary contact and indigenous aquatic life waters. All Illinois waters must meet general use water quality standards unless they are subject to another specific designation (CWA Section 302.201). The general use standards protect the state’s water for aquatic life (except as provided in Illinois Water Quality Standard Section 302.213), wildlife, agricultural use, secondary contact use, and most industrial uses, and they ensure the aesthetic quality of the state’s aquatic environment. Primary contact uses are protected for all general use waters where the physical configuration permits such use. Unless otherwise specifically provided for and in addition to the general use standards, waters of the state must meet the public and food processing water quality standards at the points of water withdrawal for treatment and distribution as a potable supply or for food processing.

The designated uses and the causes of impairment addressed in this TMDL are summarized in Tables 1-1. When a waterbody is assessed as partial support for a designated use, one violation of an applicable Illinois water quality standard at an Intensive Basin Surveys (IBS) or Facility-Related Stream Surveys (FRSS) site or one violation over three years at an Ambient Water Quality Monitoring Network (AWQMN) station is considered a basis for listing the violating parameter as a potential cause.

TABLE 1-1 DESIGNATED USES OF IMPAIRED SEGMENTS

Segment	Designated Use and Support Status (in parenthesis)	Causes of Impairment	Impairments addressed in TMDL
North Fork Vermilion River (BPG05)	Aquatic life (full) Drinking water supply (partial)	Nitrogen Nitrate	Nitrogen Nitrate
North Fork Vermilion River (BPG09)	Aquatic life (full) Primary contact (not supporting)	Pathogen	Fecal Coliform
North Fork Vermilion River (BPG10)	Aquatic life (partial) Fish Consumption (not assessed)	Total Nitrogen	None
Hoopeston Branch (BPGD)	Aquatic life (partial)	Total Nitrogen (TN) Dissolved Oxygen (DO) Total Phosphorus (TP)	DO
Lake Vermilion (RBD)	Overall use (partial) Aquatic life support (fully) Fish consumption (fully) Primary contact (partial) Secondary contact (partial) Drinking water supply (partial)	TP and Nitrate	TP and Nitrate

Source: IEPA 2004 303(d) list

The North Fork Vermilion River and Hoopeston Branch segments addressed in this report are designated as a general use water body. As specified under Title 35 of the Illinois Administrative Code, Subtitle C, Part 302, waters of the state shall be free from sludge or bottom deposits (narrative standard for siltation), visible oil, odor, plant or algal growth (narrative standards for nutrients, eutrophication, or noxious aquatic plants), and color or turbidity of other than natural origin. Aquatic life is fully supported in segments BPG05, BPG09, and RBD while partially supported in segments BPG10 and BPGD. The primary contact use of the river is listed as non-support in segment BPG09 due to violation of the fecal coliform standard. Lake Vermilion (RBD) is the drinking water supply for the City of Danville. Drinking water supply use of Lake Vermilion is listed as partial support due to nitrate concentrations in excess of the 10 mg/L Public and Food Processing Standard. This standard applies to raw (untreated) sources water at any point at which water is withdrawn from the waterbody for treatment and distribution as a potable water supply or for food processing. BPG05 is also assessed as partial support for drinking water supply use because it is located immediately upstream of RBD. In Lake Vermilion, aquatic life and fish consumption are fully supported, while its uses as a drinking water supply and for primary and secondary contact are partially supported, resulting in partial support of overall use. One purpose of this report is to verify the causes of impairment by comparing the available data to water quality standards.

In the 2004 Illinois Water Quality Report (IEPA 2004), dissolved oxygen, total nitrogen, nitrate nitrogen, total suspended solids, sedimentation/siltation, and excessive algal growth were listed as potential causes of impairment for Lake Vermilion. The determination of these potential causes was based on applying the 2002 assessment methodology to the data collected from Lake Vermilion in 2000. As a result of the 2004 assessment update for Lake Vermilion, dissolved oxygen, sedimentation/siltation, and total nitrogen no longer apply as a potential causes of impairment because Aquatic Life Use is not impaired. Therefore, since dissolved oxygen is not considered a potential cause of Aquatic Life Use impairment, a TMDL will not be developed for dissolved oxygen at this time. Furthermore, data show that the numeric general use water quality standard for total phosphorus (0.05 mg/L) was exceeded during the 2000 monitoring season and therefore, total phosphorus will be added as a potential cause of impairment for Secondary Contact Use and a TMDL will be developed for total phosphorus.

2.0 WATERSHED AND WATER BODY CHARACTERISTICS

This chapter describes the general hydrological characteristics of the North Fork Vermilion River watershed and water bodies, including their location, population, land use and cover, topography and geology, and soils. The discussion of general watershed characteristics is followed by specific information for the listed segments of the river and the lake.

2.1 LOCATION

The North Fork Vermillion River Watershed is located in central Illinois along the Illinois-Indiana border, as shown on Figure 2-1. Most of the watershed is located in Vermilion County, Illinois, with portions extending to Iroquois County in Illinois, and to Warren and Benton Counties in Indiana. The watershed drains about 295 square miles, with about 200 square miles in Illinois and 95 square miles in Indiana. The distribution of watershed area by county is shown in Table 2-1.

TABLE 2-1 WATERSHED AREA DISTRIBUTION BY COUNTY

County, State	Area of Watershed in County (Square Miles)	Percent of Watershed in County (Percent)
Vermilion County, Illinois	190	64
Iroquois County, Illinois	10	3
Warren County, Indiana	66	23
Benton County, Indiana	29	10

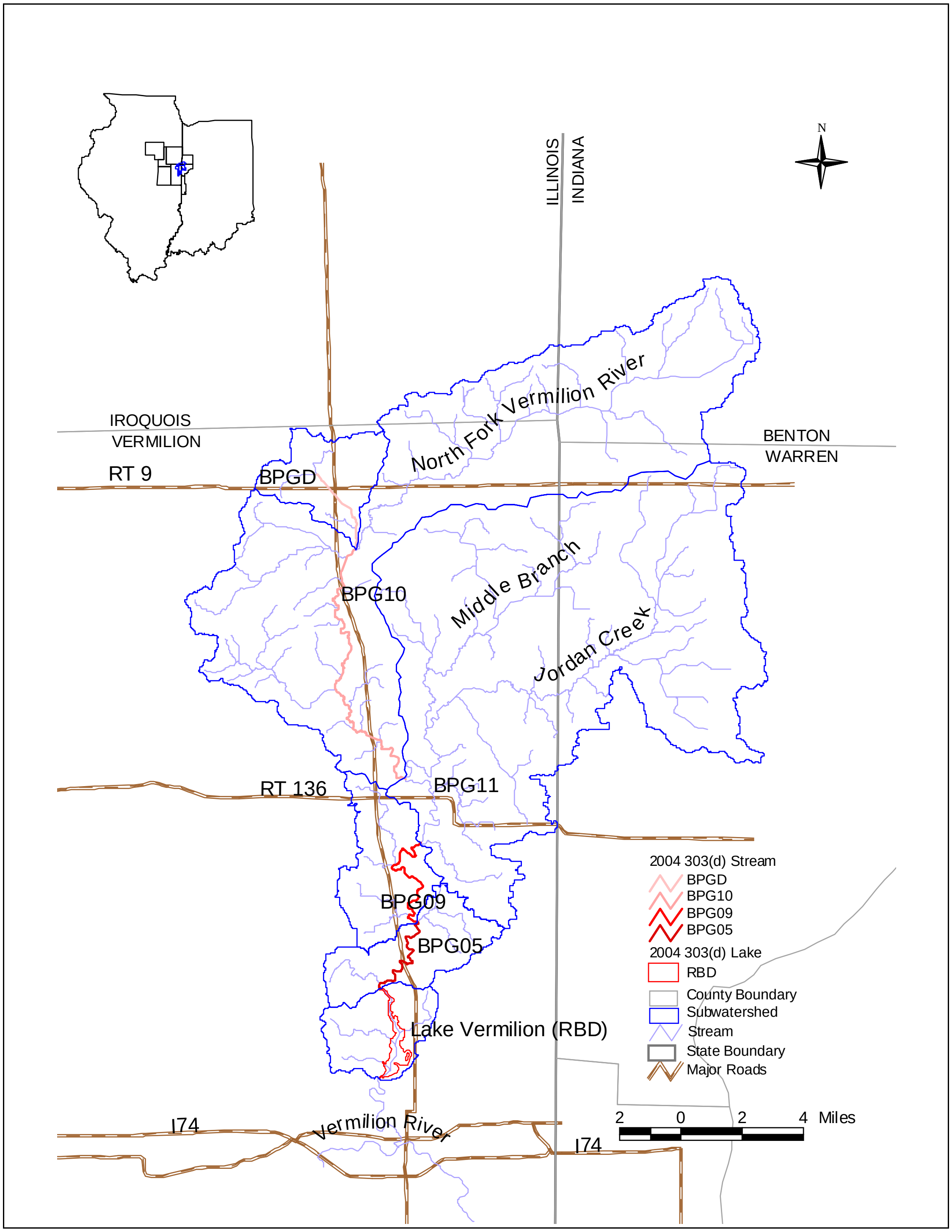
Lake Vermilion (RBD) is located in the southern portion of the watershed, 1 mile northwest of the City of Danville, about 5.2 miles upstream of the confluence of the North Fork Vermilion River with Vermilion River. BPG05 is located immediately upstream of Lake Vermilion, and extends about 9.82 miles. BPG09 starts at the confluence with Painter Creek and extends downstream 5.91 miles, directly flowing into BPG05. BPG10 starts at the confluence of Middle Branch and extend upstream 24.1 miles. BPGD is 4.72 mile Hoopeston Branch, extending from the confluence with North Fork Vermilion to the source water. The North Fork Vermilion River watershed is delineated into six subwatersheds, including the one draining to BPG11 (Figure 2-1). This TMDL focuses on the subwatersheds that drain to the listed North Fork Vermilion River segments (except BPG10), Hoopeston Branch, and Lake Vermilion segments. The watershed area between the dam and the confluence with the Vermilion River is not included in the TMDL. The characteristics of subwatersheds will be used for the load allocation for each segment in the TMDL development. The load allocation from the river segment (BPG05) can be treated as lumped point source load to Lake Vermilion.

2.2 POPULATION

Total watershed population data is not directly available but population estimates may be calculated from the 2000 U.S. Census data. The census data were downloaded for all towns, cities, and counties with boundaries that were fully or partially within the watershed (U.S. Census Bureau 2000). Urban and nonurban populations were estimated for the watershed area and were summed to obtain the total watershed population. This section describes how urban and nonurban population estimates were determined from town, city, and county census data.

The urban watershed population is the sum of the populations for all municipalities located entirely in the watershed. For Danville, which is located partially in the watershed, a population weighting method was used to estimate its contribution to the urban watershed population. A geographic information system (GIS) spatial overlay of the town and city boundaries was used to determine that 27 percent of Danville is located in the Lake Vermilion subwatershed. Assuming a uniform distribution of population throughout

FIGURE 2-1 NORTH FORK VERMILION RIVER WATERSHED



Danville, the population of Danville was multiplied by 27 percent to estimate its contribution to the urban population. Table 2-2 lists the populations of each municipality in the watershed. The contributing population for each area was summed to obtain total urban watershed population for the two subwatersheds.

TABLE 2-2 MUNICIPALITY POPULATION IN THE NORTH FORK VERMILION RIVER WATERSHED

Subwatershed	Municipality/County	Urban population
BPGD	Hoopeston/Vermilion	5,965
BPG10	Ambia/Benton Rossville/Vermilion	197 1,217
BPG09	Alvin/Vermilion Bismarck/Vermilion Henning/Vermilion	316 542 241
BPG05	NA	NA
RBD	Danville/Vermilion	9,154[a]
Total		**17,632**

Notes:
NA Not applicable (no municipalities located in the subwatershed)
a Represents 27 percent of the total Danville population of 33,904; 27 percent of Danville is located in the watershed.
Source: U.S. Census Bureau 2000

The first step in calculating the nonurban watershed population was to subtract the county urban population from the total county population. The portion of nonurban population in each subwatershed was then calculated by multiplying the percent area of the county in the subwatershed by the nonurban population of the county. For example, the nonurban population of Vermilion County is 23,263. 2.51 percent of Vermilion County is in the Lake Vermilion subwatershed, and 18.7 percent of Vermilion County is in the North Fork Vermilion River subwatershed. Therefore, 2.51 percent of 23,263 (584) is assumed to be in the Lake Vermilion subwatershed, and 18.7 percent of 23,263 (4,350) is assumed to be in the North Fork Vermilion River subwatershed. The results from these calculations for each subwatershed and county are shown in Table 2-3. These results are based on the assumption that nonurban populations are uniformly distributed throughout each county.

TABLE 2-3 WATERSHED POPULATION SUMMARIZED BY WATER BODY SEGMENT

Waterbody Segment	County	Watershed Population	Percent Watershed Population	Urban population	Percent Urban Population	Nonurban Population	Percent Nonurban Population
North Fork Vermilion River[a]	Benton	424	2.99	197	1.39	227	1.60
	Iroquois	102	0.73	0	0.00	102	0.73
	Vermilion	12,631	89.21	8,281	58.49	4,350	30.72
	Warren	1,001	7.07	0	0.00	1,001	7.07
	Total	**14,158**	**100**	**8,478**	**59.88**	**5,680**	**40.12**
Lake (RBD)	Vermilion	**9,738**	**100**	**9,154**	**94.00**	**584**	**6.00**

[a] Include BPGD, BPG05, BPG09, and BPG10 subwatersheds

Source: U.S Census Bureau 2000 and USEPA 1998

Table 2-4 shows the population change between 1990 and 2000 for each county in the watershed. Detailed population data by county and town was not available for 1990, so percent urban and nonurban population change in each watershed could not be calculated. However, data indicates that population in the watershed is likely decreasing. Between 1990 and 2000, the population of Danville decreased from 37,025 to 33,904, which further supports a decreasing population trend in the watershed (U.S. Census Bureau 1990 and 2000).

TABLE 2-4 POPULATION CHANGE

County in the Watershed	1990 Population	2000 Population	Absolute Change	Percent Change
Benton	**9,441**	**9,421**	**-20**	**-0.21%**
Iroquois	**30,787**	**31,334**	**547**	**1.78%**
Vermilion	**88,254**	**83,919**	**-4,335**	**-5.17%**
Warren	**8,176**	**8,419**	**243**	**2.97%**
Weighted Average				**-2.61%**

Sources: U.S Census Bureau 1990 and 2000

2.3 LAND USE AND LAND COVER

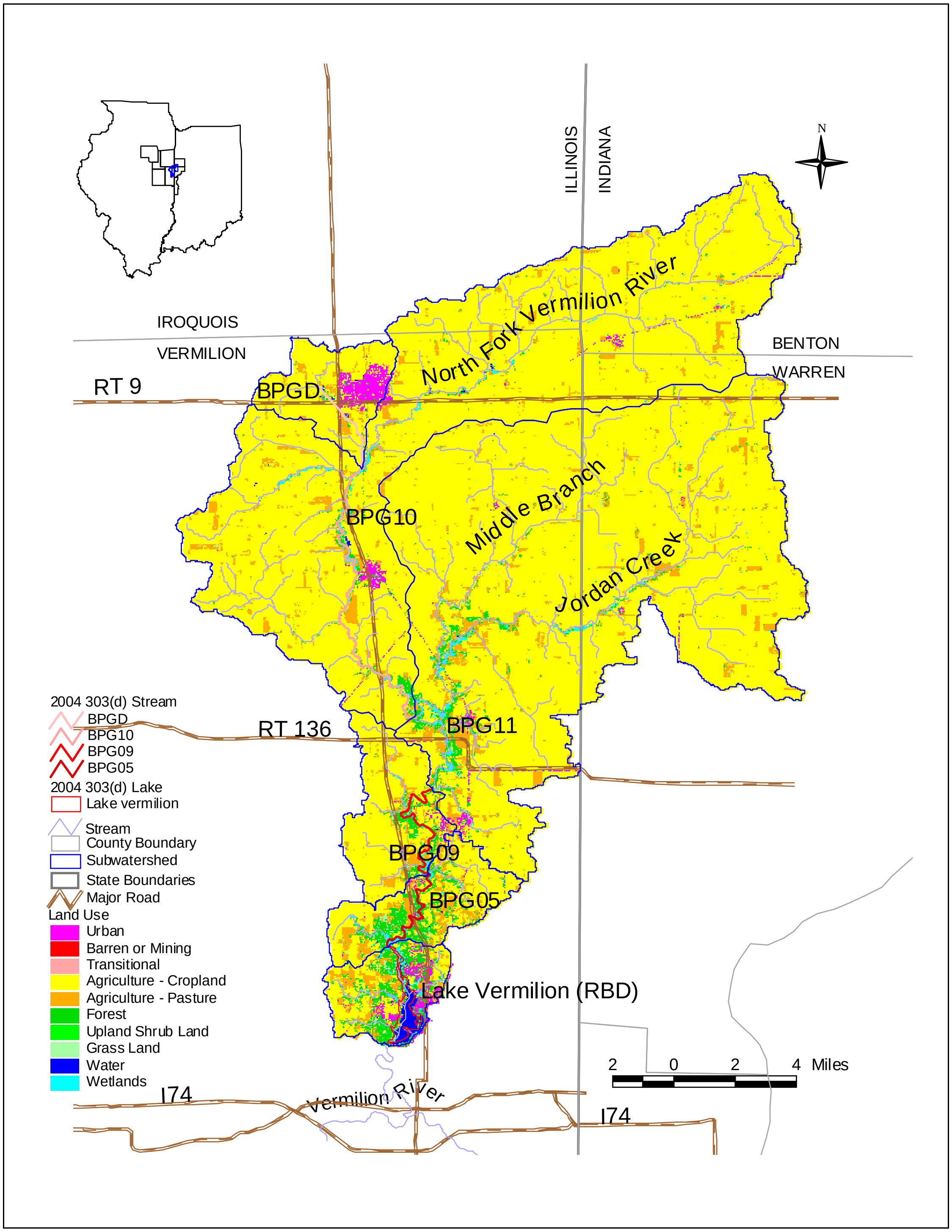
Figure 2-2 presents land use and land cover in the North Fork Vermilion River watershed. Land use data for the North Fork Vermilion River Watershed was obtained from the U.S. Geological Survey (USGS) Geographic Information Retrieval and Analysis (GIRAS) data files. The files consist of 1993 land use/land cover digital data collected by USGS and converted to ARC/INFO by USEPA (EPA 2000). The data can be used for environmental assessment of land use patterns with respect to water quality analysis, growth management, and other types of environmental impact assessment. Illinois Gap Analysis Program (GAP) land use and land cover data provides detailed classification of agriculture land. However, the State of Indiana doesn’t have land classification compatible to Illinois. The GAP data is not used for land use analysis. Land use is calculated for subwatersheds contributing to each listed segment.

Table 2-5 summarizes the land use for subwatershed of BPGD segment. It shows that the agriculture cropland account for about 75 percent of total 6,943 acre subwatershed. The urban land accounts for 14 percent, mainly attributed to the City of Hoopeston. The other land uses account for less than 1 percent respectfully. BPGD subwatershed drains to North Fork Vermilion River BPG10. Pasture Land is considered rural grassland with possible grazing activities.

TABLE 2-5 LAND USES IN SUBWATERSHED OF BPGD

Land Use	Area (acre)	Percentage of Upstream Watershed Area
Cropland	5,230.2	75.52
Pasture	575.9	8.31
Forest	68.1	0.98
Urban	979.1	14.14
Wetland	16.7	0.24
Grass Land	41.3	0.60
Water	13.1	0.19
Barren or Mining	1.6	0.02
Total	**6,925.9**	**100.00**

FIGURE 2-2 LAND USE AND LAND COVER MAP



BPG10 subwatershed consists of predominantly agriculture land, with over 90 percent, as shown in Table 2-6. Pasture land is about 6 percent, followed by urban land 1.8 percent, and forestland 1.2 percent. No TMDL will be developed for BPG10 because there is no existing numeric water quality standard for total nitrogen, which is the cause for listing.

TALBE 2-6 LAND USES IN SUBWATERSHEDS OF BPG10

Land Use	Area (acre)	Percentage of Upstream Watershed Area
Cropland	72,865.3	90.25
Pasture	4,706.3	5.83
Forest	960.5	1.19
Urban	1,464.4	1.81
Wetland	408.5	0.51
Grass Land	254.7	0.32
Water	73.4	0.09
Barren or Mining	2.3	0.003
Total	**80,735.5**	**100.00**

Table 2-7 summarizes land use for the BPG09 subwatershed of North Fork Vermilion River subwatershed. It is predominantly agricultural crop land, accounting for 89.6 percent of the total watershed area. Pasture land accounts for about 6.5 percent, and forest land accounts for 1.8 percent. Agriculture lands are mostly located upstream near the headwater area. Major crops are corn, small grains, and soybeans.

TABLE 2-7 LAND USES IN SUBWATERSHEDS OF BPG09

Land Use	Area (acre)	Percentage of Upstream Watershed Area
Cropland	156,359.1	89.56
Pasture	11,293.4	6.47
Forest	3,215.1	1.84
Urban	1,896.3	1.09
Wetland	969.7	0.56
Grass Land	752.8	0.43
Water	93.5	0.05
Barren or Mining	3.0	0.002
Total	**174,583.0**	**100.00**

BPG05 subwatershed represents the drainage area upstream of North Fork Vermilion River entrance to Lake Vermilion, which includes BPG09 subwatershed plus the lateral contributing area along BPG05 segment. The land use distribution is similar to BPG09 subwatershed, with agriculture cropland at 90 percent, pasture at 5.8 percent, forest 1.19 percent, and urban 1.8 percent. Wetland, grassland, water, and barren or mining together account for about 1 percent (Table 2-8)

TABLE 2-8 LANDUSES IN SUBWATERSHEDS OF BPG05

Land Use	**Area (acre)**	**Percentage of Upstream Watershed Area**
Cropland	160,803.2	90.25
Pasture	12,925.4	5.83
Forest	4,541.8	1.19
Urban	1,984.6	1.81
Wetland	1,132.7	0.51
Grass Land	1,037.3	0.32
Water	105.0	0.09
Barren or Mining	3.0	0.003
Total	**182,532.9**	**100.00**

RBD subwatershed is the portion of Vermilion River Watershed upstream of Lake Vermilion, including BPG05 watershed and the area that drains directly to the lake. Table 2-9 summarizes the land use for the RBD subwatershed that drains directly to the lake. The area surrounding Lake Vermilion is also predominately agricultural land and urban land.

TABLE 2-9 LAND USE IN RBD SUBWATERSHED (UPSTREAM OF LAKE VERMILION DAM)

Land Use	**Area (acre)**	**Percentage of Upstream Watershed Area**
Cropland	162,868.9	86.20
Pasture	14,102.5	7.46
Forest	5,981.2	3.17
Urban	2,604.2	1.38
Wetland	1,344.7	0.71
Grass Land	1,307.4	0.69
Water	708.8	0.38
Upland Shrub Land	27.5	0.01
Barren or Mining	3.0	0.002
Transitional	1.6	0.001
Total	**188,949.9**	**100.00**

2.4 TOPOGRAPHY AND GEOLOGY

The North Fork Vermilion River watershed has rough topography resulting from streams eroding its valleys into glacial drift. The rivers have broad floodplains formed by glacial lakes. The highest point in the watershed is at an elevation of about 820 feet (NGVD 1929), and the lowest point is at about 520 feet (NGVD 1929). The rivers have incised through a relatively thin cover of unconsolidated materials overlying the La Salle Anticlinorium, and their drainage patterns are largely controlled by joint patterns associated with the La Salle Anticlinorium. Sedimentary rocks of Ordovician and Pennsylvanian age are exposed along the waterways throughout the area. Two geological time periods are well represented: the Pennsylvanian (the age of coal) and the Quaternary (the age of glaciers).

The bedrock strata that immediately underlie most of the surface materials in the Vermilion River area are Pennsylvanian age. They were formed from sediments deposited some 290 million years ago when what is now Illinois was covered by shallow seas with large swamps near the shore. These wet, swampy areas supported a lush forest of large trees, tree and seed ferns, and giant scouring rushes. As the plants fell into the swampy waters, they were partially preserved, buried by later sediments and eventually converted into coal. Pennsylvanian-age bedrock is classified by cyclothems, which are based on this cyclical sedimentation.

Other landscape features resulted from the multiple glacial advances across the region. The glaciers left moraines, terraces, kames, an entrenched meander, and sand dunes. A succession of moraines (deposits that mark where a glacier melted and advanced at the same rate) are present across the land surface. These moraine ridges generally trend northwest to southeast, then continue to loop around to the east. The Bloomington Moraine, a prominent feature of the Oakwood area, is one of the largest in Illinois and represents the southernmost extent of a readvance of a glacier some 15,000 years ago.

As the glaciers melted, water poured down the Wabash Valley, rapidly deepening it. In addition, glacial Lake Watseka, located to the north, breached the Chatsworth moraine. Its outwash material flowed south following what is now the course of the North Fork Vermilion River. The valley of the Vermilion River, including the Salt Fork, became entrenched below the upland. The Vermilion River cut its channel 60 feet below the upland into the Pennsylvanian bedrock.

East of Rossville is an area of sand 2 miles wide and 3 miles long that has been blown into dunes. The sand dunes are the result of glacial ice. They were deposited when the valley of the North Fork Vermilion River filled with outwash from a melting glacier or with valley train deposits (outwash that has been deposited in a stream valley) from the draining of ancient Lake Watseka.

2.5 SOILS

Soils data and GIS files from the Natural Resources Conservation Service (NRCS) were used to characterize soils in the North Fork 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. Identification fields in the GIS coverage can be linked to a database that provides information on chemical and physical soil characteristics. The STATSGO database contains many soil characteristics associated with each map unit. Of particular interest are the hydrologic soil group, the K-factor of the Universal Soil Loss Equation (USLE), and depth to water table.

The hydrologic soil group classification identifies soil groups with 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 2-10.

TABLE 2-10 NRCS HYDROLOGIC SOIL GROUP

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.

Dual hydrologic groups, A/D, B/D, and C/D, are given for certain wet soils that can be adequately drained. The first letter applies to the drained condition, the second to the undrained. Only soils that are rated D in their natural condition are assigned to dual classes. Soils may be assigned to dual groups if drainage is feasible and practical. Figure 2-3 displays the STATSGO hydrologic soil group map for the North Fork Vermillion River watershed. For the North Fork Vermilion River watershed, Hydrologic Soil Group C accounts for 30.2 percent and is mostly located along the river channel. Hydrologic Soil Group D (poorly drained) accounts for 42.7 percent and located in upper land of the watershed. Hydrologic Soil Group B covers about 27.1 percent in the northern portion of the watershed.

A commonly used soil attribute of interest is the K-factor, a coefficient used in the USLE (Wischmeier and Smith, 1978). The K-factor is a dimensionless measure of a soil's natural susceptibility to erosion. 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 potential soil erodibility. The distribution of K-factor values in the North Fork Vermilion River watershed is shown in Figure 2-4. The figure indicates that soils with erosion K-Factor range from 0.28 to 0.43; 44 percent of watershed area has a K-factor of 0.32, 35 percent has a K-factor of 0.43, and 21 percent of the area has a K-factor of 0.28. A very small portion of the watershed in Indiana has a K-factor of 0.37. These more highly erodible soils are primarily distributed on both sides of North Fork Vermilion River in the central portion of the watershed.

FIGURE 2-3 HYDROLOGIC SOIL GROUP MAP

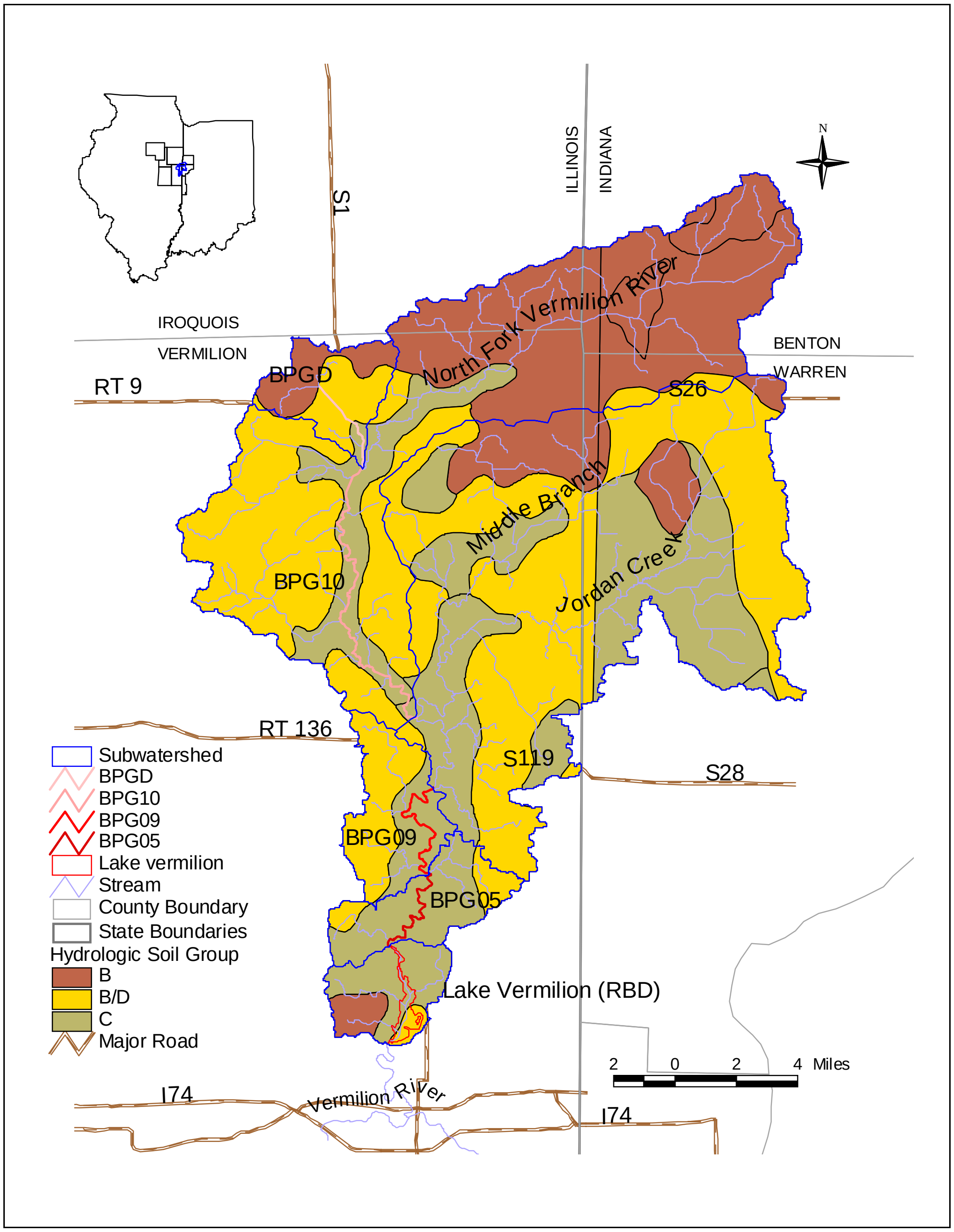
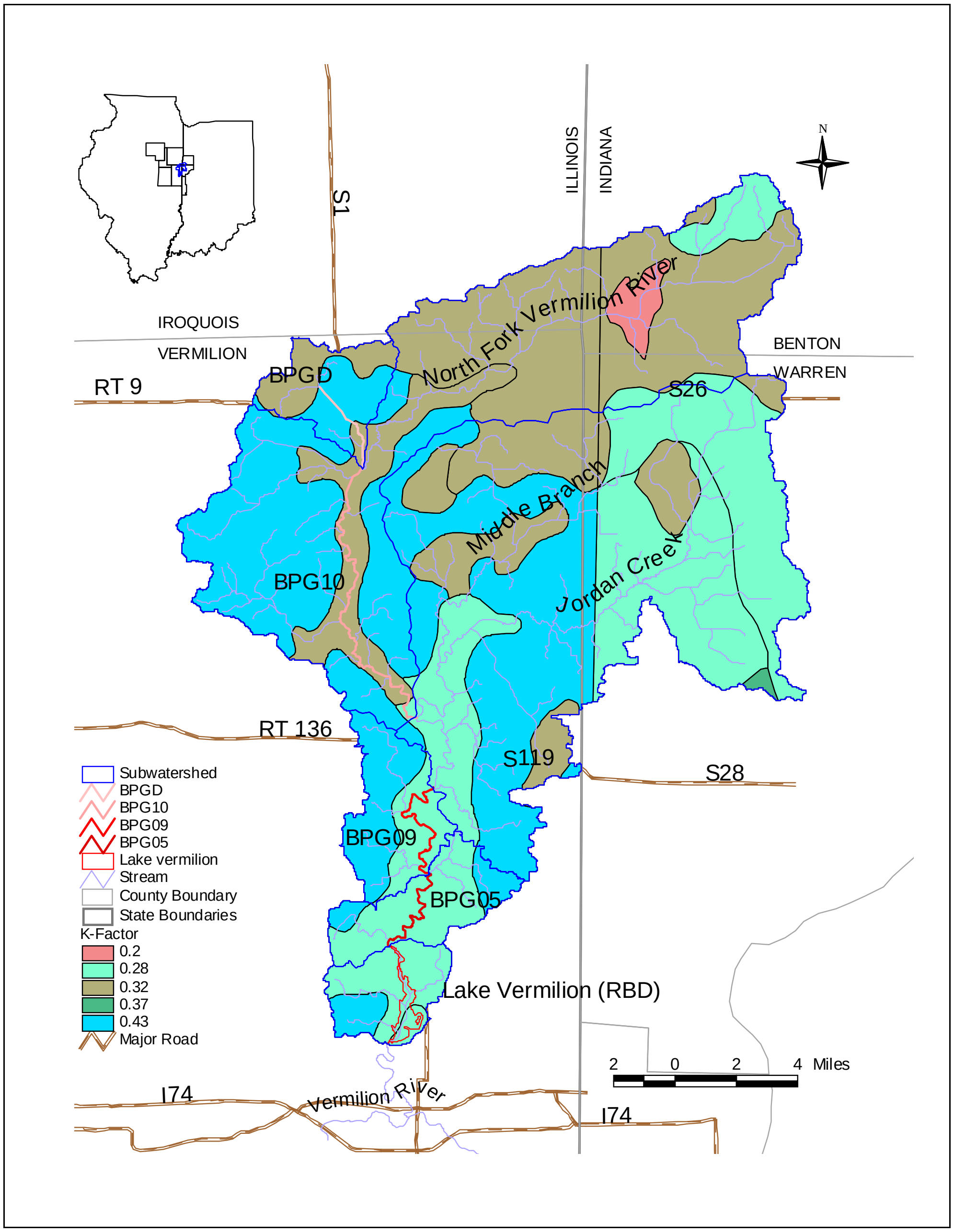
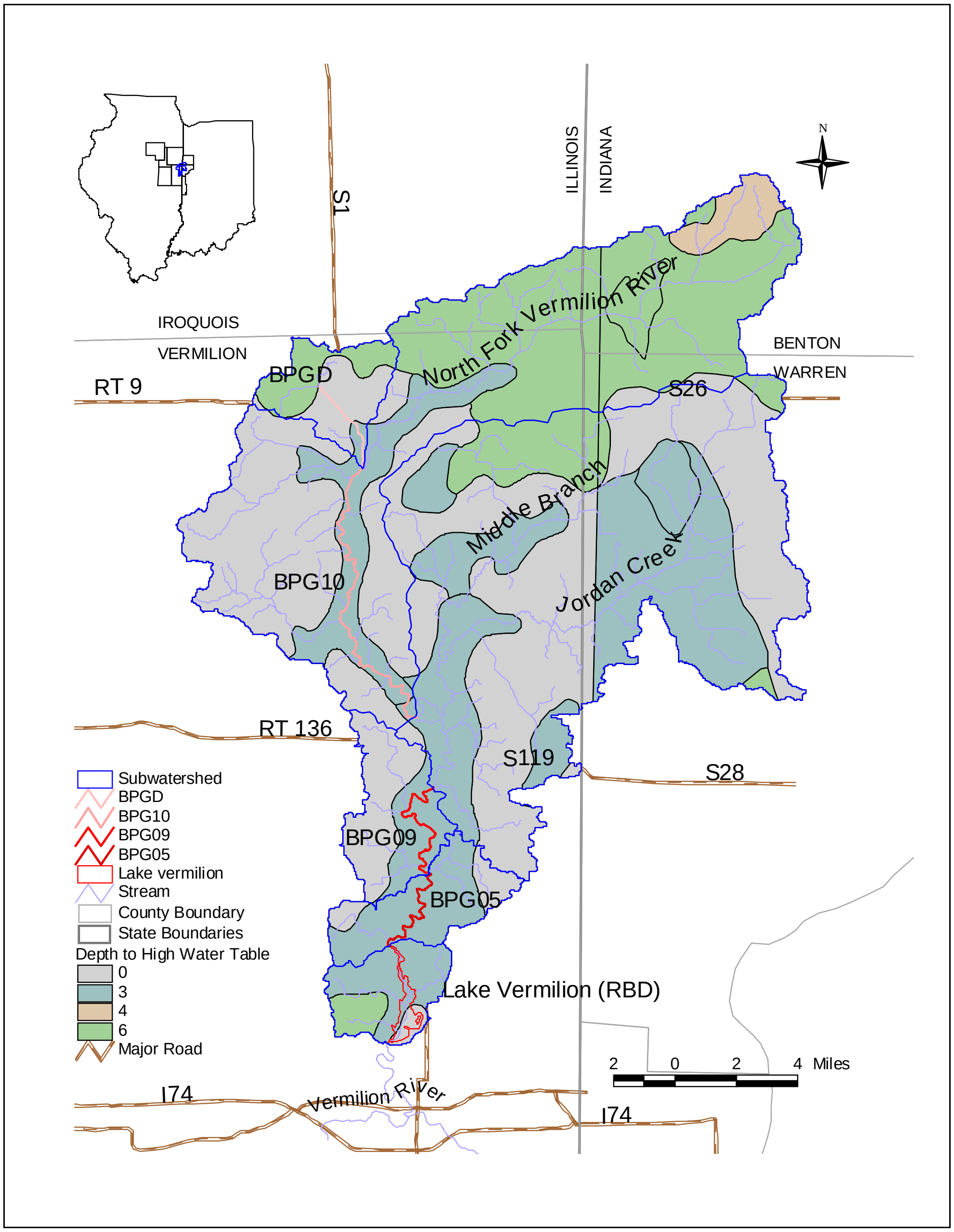


FIGURE 2-4 SOIL EROSION K-FACTOR MAP



The depth to the groundwater table determines the groundwater flow contribution to the North Fork Vermilion River. When the depth is shallower, there is a better chance for groundwater to discharge to the river and lake. The depth to the water table varies seasonally. The estimated depth to the water table is based on NRCS Soil Survey. Each soil unit has an estimated depth to the water table associated with it. Figure 2-5 presents the distribution of depth to the seasonal high water table in the watershed. The southern portion of the watershed and channel valley has relatively shallower groundwater level, with the depth to water table ranging from 0 to 3. The water table at the northern end of the watershed is deeper, with a depth of about 6 feet.

FIGURE 2-5 DEPTH TO SEASONAL HIGH WATER TABLE



2.6 WATERBODY CHARACTERISTICS

This section discusses waterbody characteristics for the North Fork Vermilion River and Lake Vermilion.

2.6.1 Hoopeston Branch

Hoopeston Branch is a 4.72 miles 2nd order tributary to North Fork Vermilion River, flowing from northwest to southeast. Its headwater is located in the northwest corner of the North Fork Vermillion River watershed. The average slope of the branch is about 0.006%. The subwatershed area is 10.8 square miles. Based on USGS topography, the portion of Hoopeston Branch near Hoopeston is channelized. The estimated channel width is about 8 feet.

2.6.2 North Fork Vermilion River

The North Fork Vermilion River flows about 62 miles from its headwaters in Benton County, Indiana, to Lake Vermilion in Danville, Illinois, then into the Vermilion River. The river flows through the following towns from upstream to downstream: Ambia, Indiana, and Hoopeston, Rossville, Henning, Alvin, Bismarck, and Danville, Illinois. The North Fork Vermilion River has a sand, gravel, and rubble substrate. The listed segments include BPG10, BPG09, and BPG05 from upstream to downstream, as shown on Figure 2-1. Table 2-10 summarizes characteristics of the North Fork Vermilion River including both listed and not listed segments.

TABLE 2-10 NORTH FORK VERMILION RIVER CHARACTERISTICS

Characteristic	Value
Reach length	58 miles[b]
10-year, 7-day low flow	1.24 cubic foot per second (cfs)
Low flow mean velocity	0.22 cfs
Mean flow	297 cfs
Mean velocity	1.01 fs
Bottom of reach elevation	520 feet above sea level[b]
Mean stream slope	0.071 percent[b]
Mean width	24.1 ft
Mean width/depth	To Be Evaluated[c]

Notes:

a	Table includes characteristics for segment of North Fork Vermilion River upstream of Lake Vermilion.
b	Source: Illinois State Water Survey 2003
c	Cross sections for North Fork Vermilion River were not readily available at time of characterization report; however, the U.S. Geological Survey will provide cross sections prior to TMDL development.

Source: USEPA 1998 unless otherwise noted

2.6.3 Lake Vermilion

Lake Vermilion is a drinking water reservoir located northwest of Danville, Illinois. The lake is managed by Consumer Illinois Water Company (Tetra Tech 2004a). In 1902, a dam was constructed near Jaycee's Park to increase in-stream storage for water supply. The dam was reconstructed in 1914 to augment flow to the pre-existing channel dam adjacent to the water treatment plant. A review of the lake bathymetry indicates that the old dam still exists, which may affect local hydrodynamic and lake circulation.

The present dam and spillway was constructed in 1925 south of the old dam. In 1991, it was further enhanced to increase reservoir capacity. The dam is located at 40°9'24" North latitude and 87°39'8" West longitude in Section 31, T 20N R 11W Township in Vermillion County, Illinois. The 1991 enhancements increased the pool level from 576 to 582.2 feet (National Geodetic Vertical Datum (NGVD 1929)) using extensions that had been added to the original spillway gates (ISWS 1999). The elongated lake has an average length-width ratio of about 18. County Highway 20 (Denmark Road) crosses the southern portion of the lake. The road embankment narrows the waterway, which separates the lake into two parts and may affect lake circulation. West Newell Road crosses the lake's north end, where the North Fork Vermilion River flows in. More detailed information about the old dam and roads will be needed to model the lake's hydrodynamic conditions and water quality. Consumer Illinois Water Company uses 13 cubic feet per second from the lake to meet water supply demands. Table 2-9 summarizes characteristics of Lake Vermilion.

TABLE 2-11 LAKE VERMILION CHARACTERISTICS

Characteristic	**Value**
Drainage area	295 square miles
Water surface	880 acres[a]
Service spillway crest elevation	582.2 feet NGVD[a,b]
Emergency spillway elevation	582.7 feet NGVD[b]
Maximum storage	7,900 acre-feet[a]
Normal storage	7,900 acre-feet[a]
Maximum pool length	3.6 miles[a]
Shoreline length	22 miles[b]
Average depth	12 feet near center [a,b] 6 feet near northern end[a,b]
Maximum depth	22 feet (near dam)[b]
Dam length	600 feet[b]
Designed maximum discharge	38,220 ft^3/s[b]
Average hydraulic retention time	15 days

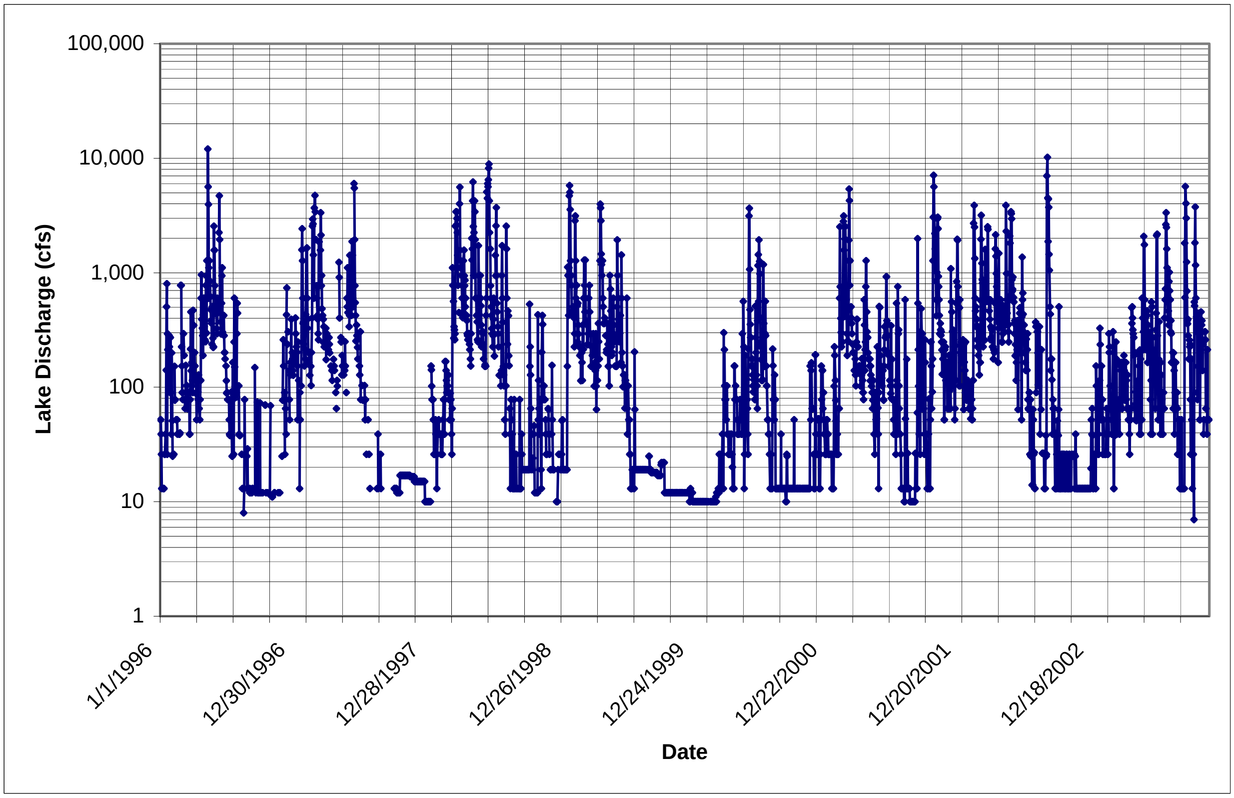
Notes:

NGVD	National Geodetic Vertical Datum
a	Source: Illinois State Water Survey 1999
b	Source: Tetra Tech 2004a

Source: USEPA 1998 unless otherwise noted

Discharge from the lake is controlled by the extended spillway gate. Figure 2-6 shows the lake discharge data for 1996 to 2002. The minimum discharge from the lake is 13 cfs, the average discharge from the lake is 100 cfs, and the maximum discharge of 16,000 cfs was recorded in 1994 (Tetra Tech 2004a). The average annual lake evaporation rate observed at Urbana, Illinois, is 10.5 inches per year. The Consumers Illinois Water Company treatment plant is located near the downstream side of the new dam. There is no water intake structure in the lake; instead, water is released through the spillway to a holding basin 2.5 river miles downstream near the water treatment plant, then pumped in to the plant. The plant's design production capacity is 14 million gallons per day (MGD). The spillway gate is regulated to maintain the stable lake level. During low flows, the release is controlled to sustain the water yield of the plant. In 2002, the water treatment plant was improved to increase the nitrate removal efficiency, chloramines disinfections, and other performance enhancements (Lin and Bogner 2004).

FIGURE 2-6 LAKE VERMILLION DISCHARGE



Source: Consumer Illinois Water Company (2004)

3.0 CLIMATE AND HYDROLOGY

This section discusses the climate of the watershed and its hydrology.

3.1 CLIMATE

The eastern portion of Illinois has a continental climate with cold, rather dry winters, and warm humid summers. Table 3-1 summarizes climate characteristic near Danville, Illinois. The average annual precipitation at Danville, Illinois is about 40.8 inches. Monthly average precipitation is about 3.4 inches. Months from March through August are wet months, with average precipitation between 3.2 and 4.7 inches per month. Months from September to February are relatively dry, with average precipitation of 2.5 inches for the normally driest months of October and February. On average, there are 122 days with precipitation. Severe droughts are infrequent, but prolonged dry periods during a part of the growing season are not unusual. Such periods usually cause reduced crop yields. A single thunderstorm often produces more than 1 inch of rain and occasionally is accompanied by hail and damaging winds. More than 4.5 inches of rain has fallen within a 24-hour period and nearly 15 inches during a month. Some fall and winter months have had less than 0.25 inch of precipitation. The average annual temperature at Danville, Illinois is approximately 52.5 °F. The maximum and minimum average temperatures are 65.9 and 42.9 °F, respectively.

TABLE 3-1 CLIMATE CHARACTERISTICS NEAR DANVILLE, ILLINOIS

Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Average temp. (°F)	25.8	31	41.9	52.8	63	71.8	75.3	73.4	66.6	55	42.7	30.9	52.5
High temperature (°F)	34.2	40	52	64.5	75.2	83.5	86.2	84.1	78.4	66.6	51.6	38.7	62.9
Low temperature (°F)	17.3	21.9	31.7	41	50.7	60	64.3	62.6	54.7	43.3	33.8	23	42.0
Precipitation (in)	2	2	3.2	3.8	4.5	4.7	4.4	3.9	3	3	3.5	2.8	40.8 (total)
Days with Precip	11	9	12	12	12	10	10	9	8	8	10	11	10.2
Wind speed (mph)	11.1	11.1	11.9	11.6	9.9	8.8	7.7	7.3	8.1	9.2	10.8	10.8	9.9
Morning humidity (%)	81	81	80	79	82	83	87	90	89	86	84	83	83.8
Afternoon humidity (%)	71	68	62	57	58	58	61	61	59	58	67	72	62.7
Sunshine (%)	42	50	50	54	61	66	67	68	65	61	43	40	55.6
Days clear of clouds	6	6	6	6	7	7	8	9	11	11	6	6	7.4
Partly cloudy days	6	6	7	7	9	11	12	11	9	8	7	6	8.3
Cloudy days	19	16	18	17	15	12	10	10	11	12	17	20	14.8
Snowfall (in)	6.6	5.4	3.7	0.6	0	0	0	0	0	0.2	1.9	5.4	2.0

Notes:

°F	Degrees Fahrenheit
in	Inch
mph	Miles per hour
%	Percent

Source: http://www.sws.uiuc.edu/atmos/statecli/Summary/112140.htm, Data Period: 1971-2000

The region has daily high temperatures ranges of greater than 90 °F about 45 days per year and subzero degrees Fahrenheit temperatures on the average of 1 day, or less, per year. Annual average snowfall is about 10-inches with large variations in snowfall occurring from year to year. Sunshine averages more than 70 percent of that possible during the three summer months, but only 45 percent of that possible during the winter months. Precipitation occurs an average of 10-days per month with snowfall occurring in October through April (ISWS 1998).

3.2 HYDROLOGY

Hydrology in North Fork Vermilion River is mostly affected by glacial processes and deposits that cover the watershed. The principal source of surface runoff is precipitation that enters the stream as overland flow, which is rainwater or snowmelt that flows over the land surface toward stream channels. In agricultural areas, there is more infiltration and much less overland flow compared to urban areas. The average annual runoff is 15.43 inches (total annual runoff volume divided by watershed area), which account for about 38 percent of annual precipitation. Groundwater discharge to streams affects the flow and water quality of the stream. The actual groundwater contribution can be determined by a water balance in the river.

USGS station 03338780 is located in the North Fork Vermilion River near the bridge at the intersection of Vermilion County Road 2750 N, about 1.8 miles west of Bismarck, 1.9 miles downstream from the Painter Creek confluence, and 6.6 miles downstream from the confluence of the Middle Branch of the North Fork Vermilion River. The station measured flow from June 1970 to September 1974 partially and from October 1988 to present. Figure 3-1 shows the flows from 1988 to 2001. The mean flow is 297.4 cfs, and the median flow is 107 cfs. The maximum flow of 14,500 cfs was recorded on April 12, 1994. The minimum flow of 2.5 cfs was recorded in September 1991, which was a very dry month.

FIGURE 3-1 NORTH FORK VERMILION RIVER FLOW (1988 TO 2001)

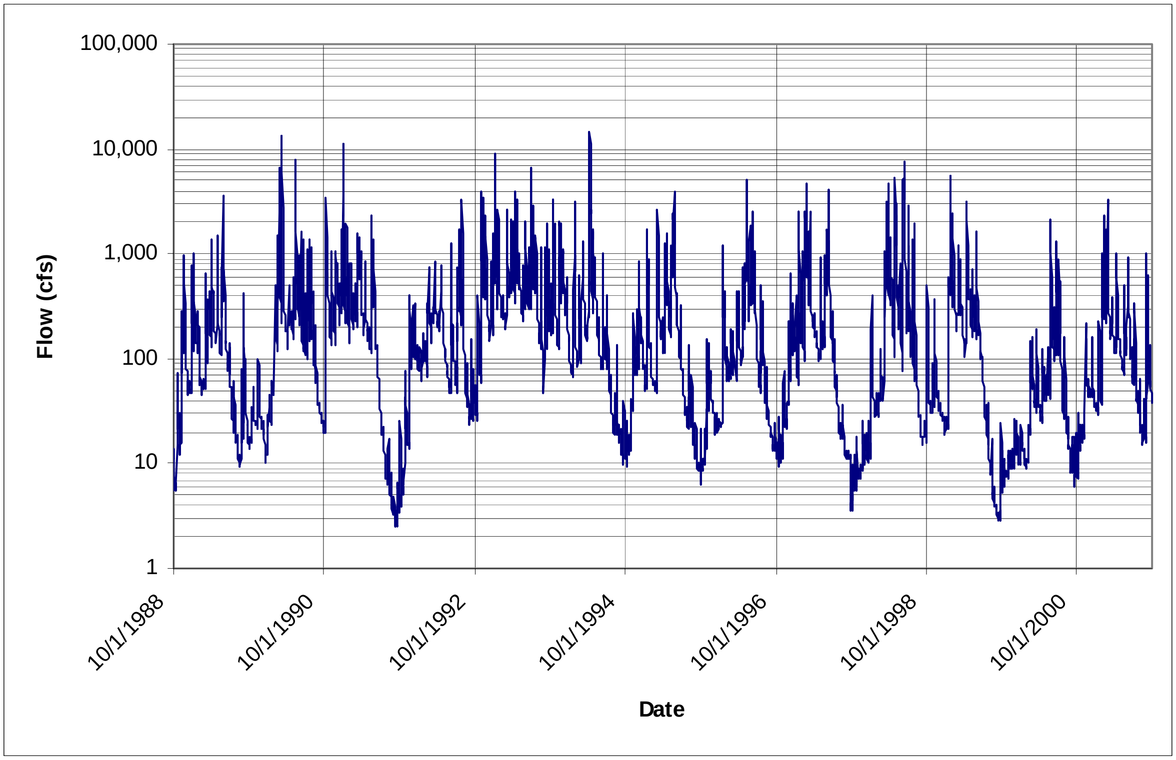


Figure 3-2 presents a flow frequency curve for the North Fork Vermilion River, based on flow data from 1988 to 2001. It shows the 25-percentile flow of 28 cfs and 75-percentile flow of 289 cfs. The flow in the river is greater than 100 cfs 50 percent of the time.

FIGURE 3-2 NORTH FORK VERMILION RIVER FLOW FREQUENCY CURVE

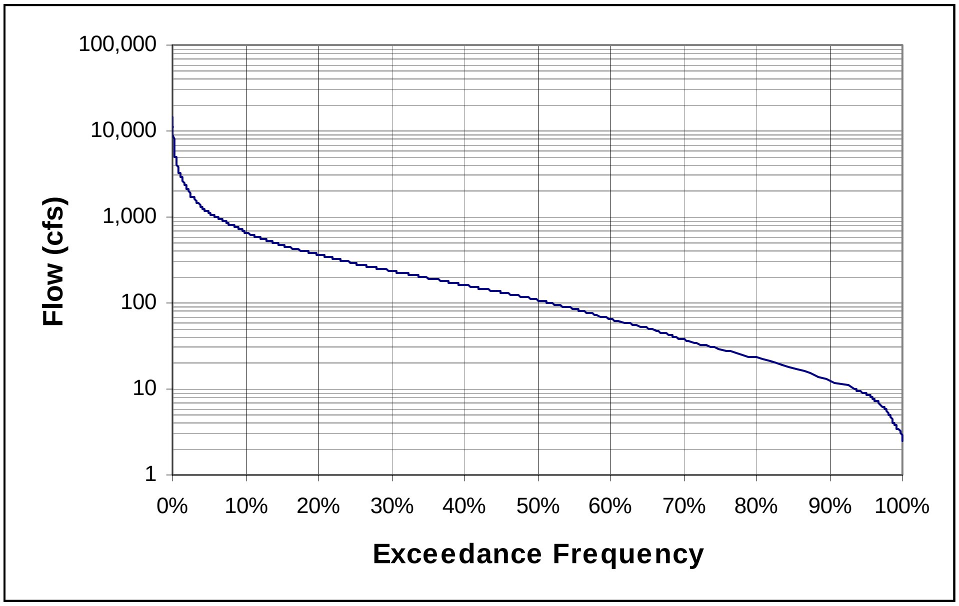
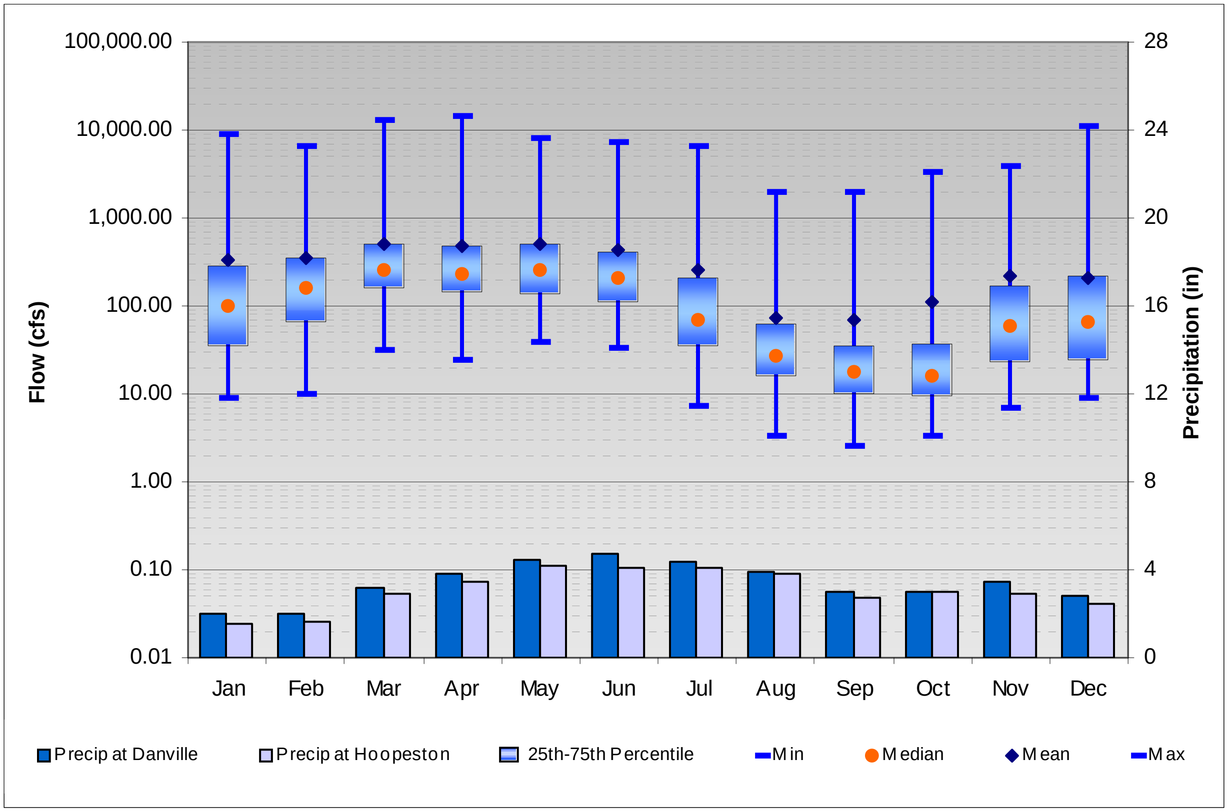


Figure 3-3 shows the monthly statistics of North Fork Vermilion River Flow and monthly average precipitation at Danville and Hoopeston, Illinois. The Hoopeston climate station is located near the northwest boundary of the watershed. The monthly variation of flow is somewhat different from precipitation in the watershed though both exhibit the yearly cycle. The monthly average flow starts to increase in January and peaks in May and decreases to reach the lowest in September. However, the monthly average rainfall starts to increase in March and reach the highest in June and then decreases. January and February have the lowest rainfall among a year but lowest monthly average flows occur in August and September. The yearly cycle of flow and precipitation differs by about 2 months. The phenomena may be attributed to snow melting, temperature trends, and vegetation growth throughout the year.

FIGURE 3-3 MONTHLY AVERAGE FLOW AND PRECIPITATION IN NORTH FORK VERMILION RIVER WATERSHED



The hydrology of the North Fork Vermilion River watershed is also affected by the channelization of streams or drainage ditches and extensively artificial drainage tiles. Subsurface tile drains predominantly drain agricultural fields in East-Central Illinois, as in many other regions of the central plains. Improved subsurface drainage not only improves crop production and farm income, it also reduces surface runoff. This results in reduced soil erosion and sediment load to streams and water bodies. The subsurface drainage system, however, results in increased flow through the soil profile, increasing leaching of nitrates and dissolved phosphorus to the streams. If private septic systems are connected to drain tile, the domestic wastewater moves faster to reach the water bodies. There are very few records of the actual locations of many of these drainage systems, especially those installed more that 75 years ago. The unavailability of drainage maps makes it difficult to locate nonfunctioning tile lines or even determine the position of functional systems in cases where additional drains are to be installed. Color infrared (CIR) aerial photographs and GIS analysis have been used to map tile lines in Vermilion County, Illinois in a study by Verna and et al (1996). The technique is based on the fact that the soil over efficiently draining tile line dries faster than the soil at other locations in the field and has higher reflectance in the infrared region of the radiation spectrum. CIR aerial photographs for the study area were taken in the spring, a few days after a heavy rain storm, converted to digital format, and subjected to edge enhancement to heighten the sharpness of the images. A GIS package (IDRISI) was used to overlay soil data, hydrological parameters, topography, and vegetation cover. The combination of these map layers made it possible to identify the layout of functional tile drainage systems. This information will help understand the subsurface hydrology in the watershed and determine whether or not the subsurface drain tile network provide direct route for excessive nutrient loading to listed water bodies.

According to personal contact (Tetra Tech 2004e), University of Illinois has collected flow rate and water quality data at tile drain outfalls in the Vermilion River watershed in the past fifteen years. Although the monitoring sites are not in North Fork Vermilion watershed, the data may be used to infer the tile drain characteristics in the tiled agricultural land in North Fork Vermilion River Watershed.

4.0 WATER QUALITY

This chapter discusses applicable water quality standards and the pollutants of concern in the North Fork Vermilion River and Lake Vermilion. The available water quality data is evaluated to verify impairments in listed segments by comparing observed data with water quality standards or appropriate targets. The spatial and temporal water quality variation as well as the correlation among the constituents are assessed.

4.1 WATER QUALITY STANDARDS AND END POINTS

This section describes applicable water quality standards for the North Fork Vermilion River and Lake Vermilion. Based on the standards, TMDL endpoints were identified as numeric water quality targets.

4.1.1 River Water Quality Standards

The North Fork Vermilion River Segment BPG09 is listed on the Illinois 2004 303(d) list for pathogens. Fecal coliform will be used as the indicator of pathogens. The Illinois fecal coliform standards for general use requires that 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 colony forming units (cfu) per 100mL (cfu/100 mL), nor shall more than 10 percent of the samples during any 30 days period exceed 400 cfu/100 mL in protected waters. Fecal coliform is the pollutant of concern in the North Fork Vermilion River Segment BPG09.

The North Fork Vermilion River Segment BPG05 is listed on the Illinois 2004 303(d) list for nitrate nitrogen, which caused the impairment of the designated use of public and food processing water supply. The not-to-exceed numeric standard for nitrate nitrogen is 10 mg/L.

Although they are not listed in North Fork Vermilion River, nutrients are listed as the causes for impairment in Lake Vermilion, which is the downstream receiving water. USEPA regulations at CFR Part 131.10(b) require that in “designating uses of a waterbody and the appropriate criteria for those uses, the State shall take into consideration the water quality standards of downstream waters and shall ensure that its water quality standards provide for the attainment and maintenance of the water quality standards for downstream waters.” There is no phosphorus standard for rivers and streams in Illinois, but IEPA considers a total phosphorus (TP) concentration of 0.61 mg/L as a guideline to protect aquatic life. The phosphorus standard for a lake states that TP shall not exceed 0.05 ml/L in any reservoir or lake with a surface area of 20 acres or more or in any stream at the point where it enters any such reservoir or lake.

Hoopeston Branch is listed for impairment caused by low DO. The applicable DO standard states that DO shall not be less than 6.0 mg/l during at least 16 hours of any 24 hour period, nor less than 5.0 mg/l at any time.

4.1.2 Lake Water Quality Standards

Lake Vermilion is listed on the Illinois 2004 303(d) list for use impairment caused by nutrients, siltation, organic enrichment and low DO, excessive algal growth, nitrates, and suspended solids. The water quality standards associated with the listing include TP, DO, total ammonia nitrogen, and nitrate. The total ammonia nitrogen must never exceed 15 mg/L in state waters. The total ammonia nitrogen acute, chronic, and sub-chronic standards are determined by temperature and pH in water. A review of total ammonia nitrogen in Lake Vermilion shows that there is no exceedance of the standard (including acute, chronic, and sub-chronic standards) at possible ranges of temperature and pH. Therefore, a total ammonia nitrogen TMDL will not be developed at this time.

Table 4-1 summarizes the applicable water quality standards for Lake Vermilion. The State of Illinois does not have TSS or turbidity numeric standards that could be used as a surrogate for siltation impairment. Nevertheless, sedimentation appears to be a concern in Lake Vermilion because between 1976 and 1998, the lake lost 1,186 acre-feet of storage capacity. The storage loss rate is about 0.9 percent per year. Based on IEPA guidelines, the storage loss rate is classified as moderate. IEPA does not require the TMDL development for constituents without numeric standards. Therefore, a TMDL will not be developed for TSS at this time. Because phosphorus load is largely associated with TSS load, the measures implemented for phosphorus reduction may also reduce the sediment load to the lake and decrease the storage loss rate.

TABLE 4-1 WATER QUALITY STANDARDS FOR LAKE VERMILION

Parameter	Standard
Nitrate	Shall not exceed 10 mg/L
Total Phosphorus	Phosphorus as TP shall not exceed 0.05 mg/L in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more or in any stream at the point where it enters any such reservoir or lake

Excessive algal growth is listed as a cause of impairment in Lake Vermilion. Algal biomass is commonly measured through a surrogate, Chlorophyll-a (Chl-a), which is a plant pigment. The abundance of Chl-a in water highly correlates with the amount of algae present. The State of Illinois does not have a numeric standard for Chl-a. The algal growth is directly related to excessive amount of limiting nutrients and light availability for photosynthesis. Phosphorus is identified as a limiting nutrient in this report. Consequently, TP can be considered a surrogate indicator for excessive algal growth.

4.1.3 TMDL Endpoints

To meet all designated uses, a water body must meet the standards identified for its most sensitive use. TMDL endpoints are the numeric target values of pollutants and parameters for a water body that represent the conditions that will attain water quality standards and restore the water body to its designated uses. The most stringent standards are chosen as the endpoints for the TMDL analysis. Usually, if an applicable numeric water quality standard violation is the basis for 303(d) listing, the numeric criterion is selected as the TMDL endpoint. If the applicable water quality standard or guideline is narrative or is not protective of the designated use, a numeric water quality target must be established or adopted from site-specific water quality and biologic assessment. Table 4-2 summarizes the endpoints that will be used in the TMDL development for the North Fork Vermilion River and Lake Vermilion.

TABLE 4-2 TMDL ENDPOINTS

Parameter	TMDL Endpoint			Indicator
	North Fork Vermilion River	Hoopeston Branch	Lake Vermilion	
Total Phosphorus (mg/L)	N/A	N/A	<0.05	Surrogate for nutrients
Fecal Coliform (cfu/100 mL)	<400	N/A	N/A	Indicator for Pathogen
Dissolved Oxygen (mg/L)	N/A	>5.0	N/A	Direct measurement
Nitrate (mg/L)	10	N/A	10	Direct measurement

4.2 DATA AVAILABILITY

From 1977 to 1998, USGS collected monthly water samples at Station 03338780 (see Figure 4-1) in the North Fork Vermilion River near Bismarck, Illinois. Continuous daily average flows are recorded at this site. Water quality constituents include TP, dissolved phosphorus (DP), ammonia nitrogen, DO, TSS, nitrite and nitrate, and fecal coliform. Data for the USGS site were retrieved from NWIS database and USEPA STORET database. IEPA collected and provided fecal coliform data at Station 03338780 from January 24, 2000 to November 04, 2003. Jordan Creek (BPGC) and Middle Branch (BPGE) are monitored during the 2001 IEPA Intensive Basin Survey. Both tributaries are full support for aquatic life use and the data is not included in this report.

As many as 26 sampling sites are located in Lake Vermillion. Only five of them monitored water quality on a regular basis since 1978. The rest of the sites either have few water quality data points or the data point is prior to 1977 so that they are not included in the analysis. The five sampling sites are RBD-1, RBD-2, RBD-3, RBD-4, and RBD-5, as shown in Figure 4-2. A topographic map is also included in Appendix D to show the site locations and surrounding areas. RBD-1 is located in the area of deep water near the Lake Vermilion dam. RBD-2 is located in the middle of the lake, 50 feet south side of old dam. RBD-3 is located in the upper portion of the lake, 500 feet north of old dam. RBD-4 is located at the north side of the old dam. RBD-5 is located near the southeast overbank of the lake. Water quality constituents from the five sites include TP, ammonia nitrogen, nitrate and nitrites, total Kjeldahl nitrogen, DO, and Chlorophyll-a. Data up to 1998 are retrieved from the USEPA STORET site. Data after 1998 are provided by IEPA. Illinois State Water Survey (Lin and Bogner, 2004) collected water quality data from May 8, 2000, through April 19, 2001, as part of a diagnostic study. In that report, RBD-5 was located at the upstream end of the lake. Both IEPA and Illinois State Water Survey (ISWS) collected water samples at a site near USGS site (03338780) in the North Fork Vermillion River inflow (RBD-T2) and the lake spillway (RBD-T1) to assess the water quality inflow and outflows. Collectively, water quality data is available for Lake Vermilion from 1978 to 2002.

In addition, IEPA Facility-Related Stream Survey event collected microvertebrate and water quality data at 8 locations at the vicinity of the Hoopeston STP. The data resulted in the listing of Hoopeston Branch and BPG10 for impairment.

FIGURE 4-1 WATER QUALITY SAMPLING SITES

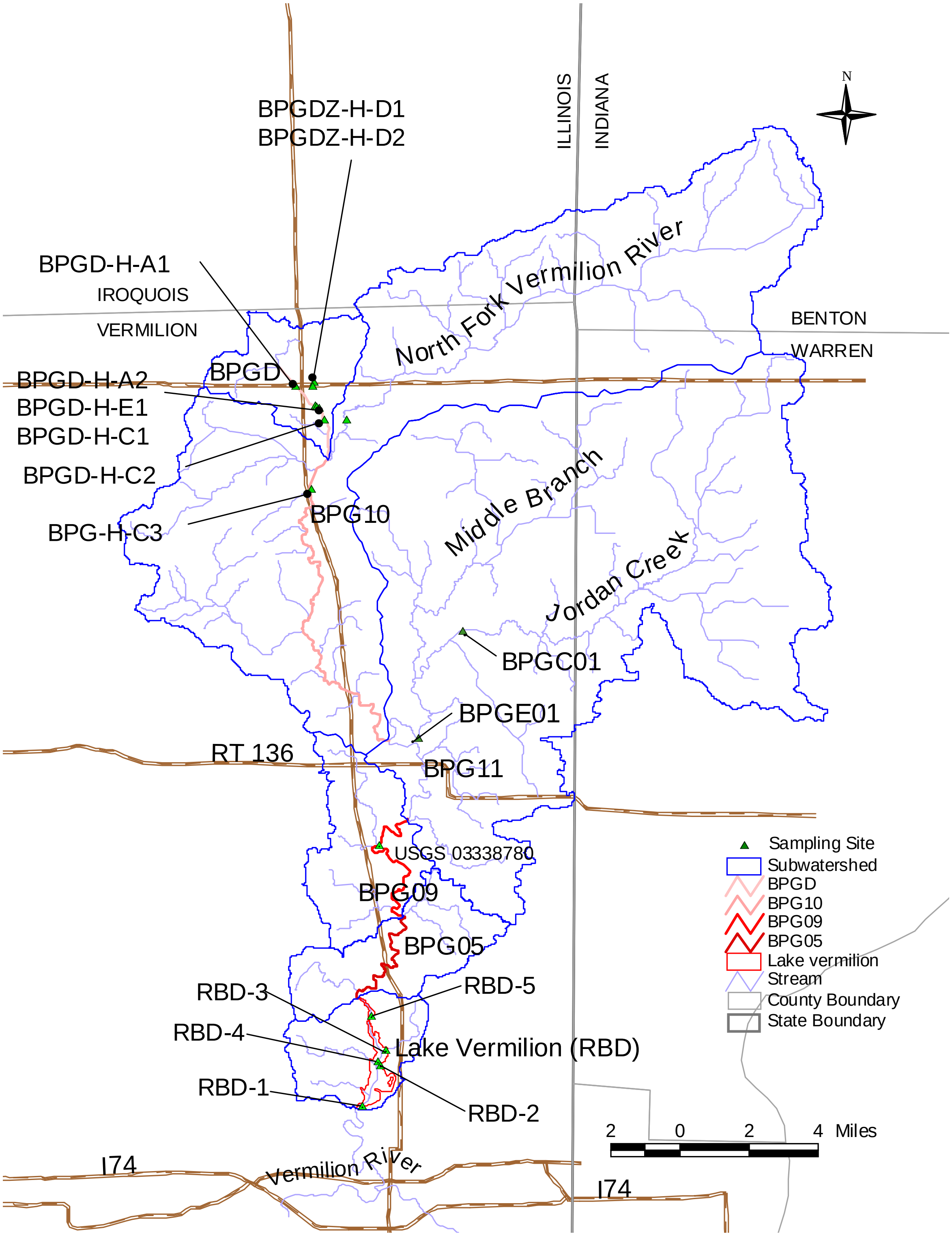
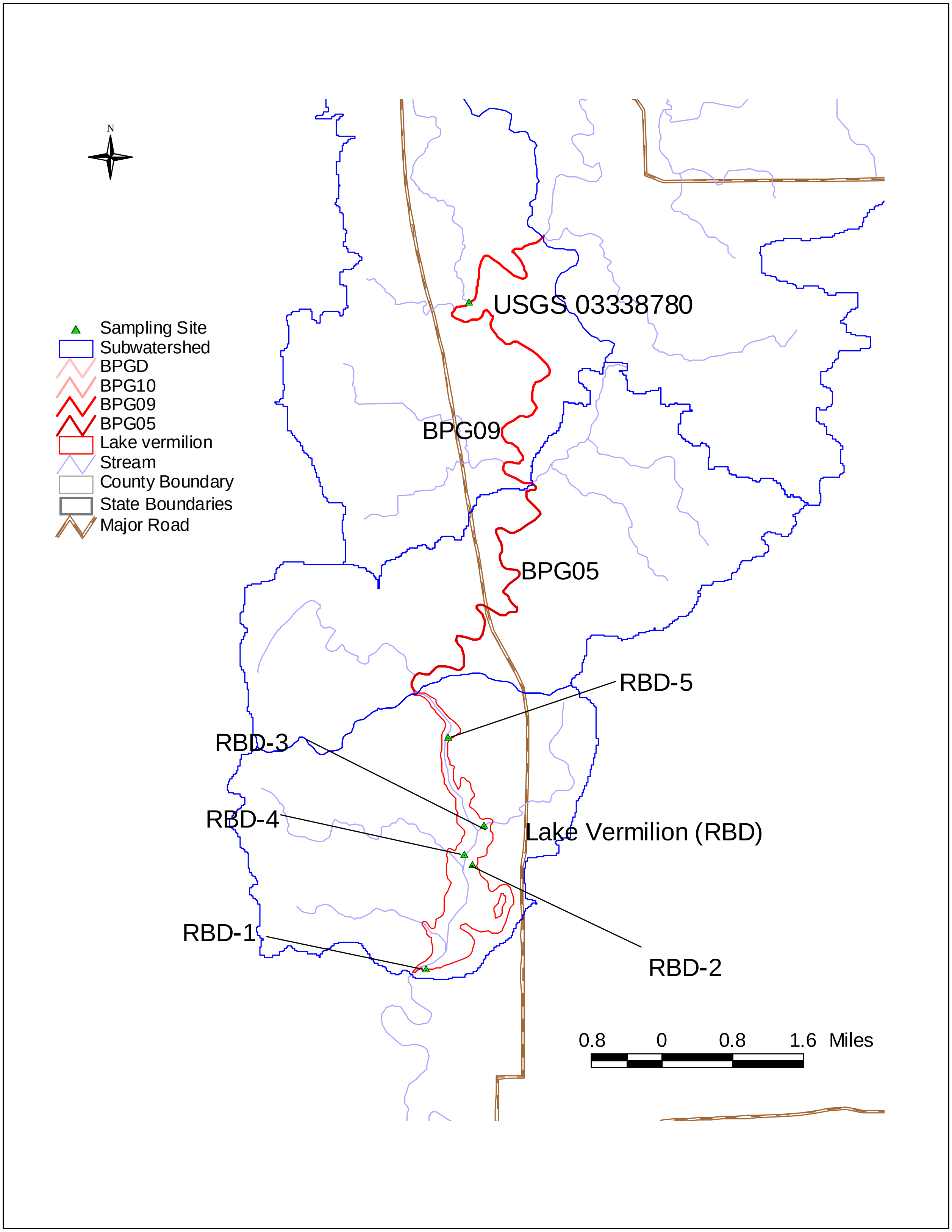


FIGURE 4-2 LOCATIONS OF SAMPLING SITES IN LAKE VERMILION



4.3 ASSESSMENT OF WATER QUALITY DATA

This section discusses the pollutants of concern for the listed segments, BPGD, BPG09, BPG05, and RBD. The available water quality data is analyzed and assessed to verify the impairments of listed segments by comparing observed data with water quality standards or appropriate targets. The potential spatial and temporal variation of water quality conditions is evaluated for the river segment and the lake.

4.3.1 Hoopeston Branch (BPGD)

BPGD segment is assessed based on 2002 Facility-Related Stream Survey (FRSS) data. Results from the 2002 survey indicated slightly impaired conditions existed within Hoopeston Branch upstream and downstream of the STP. Severely impaired conditions to the biotic communities were also recorded for Hoopeston Ditch (IEPA, 2003). General use water quality standards were not met for dissolved oxygen on Hoopeston Branch, according to FRSS data collected in September 2002. A DO concentration of 4.7 mg/l was recorded, violating the Illinois DO standards for general use.

4.3.2 North Fork Vermilion River

This section assesses nutrient and fecal coliform in North Fork Vermilion River based on data from the USGS sampling site at Bismarck, Illinois (03338780), located in BPG09. BPG05 is assessed based on extrapolation of data from upstream site in BPG09 and downstream site in RBD. No TMDL is developed for BPG 10 because no numeric water quality standard is available for total nitrogen. Phosphorus is assessed in the North Fork Vermilion River because of the TP listing for Lake Vermilion.

4.3.2.1 Phosphorus

Phosphorus is an important component of organic matter. As a constituent of nucleic acids in all cells, it is vital for all organisms. In streams and rivers, phosphorus is usually the limiting nutrient in photosynthetic production in algae. Phosphorus enters streams and rivers not only through stormwater runoff, but also through natural mineralization of phosphates in the soil and rock and man-made sources. Phosphorus is measured in two ways: as TP and as DP phosphorus. Streams with high TP and low DP levels usually have the most phosphorus input from nonpoint source pollution, such as agriculture runoff. Since phosphorus can be bound to sediments such as clay, phosphorus is measured through the suspended solids potency. DP measurements provide insights into how much of the phosphorus entering a stream is from point sources and diffusive sources such as livestock operations and animal feedlots or septic systems. Untreated wastewater can have phosphorus concentrations as high as 10 mg/L and feedlot overflow can contribute up to 4 to 5 mg/L.

Illinois water quality standard requires that TP not exceed the 0.05 mg/L in any stream at the point where it enters any reservoir or lake with a surface area of 20 acres or bigger. Although the listed North Fork Vermilion River segment is about 3 miles upstream of the entrance to the lake, it seems reasonable to set the segment's phosphorus target at the 0.05 mg/L because there is not likely to be any dramatic deposition of particulate and dissolved phosphorus in the short distance from the listed river segment to the entrance. Figure 4-2 presents the TP data at Bismarck, Illinois (03338780). It shows that TP is frequently higher than the lake standard.

Figure 4-3 shows the interannual variation in TP concentration. There is no noticeable increasing or decreasing trend from 1978 to present. The average annual concentration goes up and down, likely attributed to the precipitation change. The average annual concentrations exceed the lake phosphorus standard in almost every year.

Figure 4-4 presents the monthly descriptive statistics for TP in the North Fork Vermilion River. The month of April has the overall lowest TP during the spring season, and then TP starts to increase through the summer growing season reaching a higher level. TP decreases slightly in late fall and early winter. Phosphorus is fairly high in January through March, with a large deviation as indicated in a range between the 25th and 75th percentiles, while flow in the river is near the annual average (see Figure 3-3). A possible explanation is that the phosphorus sources may include steady sources other than precipitation induced overland runoff. This explanation seems appropriate based on a review of the ratio of DP to TP in Table 4-3.

FIGURE 4-2 PHOSPHORUS CONCENTRATIONS IN NORTH FORK VERMILION RIVER AT BISMARCK (1978-2002)

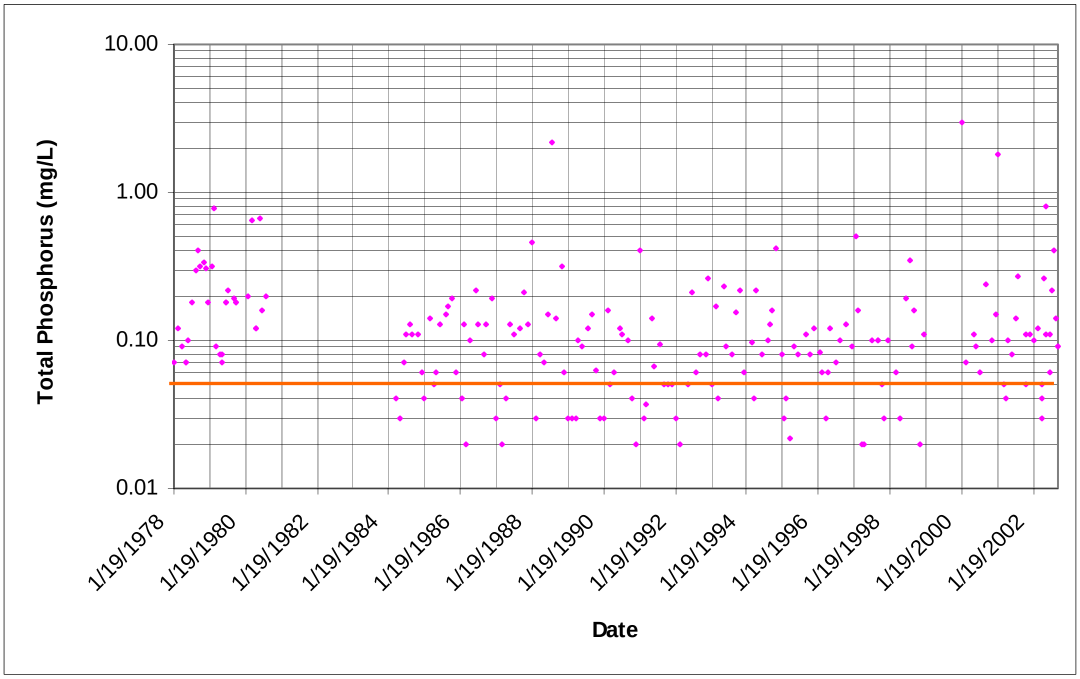


FIGURE 4-3 INTERANNUAL VARIATION IN TOTAL PHOSPHORUS CONCENTRATIONS NORTH FORK VERMILION RIVER (BPG09)

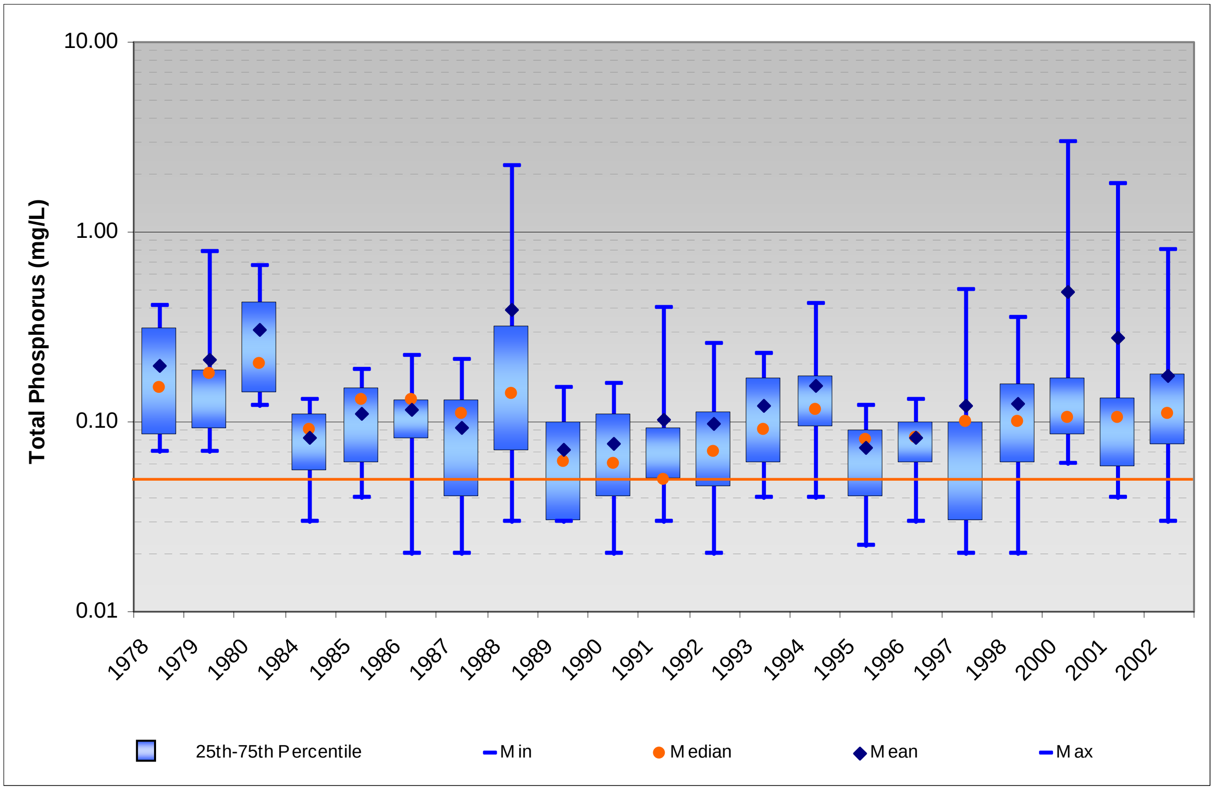
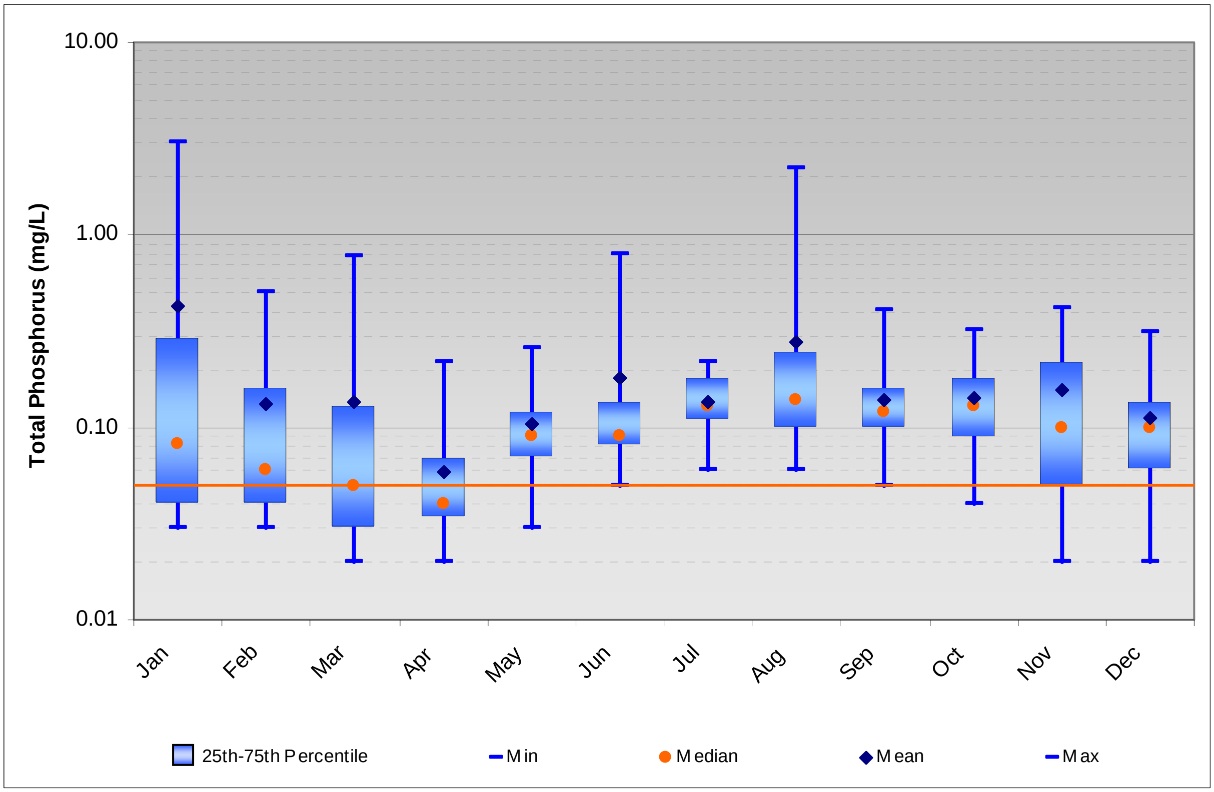


FIGURE 4-4 MONTHLY TOTAL PHOSPHORUS CONCENTRATIONS NORTH FORK VERMILLION RIVER (BPG09)



DP is the portion of TP that is biologically available for plant uptake. It is the soluble form of phosphorus that is not absorbed to soil particles. In rivers and lakes with short retention time, DP concentration is crucial for plant growth. Table 4-3 summarizes the monthly DP and TP concentrations at Bismarck. The average monthly DP is about 0.08 versus TP at 0.13, meaning that an average 60 percent of TP concentration is in the dissolved form. This ratio implies that nonpoint sources other than soil erosion may contribute to TP. A close review of Table 4-3 shows that the DP is relatively higher in January and February than March through July, when the flow is higher and runoff-induced sediments deliver more particulate phosphorus to the river. As the flow decreases in October through December, DP increases as the steady low flow sources such as septic systems account for a larger percentage of the load. Groundwater seepage may be another source of dissolved phosphorus. Speculation on sources needs to be further verified as more site-specific information becomes available in the next stage of TMDL development.

TABLE 4-3 MONTHLY AVERAGE DISSOLVED AND TOTAL PHOSPHORUS CONCENTRATIONS, NORTH FORK VERMILION RIVER (BPG09)

Month	DP	TP	Percentage of TDP in TP
Jan	0.08	0.13	60
Feb	0.07	0.12	63
Mar	0.04	0.11	40
Apr	0.03	0.06	44
May	0.06	0.10	57
Jun	0.06	0.15	40
Jul	0.07	0.13	56
Aug	0.23	0.29	78
Sep	0.09	0.12	74
Oct	0.08	0.10	77
Nov	0.10	0.15	66
Dec	0.06	0.10	61
Average	**0.08**	**0.13**	**60**

4.3.2.2 Nitrate Nitrogen

The ingestion of excessive amounts of nitrate can cause adverse health effects in very young infants and susceptible adults. Consequently, the State of Illinois has set a maximum acceptable level of 10 mg/L as the food processing and public water supply standard. The most common sources of nitrate are agriculture overuse of fertilizer, municipal and industrial wastewaters, refuse dumps, animal feed lots, and septic systems. Other sources include runoff or leachate from manured or fertilized agricultural lands and urban drainage. The fertilizers and wastes are sources of nitrogen-containing compounds that are converted to nitrates in the soil. These sources also result in elevated levels of nitrate in groundwater. Nitrates are extremely soluble in water and can move easily through soil into the drinking water supply. In addition, nitrogen compounds are emitted into the air by power plants and automobiles and are carried from the atmosphere to the earth with rainfall. Once nitrate is formed, its movement in soil and its potential to contaminate groundwater depend on several factors including soil characteristics, location and characteristics of the underground water formations (aquifers), and climatic conditions. Nitrate nitrogen is evaluated in North Fork Vermilion River BPG05 because it is listed as a cause for the partial impairment in Lake Vermilion for public and food processing water supply. The North Fork Vermilion River Segment BPG05 upstream of the lake is a potential loading source of nitrate nitrogen for the lake.

ISWS (Keefer 2003) collected nitrate nitrogen data at Bismarck, Illinois, from April 2000 to March 2002. Figure 4-5 presents the variation of the nitrate nitrogen over 2 years. The elevated nitrate nitrogen concentrations are observed from February to June, with the peak in June. From July to December, nitrogen nitrate concentrations are lower. The trend of nitrate nitrogen follows the flow pattern fairly well, meaning the nitrate nitrogen exceedance in Lake Vermilion may be caused by nonpoint sources although other sources are also significant.

4.3.2.3 Fecal Coliform

North Fork Vermilion River (BPG09) is listed for pathogen impairment. Fecal coliform is used as the indicator for pathogens in TMDL development. Various point and nonpoint sources may potentially contribute to fecal coliform loads to the North Fork Vermilion River. Point sources include wastewater treatment plants and households that are served by wastewater disposal systems. Because of the very small amount of discharge and the fact they are treated, these point sources do not pose a primary concern in the North Fork Vermilion River watershed, but they do contribute to the fecal coliform load. Fecal coliform discharge information from the point sources will be needed in the Stage 3 of TMDL development. In addition, septic systems that discharge to tile drains are potential fecal coliform sources in the North Fork Vermilion River watershed. The further data and information on wastewater treatment plant and private wastewater disposal systems are crucial to quantify loading from these point sources. Nonpoint sources that contribute fecal coliform load include septic systems, urban runoff, wildlife, animal feedlots, and manure applications.

Fecal coliform data collected at Bismarck from 1978 to 1998 was used for listing the North Fork Vermilion River on 2004 303(d) List. The data were collected on monthly basis. This sampling approach cannot facilitate the calculation of the geometric mean based on the standard, which requires a minimum of 5 samples within 30 days. However, the monthly data from 1978 to 1998 shows that fecal coliform concentrations constantly exceeded the 200 cfu/100 mL standard and 10 percent frequency standard of 400 cfu/100 mL. The maximum fecal coliform concentration is as high as 20,000 cfu/100 mL. As a result, North Fork Vermilion River was listed as partially supporting its designated use because of elevated fecal coliform concentrations. Figure 4-6 shows the fecal coliform concentration trend from 1978 to 1998. There is no obvious decreasing or increasing pattern.

Figure 4-7 presents the relationship between fecal coliform and flow. The graph reveals that the fecal coliform concentration exceeds the geometric mean standard of 200 cfu/100 mL in both low flow and high flow conditions. Fecal coliform was present at 1,700 cfu/100 mL at a low flow rate of about 11 cfs, when no overland runoff would occur. In addition, there appears to be a positive correlation between fecal coliform concentrations and flow when the flow is higher than 100 cfs.

Figure 4-8 shows variation of monthly average fecal coliform concentration within a year. The average fecal coliform concentration reached the highest in low flow months of July, August, and September. This implies that the low flow steady sources contribute to the elevated fecal coliform concentration.

FIGURE 4-5 MONTHLY NITRATE NITROGEN CONCENTRATIONS NORTH FORK VERMILION RIVER AT BISMARCK

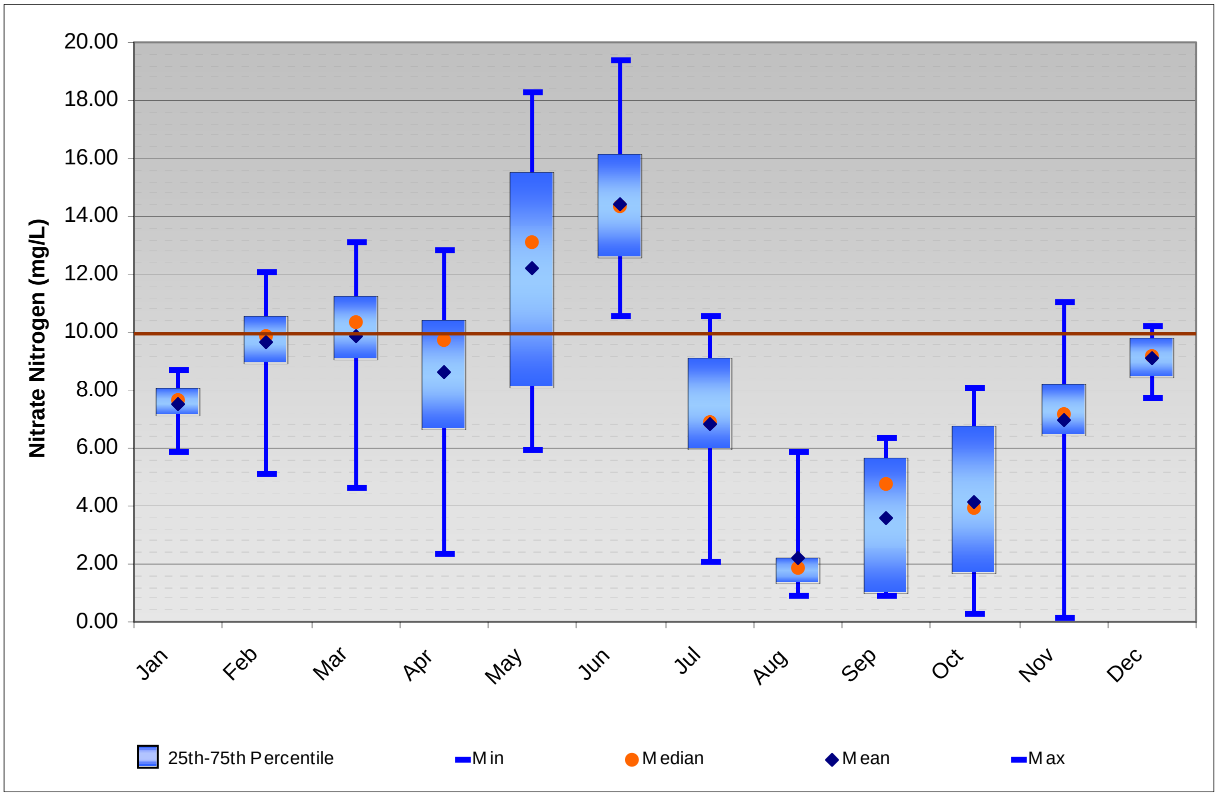


FIGURE 4-6 FECAL COLIFORM CONCENTRATIONS NORTH FORK VERMILION RIVER AT BISMARCK (1978 TO 1998)

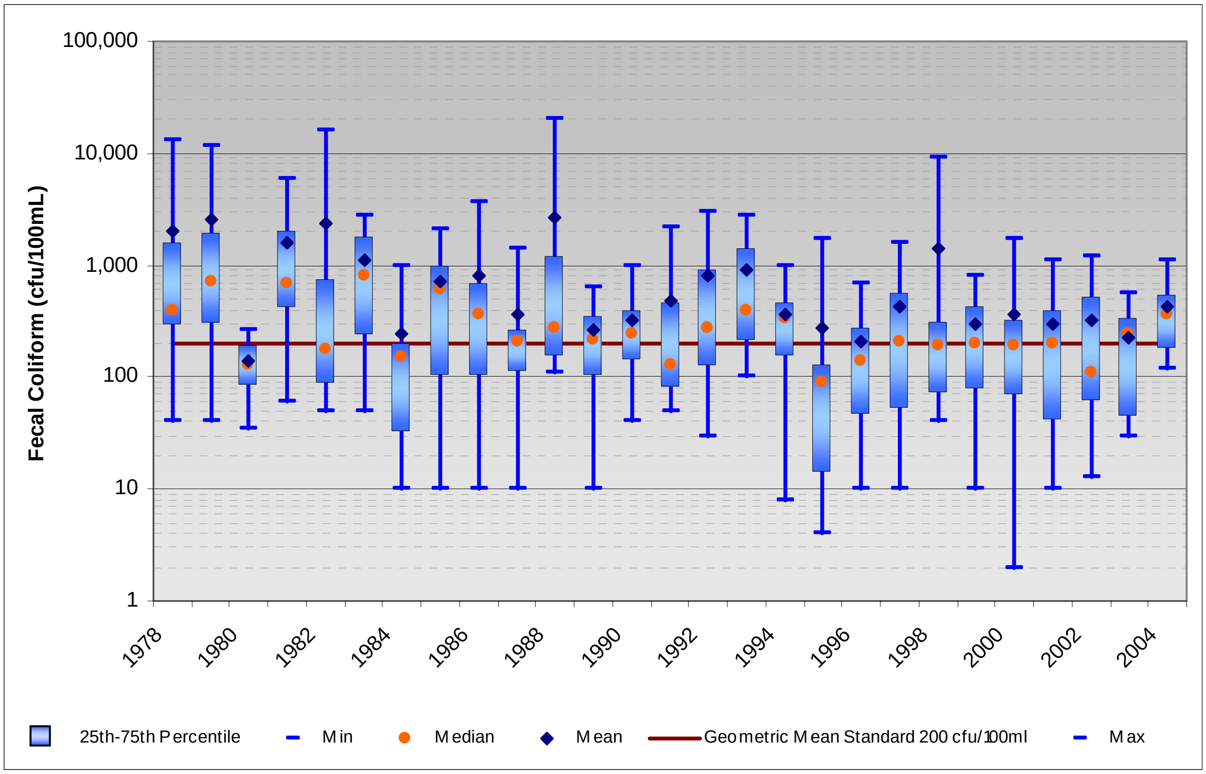


FIGURE 4-7 RELATIONSHIP BETWEEN FECAL COLIFORM CONCENTRATIONS AND FLOW RATE

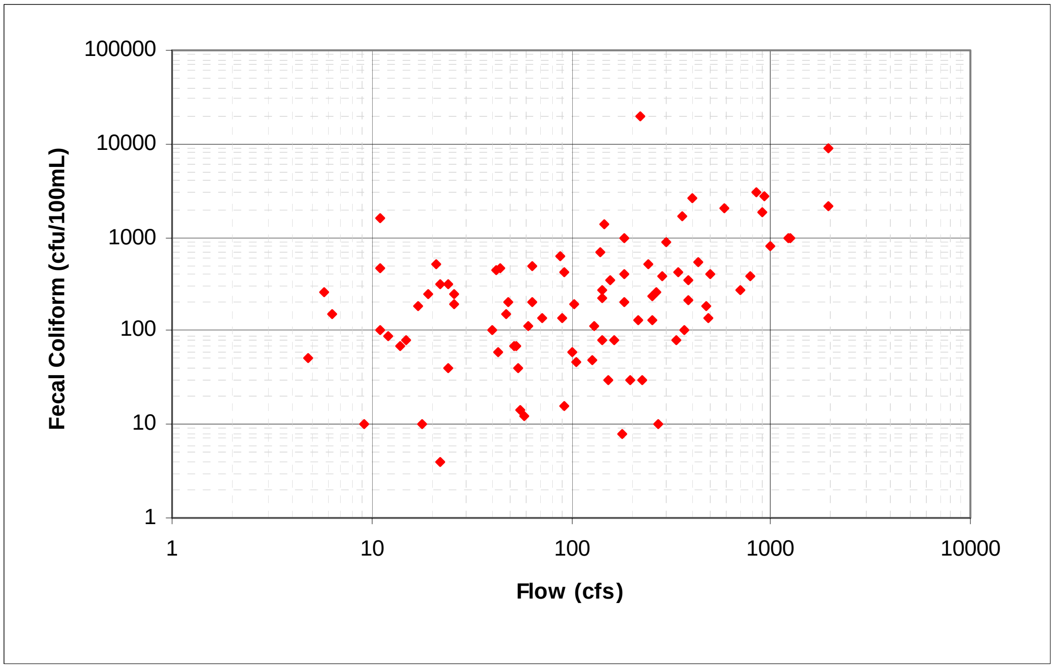
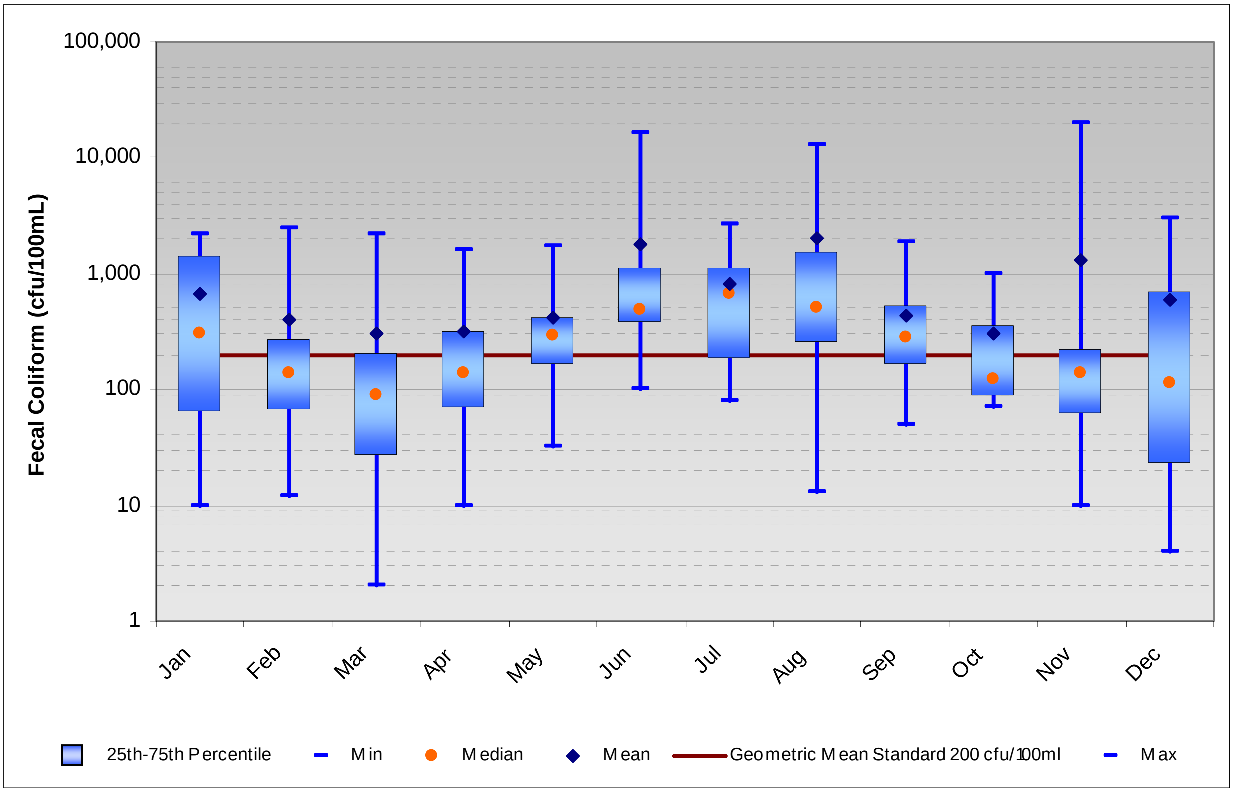


FIGURE 4-8 MONTHLY FECAL COLIFORM CONCENTRATIONS NORTH FORK VERMILION RIVER (BPG09)



4.3.3 Lake Vermilion (RBD)

This section presents the water quality assessment in Lake Vermilion using the available data from the RBD-1, RBD-2, RBD-3, RBD-4, and RBD-5 sites.

4.3.3.1 Phosphorus

Phosphorus was not explicitly listed as the cause of impairment in the 2004 IEPA 303(d) list. TP, however, is used as an indicator for organic enrichment, low DO, and excessive algae growth in Lake Vermilion (see Section 4.1.2). Figure 4-9 presents TP data collected at various sites in the lake from 1977 to 2001. RBD-T2 is located upstream of the lake in North Fork Vermilion River. The figure indicates that at all locations, TP concentrations exceed the water quality standard of 0.05 mg/L.

TP concentrations at RBD-3 and -4 are higher than other locations. One possible explanation is that TP concentrations at these two locations are affected by direct inflow from two nearby tributaries, which may provide sufficient phosphorus load to elevate the concentration locally.

FIGURE 4-9 TOTAL PHOSPHORUS CONCENTRATIONS IN LAKE VERMILION (1977-2003)

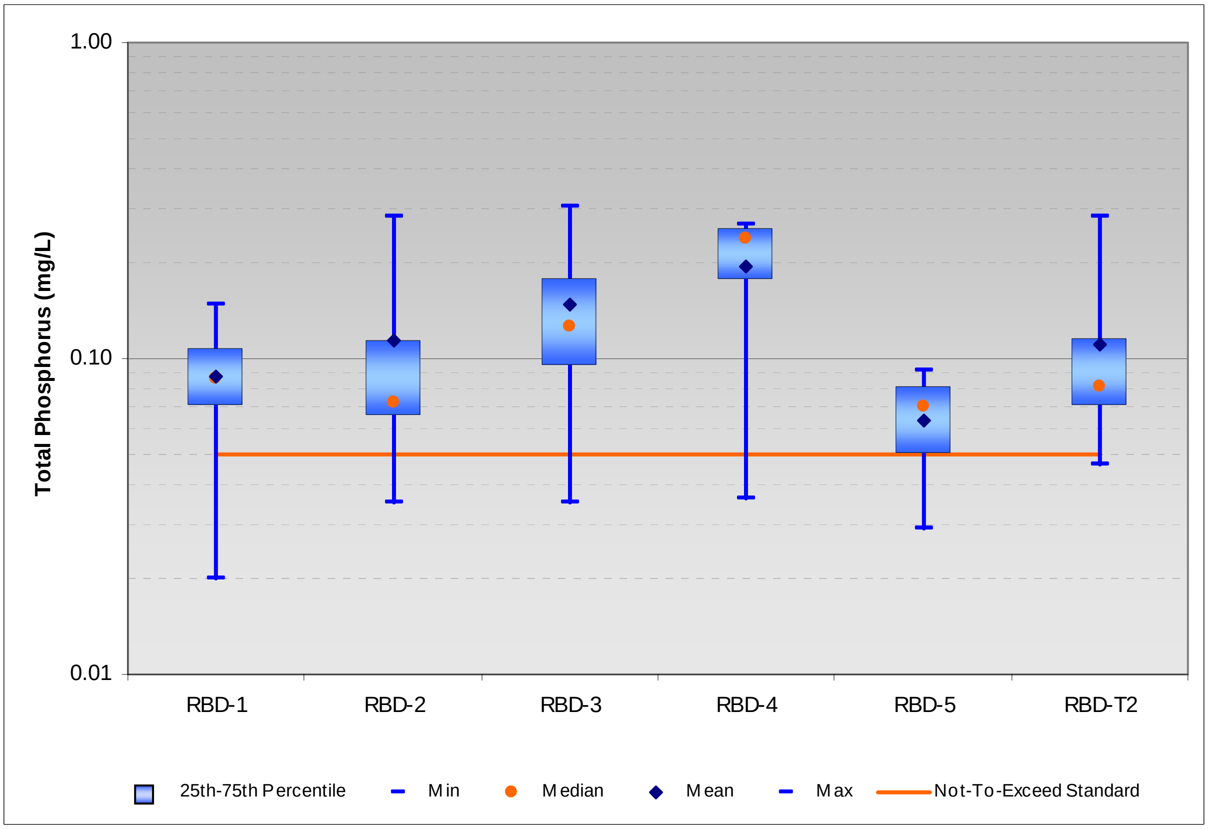


Figure 4-10 presents the variation of monthly average TP concentration in Lake Vermilion, based on data from all locations. The monthly average TP concentrations exceed the Illinois water quality standard from March to October. The monthly average TP is highest in June, roughly following the fecal coliform pattern very well. Once again, the data indicate that the phosphorus load from non-erosion related sources may be an important load component for Lake Vermilion.

Table 4-5 summarizes the monthly average DP and TP concentrations in the lake. The trend is slightly different from the North Fork Vermilion River, most likely because of algae uptake, settlement, and the long retention time of the lake.

FIGURE 4-10 MONTHLY AVERAGE TOTAL PHOSPHORUS CONCENTRATION IN LAKE VERMILION

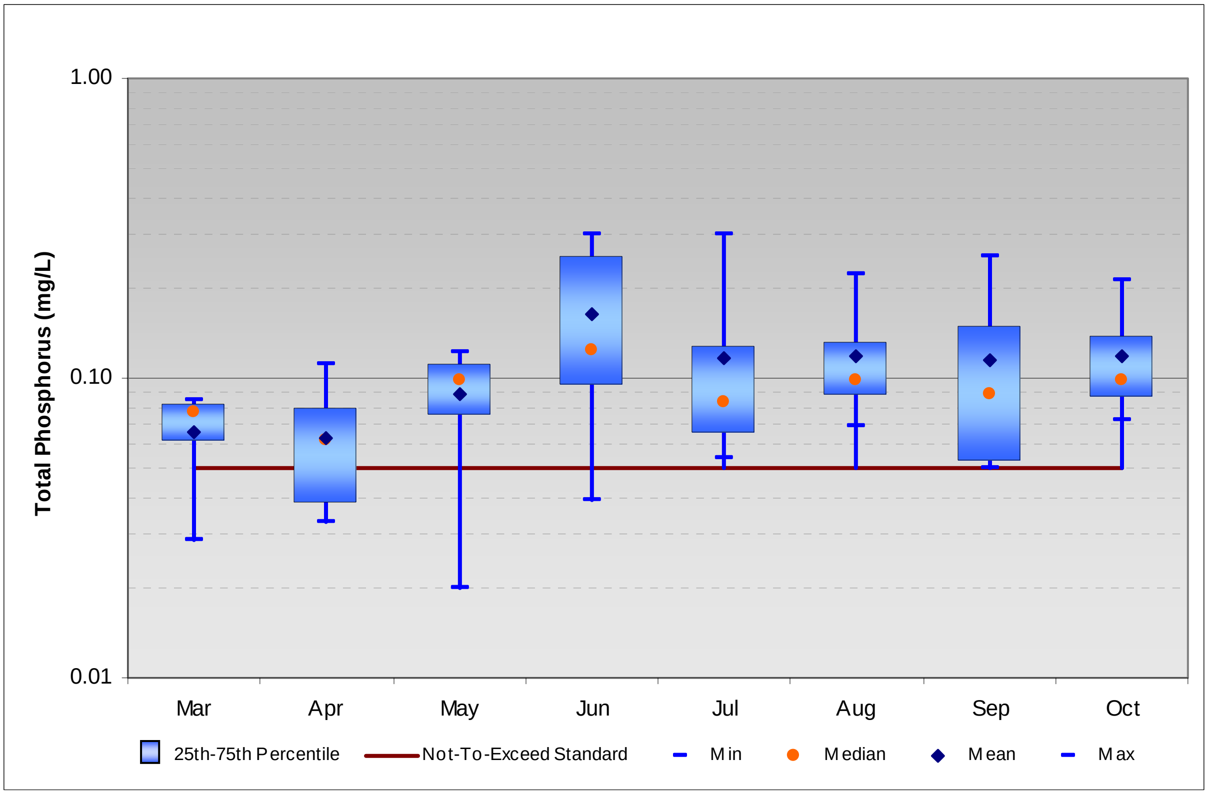


TABLE 4-5 MONTHLY AVERAGE DISSOLVED PHOSPHORUS AND TOTAL PHOSPHORUS CONCENTRATIONS IN LAKE VERMILION

Month	DP	TP	Percent DP
Apr	0.01	0.04	22
May	0.06	0.11	56
Jun	0.06	0.18	33
Jul	0.01	0.07	20
Aug	0.03	0.10	28
Sep	0.03	0.08	31
Oct	0.02	0.09	25
Average	**0.03**	**0.09**	**30**

Source: IEPA 2001

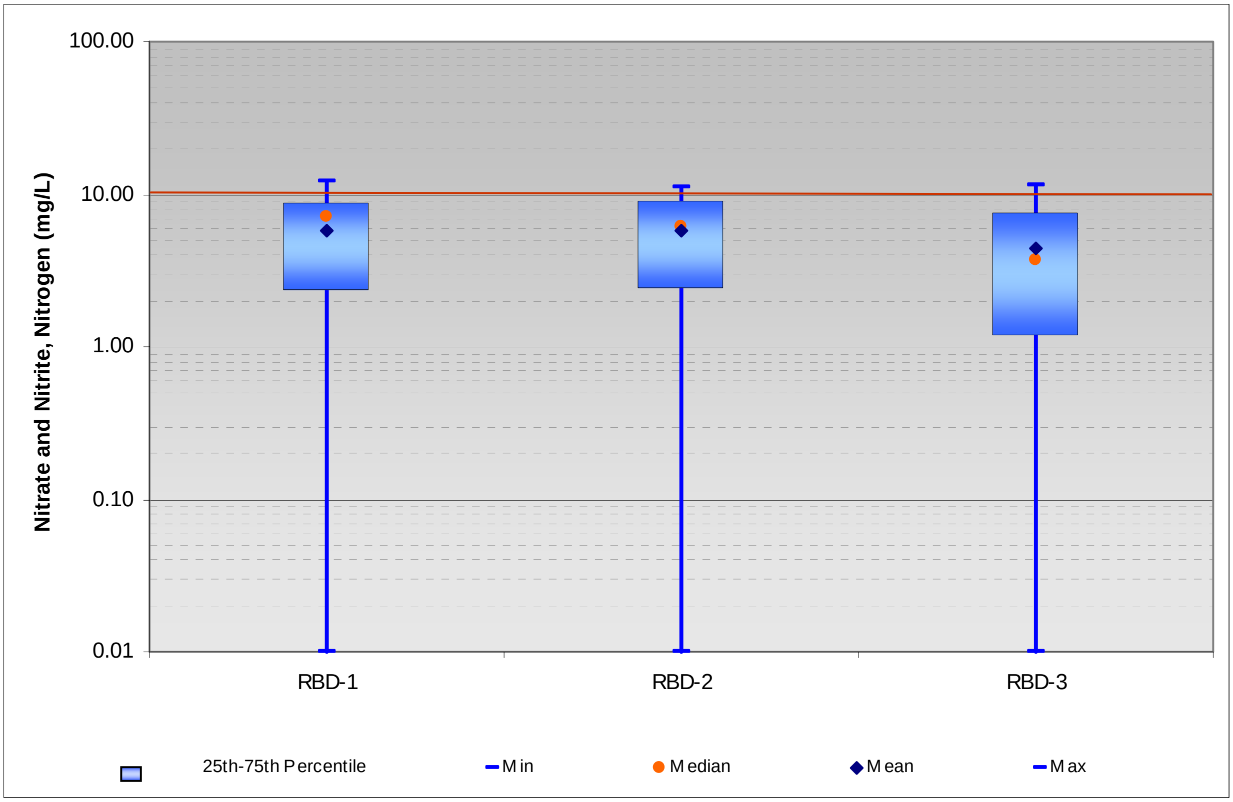
Lake mixing dynamics can greatly affect water quality in terms of chemical (nutrient) availability and the concentrations, location, and forms in which chemicals are present. Phosphorus settles out of the water column to the lake bottom as particulate-phosphorus and is bound to the lake bottom sediment. This phosphorus generally is not available for aquatic plant growth and is not a water quality problem. However, anoxic conditions at the lake bottom can result in the release of bound phosphorus. If no subsequent mixing occurs in the water column, the dissolved phosphorus will remain at the lake bottom.

If mixing occurs (from wind action, tributary inflow, fish activity, or seasonal lake turnover following thermal stratification), the dissolved phosphorus is brought up to the surface, where it is available for algal uptake and growth.

4.3.3.2 Nitrate Nitrogen

Nitrate nitrogen is a listed cause of impairment in Lake Vermilion. The water quality standard for drinking water supply sources is 10 mg/L. Because nitrite nitrogen seldom appears in concentration greater than 1 mg/L and tends to transforms to nitrate, the nitrate and nitrite concentration data is used to verify the exceedance. Figure 4-11 presents the nitrite and nitrate data from RBD-1, RBD-2, and RBD-3. Equivalent data points are not available for RBD-4 and RBD-5 and not included. The maximum observed nitrite and nitrate concentration exceeds the standards at all four locations, although the average concentrations do not exceed the standard. As discussed in Section 4.3.2.2, the nitrate nitrogen concentration exceeds the standard of 10 mg/L in North Fork Vermilion River at Bismarck. The nitrate loads from the North Fork Vermilion River may be the main reason for the exceedance in Lake Vermilion.

FIGURE 4-11 NITRITE AND NITRATE CONCENTRATIONS IN LAKE VERMILION



4.3.3.3 Limiting Nutrients

A limiting nutrient is a nutrient or trace element that is essential for plants to grow but that is available in smaller quantities than are required by the plants and algae to increase in abundance. Therefore, if more of a limiting nutrient is added to an aquatic ecosystem, larger algal populations will develop until nutrient limitation or another environmental factor (such as light or water temperature) curtails production at a higher threshold than previously possible. Reducing the limiting nutrient can lower the eutrophication level in the lake and improve the water quality. The stoichiometry ratio of nitrogen to phosphorus (TN:TP) in phytoplankton biomass is about 7.2:1. If the N:P ratio in a water body is less than 7.2, nitrogen is the limiting nutrient. Otherwise, phosphorus is the limiting nutrient. Table 4-6 summarizes the average TN:TP ratio in the Lake Vermilion, based on the IEPA 2001 sampling data. The average TN:TP ratio is about 156.54. Therefore, phosphorus is considered to be the limiting nutrient for plant growth in Lake Vermilion. TP contributes to lake eutrophication (fertility) and algal blooms. Nitrogen is also an essential nutrient for plant growth; however, it is often so abundant that it does not limit algae growth, especially in water systems with low retention times (fast-flowing systems). Some species of algae can also "fix" their own atmospheric nitrogen and do not need another nitrogen source. With nitrogen abundant and available, an increase in limiting nutrient, TP, results in rapid algal growth.

TABLE 4-6 AVERAGE TOTAL PHOSPHORUS AND TOTAL NITROGEN CONCENTRATIONS IN LAKE VERMILION

Station	Date	TP	TN	TN:TP
RBD-1	03/28/01	0.08	10.46	129.14
RBD-1	03/28/01	0.08	10.89	129.64
RBD-1	04/19/01	0.09	13.68	157.24
RBD-1	04/19/01	0.11	11.25	100.45
RBD-1	04/26/01	0.06	10.02	161.61
RBD-1	04/26/01	0.07	9.74	141.16
RBD-2	03/28/01	0.07	10.91	151.53
RBD-2	04/19/01	0.10	11.25	114.80
RBD-2	04/26/01	0.07	9.98	151.21
RBD-5	03/28/01	0.03	10.74	370.34
RBD-5	04/19/01	0.07	11.80	166.20
RBD-5	04/26/01	0.09	9.57	105.16
Average		**0.08**	**10.86**	**156.54**

4.3.3.4 Trophic Index

Trophic status (or "fertility" status) is often used to describe the nutrient enrichment status of a lake ecosystem. Higher trophic status is associated with more nutrient availability and higher productivity. Generally, mesotrophic to eutrophic lakes are considered to be the best environments for supporting a variety of uses, including fishing, aquatic life support, swimming, boating, and other uses. Excessive nutrient loads can result in nuisance algal blooms and excessive turbidity. Very low nutrient status also can limit the support of aquatic life. Carlson Trophic State Index (TSI) values are used as indicators of trophic status, which can be calculated using TP concentrations, Chl-a concentrations, or Secchi disk depth respectively (Carlson 1977). Generally, TP is considered the best indicator of *potential* trophic status, especially when the TP is the limiting nutrient. The diagram in Figure 4-12 depicts the relationship between the TSI, trophic status, and nutrient status.

Table 4-7 summarizes the TSI in Lake Vermilion, based on TP, Chl-a, and Secchi disk depth. Using the TP-based TSI, the Lake Vermilion is classified as hypereutrophic. This conclusion is similar to that of Lin and Bogner (2004).

FIGURE 4-12 TSI RELATIONSHIP TO LAKE FERTILITY

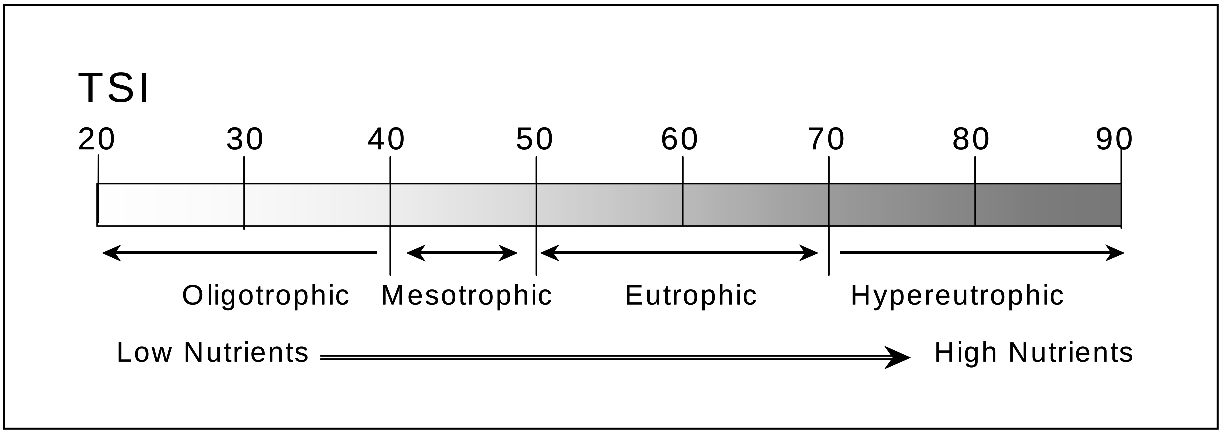


TABLE 4-7 TROPHIC STATE INDEX FOR LAKE VERMILION

Location	TSI (for Total Phosphorus)	TSI (for Chl-a)	TSI (for Secchi Depth)
TSI-1	68.7	62.0	71.9
TSI-2	72.5	65.9	75.2
TSI-3	76.2	65.9	78.1
TSI-4	80.1	no data	78.6
TSI-5	64.0	60.7	72.1
TSI-T2	72.1	no data	no data
Average	72.3	63.6	75.2

4.3.3.5 Excessive Algal Growth/Chlorophyll-a

Lake Vermilion is listed for impairment of excessive algal growth. Chl-a, as an indicator for algal growth, is the dominant pigment in the algae cell, which is commonly used as a surrogate for algae. Algae blooms are also an indirect cause of low DO related to organic enrichment. The narrative water quality standard for general use in the State of Illinois requires that waters of the state shall be free from algal growth of other than natural origin. Figure 4-13 shows that Chl-a concentration at five sampling locations. Chl-a concentrations do not show large spatial variation. The maximum Chl-a concentration of 170 ug/L occurred at RBD-3.

Figure 4-14 shows the observed monthly average Chl-a concentration values in Lake Vermilion. The figure indicates that the Chl-a concentration is slightly higher in late summer and fall than the rest of the year.

FIGURE 4-13 CHLOROPHYLL-A CONCENTRATIONS IN LAKE VERMILION

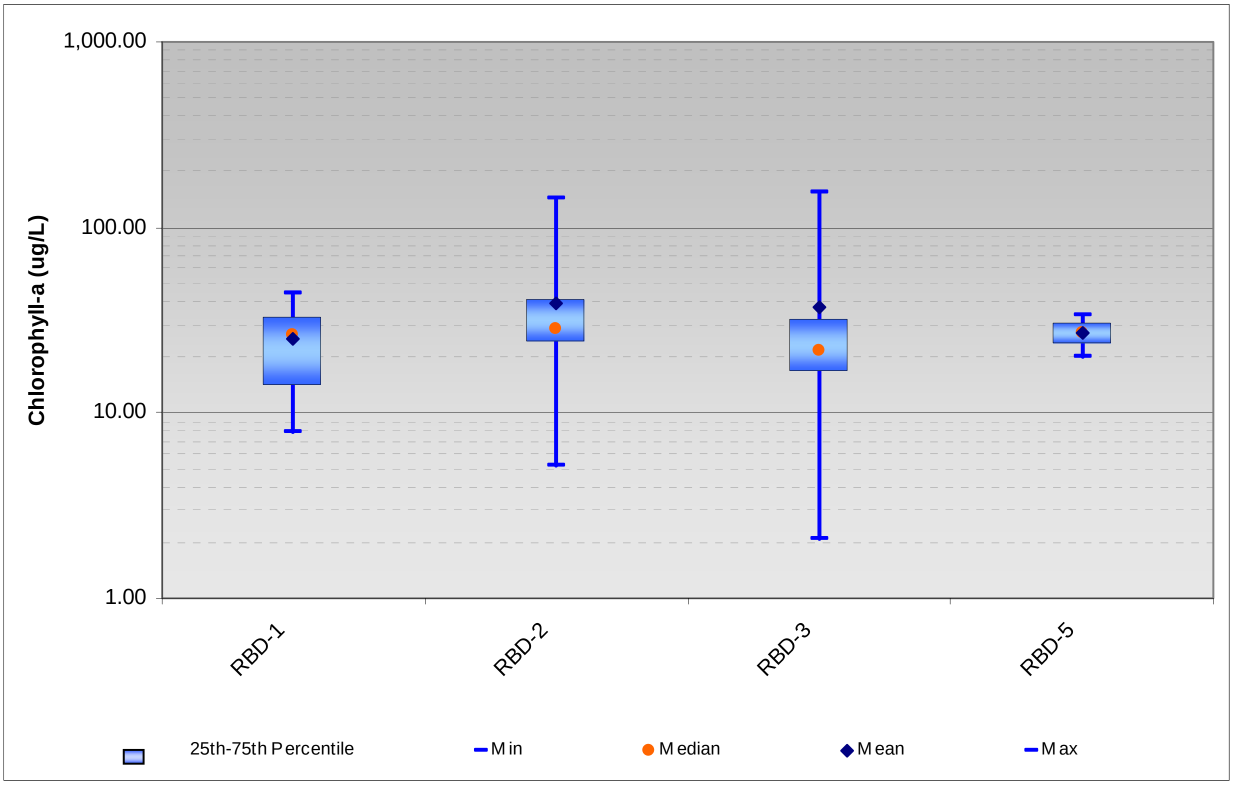
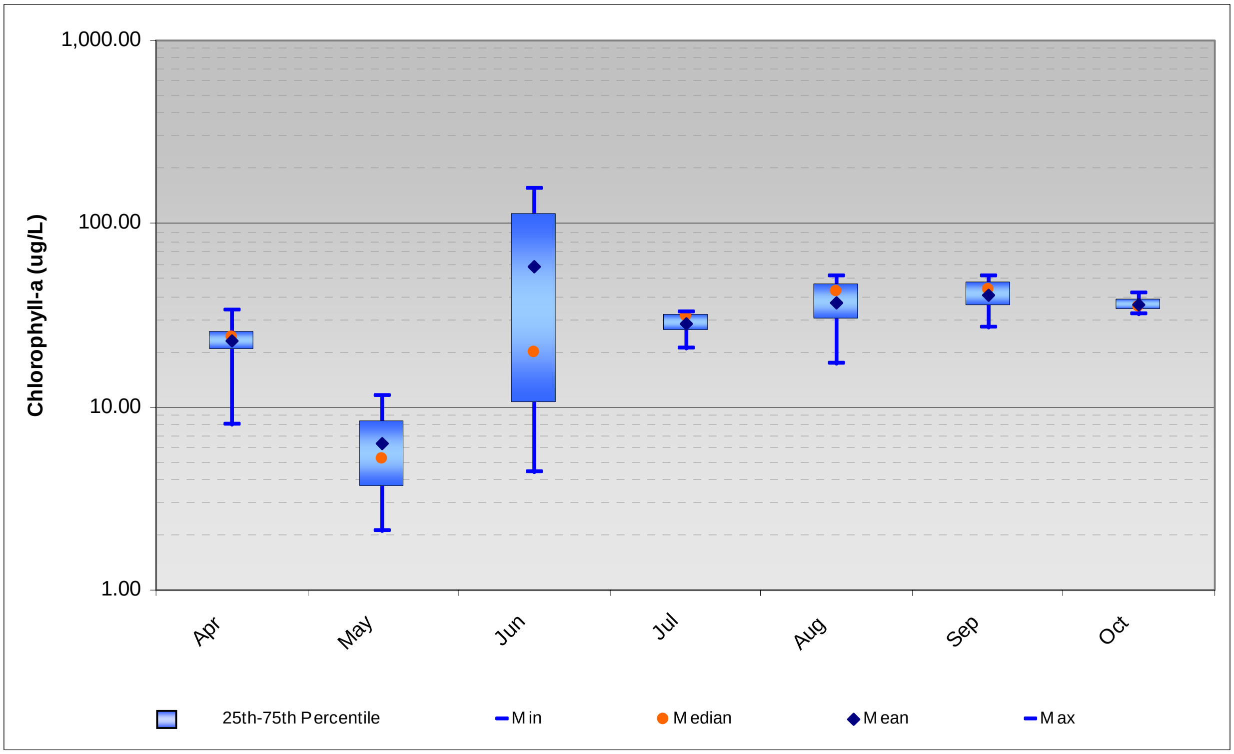


FIGURE 4-14 MONTHLY AVERAGE CHLOROPHYLL-A CONCENTRATIONS IN LAKE VERMILION



5.0 SOURCE ASSESSMENT

This section discusses point and nonpoint sources that potentially contribute to the impairment of the North Fork Vermilion River and Lake Vermilion.

5.1 NONPOINT SOURCES

The Illinois 2004 303(d) List identified agriculture (crop related, non-irrigated crop production) and hydrologic/habitat modification (flow regulation, stream bank modification, destabilization, recreation, salt storage, and unknown sources) as sources of nutrient loads to Lake Vermilion. Sources of pathogens to the North Fork Vermilion River have not been identified. Row crop agriculture is a common source of sediment and nutrient loads and is prevalent in the watershed. Overall about 96 percent of the watershed is agricultural land. Crops primarily consist of corn and soybean rotations. Fertilizers commonly used in the watershed include anhydrous ammonia, ammonium phosphate, and potash. Fertilizers are applied in the fall and spring with a variety of application methods (Tetra Tech 2004b).

Animal feedlots are another potential source of nutrient loads and pathogens. According to local Natural Resources Conservation Services (NRCS) staff, only 9,063 animal units were distributed among 217 farms in Vermilion County in 1997. Only five farms had more than 200 animal units, and only one farm had more than 500 animal units. No farm had more than 1,000 animal units.

Soils in the North Fork Vermilion River watershed have relatively low permeability of 0.5 inch per hour. Rainfall does not easily infiltrate low permeability soils, and the resulting overland runoff rates may be high. Increased overland runoff typically results in larger nutrient and sediment loads to receiving water bodies. The absence of cropland buffer and filter strips in agricultural areas may not allow for adequate trapping of particles, uptake of dissolved nutrients, and infiltration of water and nutrients to the river. Furthermore, grazing areas and pastureland may be crossed by small tributaries that are damaged and degraded by livestock. 2004 Illinois Soil Conservation Transect Survey Summary indicates that about 15 percent of the points (locations) surveyed are still exceeding tolerable soil loss level (Illinois Department of Agriculture, 2004). Vermilion County recorded 13 percent of the survey points exceeding tolerable soil loss level, slightly lower than state average. Vermilion County, however, has high percentage (89 percent) of conventional tillage in corn fields, compared to the state average of 35.5 percent. The need for soil management adjustment is warranted to lower the soil loss level. It was also observed that the State average ephemeral and/or gully erosion increased in the past 8 years. Although this may be partially attributed to heavy rainfall intensity, the disturbance of soil surface may have contributed to the increased erosion.

Private septic systems are prevalent in Vermilion County and are another potential source of nutrient, sediment, and pathogen loads. Septic systems can potentially leach nutrients into the groundwater and can contaminate surface water if the system is not functioning properly. Except for residents of Danville, Rossville, and Hoopeston, all residents in the watershed use septic systems, for which the population is estimated to be 7,560, based on urban and nonurban population data shown in Tables 2-2 and 2-3 (Tetra Tech 2004c). According to U.S. Census data, each household represents an average of 2.3 people; therefore, about 3,300 septic systems exist in the watershed. Only septic systems installed after 1970 are permitted. The number of permitted and nonpermitted septic systems in the watershed was determined as follows. There are 7,500 permitted septic systems in Vermilion County, and 1,013 permitted septic systems in Warren County (Tetra Tech 2004c and d). Assuming permitted septic systems are distributed evenly throughout the county, and knowing that 21 percent of Vermillion County is in the watershed and 19 percent of Warren County, Indiana is in the watershed, about 1,767 permitted septic systems are located in the watershed. By subtracting 1,767 from 3,300, there are about 1,533 unpermitted septic systems in the watershed. These unpermitted septic systems may be a significant source of nutrient and fecal coliform loads to North Fork Vermilion River and Lake Vermilion.

Furthermore, it was reported that there are about 70 houses located around the shoreline of Lake Vermilion. About 40 percent of the houses discharge to the Danville wastewater treatment plant. The rest use septic tanks to treat their wastewater (Tetra Tech, 2004c). The potential influence of septic tank effluent on the lake will be investigated, based on site-specific information. About 95 percent of the soils in Warren County have severe limitations for conventional septic systems. Some older systems are connected to underground tile drains or discharge directly to drainage ditches. Both practices are illegal in Illinois and Indiana. Information from a detailed drain tile survey is needed to further quantify the density of the drain tile and its impact on the water quality.

5.2 POINT SOURCES

Most facilities in the North Fork Vermilion River watershed discharge a negligible flow and do not discharge loads of pollutants of concern. Six facilities either discharge a significant flow or discharge sediment and nutrient loads potentially. The six facilities are as follows, listed from upstream to downstream (see Table 5-1 and Figure 5-1):

1. **Hoopeston Foods Inc.** discharges non-contact cooling water and boiler blowdown through two outfalls. Each is monitored for temperature, biological oxygen demand (BOD), pH, and TSS (EPA 2003). It is likely that the receiving ditch of the discharge is tributary to Hoopeston Branch (BPGD), which is listed as impaired by low DO. A new NPDES discharge permit is issued to the facility, which sets 30-day average BOD discharge at 10 mg/L and daily maximum at 30 mg/L. Discharge monitoring reports (DMR) for Hoopeston Foods Incorporated will be evaluated as part of TMDL development.

2. **Hoopeston Sewage Treatment Plant** (STP) regularly discharges through one main outfall. The treatment facilities include bar screens, grit chambers, two treatment tanks, two oxidation ditches, and four sand filters. The monitoring discharge record from April 2000 to May 2001 shows that the maximum discharge rate in the year is about 2.36 MGD. Monthly average CBOD, ammonia, and TSS are included in Table 5-1. The concentrations of these constituents did not exceed the NPDES permitted limits (Lin and Bogner 2004). Hoopeston STP has a year-round disinfection exemption that includes the entire length of Hoopeston Branch to the point where it enters North Fork Vermilion River.

3. **Rossville STP** discharges regularly through one outfall, which is monitored for pH, TSS, total residual chlorine, and BOD (EPA 2003). The treatment facility uses two-lagoon system as primary and secondary treatments. Two intermittent sand filters polish the effluent before discharging (Lin and Bogner 2004). The average discharge concentration for BOD and TSS are included in Table 5-1. No discharge violation was reported. Rossville has a year-round disinfection exemption and discharges to Segment BPG-10.

4. **Alvin Water Treatment Plant** (WTP) discharges regularly through one outfall. The WTP regularly monitors pH, TSS, iron, and total residual chlorine (EPA 2003). The DMR has not been retrieved. The Village of Alvin is an unsewered community.

5. **Bismarck Community Unit School** has an STP outfall that discharges regularly to Painter Creek, a tributary to North Fork Vermilion River. The school uses a septic tank system and two tertiary sand filers to treat the wastewater. The outfall is monitored monthly for pH, TSS, ammonia-nitrogen, total residual chlorine, and BOD (EPA 2003). The DMR records from July 2002 to October 2003 show that the average discharge is about 0.005 MGD. The discharge record in January 2001exceeded the NPDES permitted ammonia concentration of 4.00 mg/L (Lin and Bogner 2004).

6. **Bismarck Community Water District** is the water treatment plant for local water supply. The outfall is only monitored for suspended sediment discharge and pH since it probably does not contribute significant nutrient and fecal coliform to the North Fork Vermilion River.

TABLE 5-1 MAJOR POINT SOURCES DISCHARGER IN NORTH FORK VERMILION RIVER WATERSHED

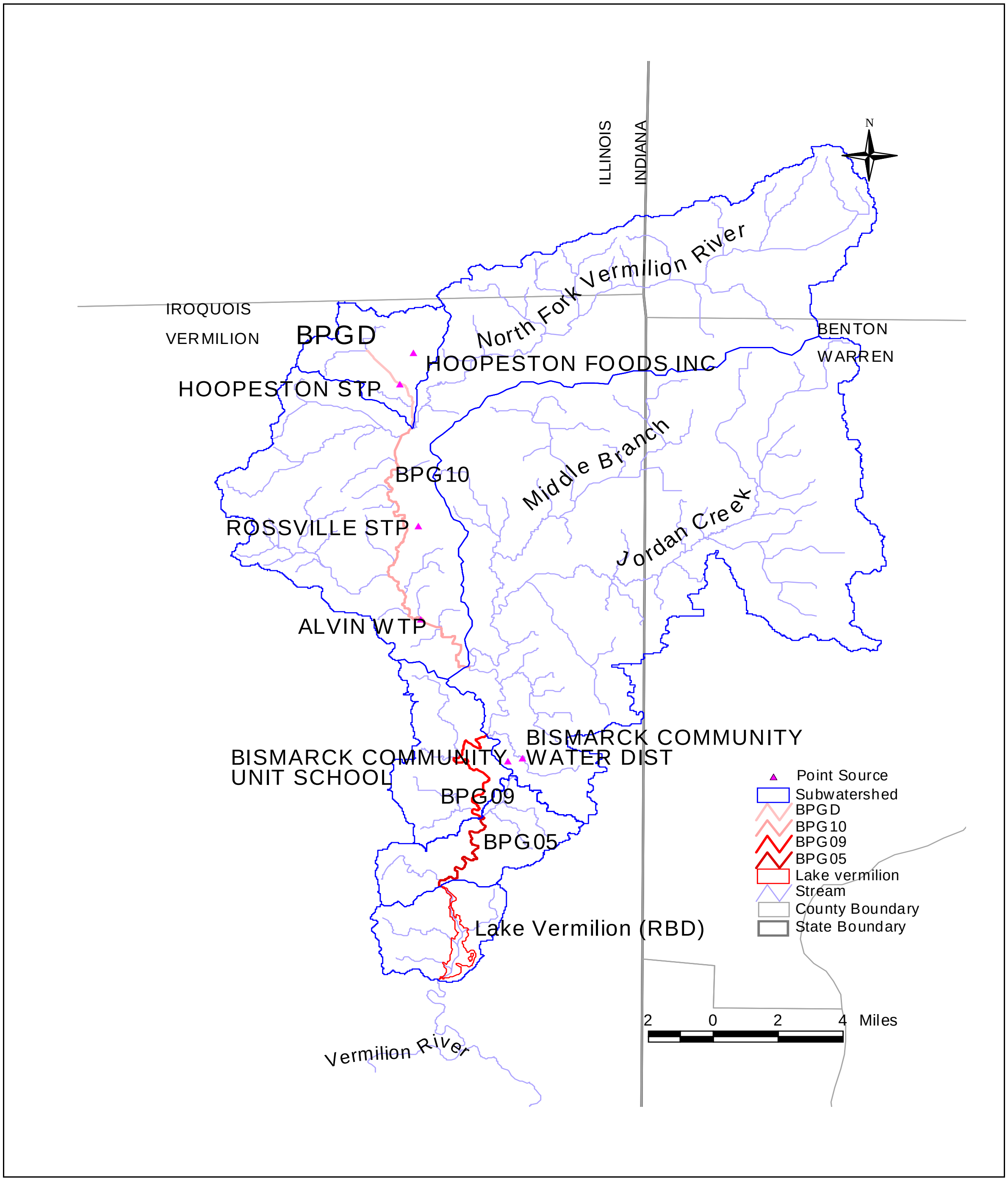
Facility Name	Location	NPDES No.	SIC No.	Receiving Waterbody	Average CBOD (mg/L)	Average TSS (mg/L)	Average Ammonia (mg/L)	Average Discharge (MGD)
Hoopeston Foods Inc.	Hoopeston, IL	IL0022250	2033	Stream Sewer to North Fork Vermilion River	Unknown	Unknown	Unknown	0.15
Hoopeston STP	Hoopeston, IL	IL0024830	4952	Unnamed Ditch to North Fork Vermilion River	3	3	0.21	1.652
Rossville STP	Rossville, IL	ILG580064	4952	North Fork Vermilion River	11.5	16	Unknown	0.18
Alvin WTP	Alvin, IL	ILG640002	4941	North Fork Vermilion River	Unknown	Unknown	Unknown	0.0006
Bismarck Community Unit School	Bismarck, IL	IL0067156	4941	Painter Creek	4.3	3.8	1.7	0.004
Bismarck Community Water District	Bismarck, IL	ILG640101	8211	Unnamed Tributary of Painted Creek	Unknown	Unknown	Unknown	0.007

Notes:

IL	Illinois
MGD	Million gallons per day
STP	Sewage treatment plant
WTP	Water treatment plant (water supply)

Source: USEPA 2003 and USEPA 1998

FIGURE 5-1 POINT SOURCE LOCATION MAP



6.0 METHODOLGY SELECTION

This chapter discusses the methodology that may be used for the development of TMDLs for Hoopeston Branch (BPGD), North Fork Vermilion River (BPG05 and BPG09), and Lake Vermilion (RBD). Both a simple approach and a modeling approach are considered. The final selection of a methodology will be based on following factors:

1) Fundamental requirements of defensible and approvable TMDL
2) Data availability
3) Fund availability
4) Public acceptance
5) Complexity of water body

A simpler approach shall be used as long as it meets TMDL requirement since it is more economical. On other hand, a sophisticated model approach is often used to establish a scientific link between the pollutant sources and the water quality indicators for the attainment of designated uses. Models enable the prediction of water body response to the pollutant loads and comparison of the various reduction scenarios. The linkage allows for the evaluation of management options and the selection of the option that will achieve the desired load reductions.

Section 6.1 discusses the simple approach. Section 6.2 discusses the sophisticated approach, describes the criterion for the model selection and preliminary model selection, followed by brief descriptions of each model. Section 6.3 discusses model calibration. Section 6.4 discusses sensitivity analysis.

6.1 SIMPLE APPROACH

A simple approach such as a flow duration curve is considered for the TMDL development in North Fork Vermilion River. In order to use a duration curve, both flow and water quality data is needed through long-term sampling to trace where the major sources of pollution are coming from. The duration curve approach is not labor intensive and can be used efficiently to meet time constrain. The method, however, is not able to link the loadings and water quality response and allocate loads to specific sources based on transport mechanisms. While a flow duration approach appears to be a good tool for screening and gaining an overall picture of watershed conditions and meet the requirements of TMDL, a more complex modeling may be used for TMDL development to better represent watershed processes and calculate more accurate load allocations (Miller-McClellan, 2003). One sampling site is located in BPG09 (USGS station 03338780) of North Fork Vermilion River watershed, which has over 20-years continuous flow and water quality data and can be used to develop a duration curve and a loading curve and subsequently calculate the total loads. This total load may be used to extrapolate the loads for segment BPG05. This approach is not applicable to BPGD because few data points are available.

For Lake Vermilion, a mass-balancing BATHTUB model may be considered as a simple approach to link the nutrient loads and water quality parameters such as nitrate and phosphorus. BATHTUB applies a series of empirical eutrophication equations and performs steady-state water and nutrient balance calculations in a lake. Eutrophication-related water quality conditions (total phosphorus and total nitrogen) are predicted using empirical relationships derived from assessments of lake data. Applications of BATHTUB are limited to steady-state evaluations of relations between nutrient loading, hydrology, and eutrophication responses.

6.2 SOPHISTICATED MODELING APPROACH

Generally, the sophisticated modeling approach will consist of two steps: (1) use of a watershed model to simulate hydrology and estimate pollutant loads to each water body as a function of land use and pollutant export, and (2) use of a water quality model to predict pollutant concentrations and other responses in the water body as a function of pollutant loads. The following criteria were used to select watershed and water body models for developing North Fork Vermilion River and Lake Vermilion TMDLs:

- Capable of simulating watershed hydrology and loading process
- Capable of simulating pollutant (particularly, fecal coliform, nitrogen, and phosphorus) transport and water quality
- Capable of simulating best management practices (BMP) scenarios
- Ease of use and calibration
- Well tested and documented

6.2.1 Watershed Model

The Soil Water Assessment Tool (SWAT) model is considered as a watershed model to calculate nonpoint sources loading. SWAT is specifically developed for agriculture areas. It simulates both hydrology and water quality continuously and predicts the effect of land management practices. Compared to Hydrologic Simulation Program in Fortran (HSPF), SWAT is not as parameter intensive and its hydrologic algorithm is based on well-known NRCS Curve Number, which can be varied as surface moisture changes. In addition, SWAT is capable of simulating the pollutants of concerns in North Fork Vermilion River, such as nitrogen, phosphorus, and fecal coliform. A SWAT model can be developed for the entire North Fork Vermilion River watershed, including subwatersheds for all listed segment. Therefore, loads can be estimated at each segment. The SWAT model calculates flow and loads to be used in water body model.

6.2.2 Water Body Model

The water body model has to be able to simulate pollutant fate and transport in the North Fork Vermilion River as well as eutrophication in Lake Vermilion. Because the river and lake are connected, it is more natural to simulate the river and lake as a whole system and predict the response to loads from both point and nonpoint sources. Water Quality Analysis Simulation Program (WASP) is selected to simulate the water quality for the North Fork Vermilion River and Lake Vermilion. WASP is a dynamic compartment-modeling program for aquatic systems such as river, estuary, and lakes, widely used throughout the Unite States for the development of TMDL and load allocations. WASP enables the 1-, 2-, or 3-D analysis of eutrophication and toxicants to meet the need to understand the water quality kinetics in the river and lake. The model includes the algorithms for simulating eutrophication, temperature, and fecal coliform. The fecal coliform simulation is implemented as a chemical with an appropriate exponential biodegradation rate. The time varying processes of advection, dispersion, point and diffuse mass loading and boundary exchange are represented in the model. The WASP can be linked with a hydrodynamic model (such as CE-QUAL-W2 and EFDC) that can provide flows, depth, velocities, and temperature for lake circulation. WASP model provides better temporal and spatial resolution, which is needed to represent the water quality variation within the two water bodies. With compartment segmentation, WASP represents spatial nutrient gradient in the lake. It also accounts for seasonal variation in nutrient concentration at various monitoring locations. WASP allows for the simulation of vertical DO trends observed in Lake Vermilion. The combination of SWAT watershed model and WASP water quality model not only provide the framework for TMDL development but also has a potential to be enhanced into a management tool for Lake Vermilion.

6.3 MODEL CALIBRATION AND VALIDATION

Calibration involves minimizing the deviation between measured and simulated water quality indicators output by adjusting model parameters. Data required for calibration include a set of known input values along with corresponding field observations. Although model calibration is critical, Tetra Tech believes that significant effort should be focused on sound source characterization and sensitivity analysis. A good characterization of source loadings results in a more efficient, scientifically sound, and justifiable calibration process. Tetra Tech will identify data sets for water quality calibration, identify model adjustment needs based on past experience, and work closely with IEPA to fully characterize sources and address calibration issues and their impacts on final TMDL allocations. The performance of model calibration will be assessed based on statistic method and professional judgments.

Validation involves the use of a second set of independent information to check model calibration. Data used for model validation consist of field measurements of the same type as the data output from the model. Models are tested based on their predictions of mean values, variability, extreme values, and all predicted values. If the model is calibrated properly, model predictions should be acceptably close to field observations.

6.4 SENSITIVITY ANALYSIS

A thorough sensitivity analysis provides a number of benefits, including the following:

- Assistance on proper parameter selection
- Improve understanding of the model and related assumptions
- Evaluation of different TMDL scenarios
- Evaluation of model accuracy.
- Justification of selection of Margin of Safety

The results of a sensitivity analysis will provide information regarding parameters with the greatest effect on outputs. Tetra Tech will perform a sensitivity analysis based on multiple model runs based on selected parameter range and load range. In addition to evaluating the sensitivity of the technical approach to the different sources, it is also important to estimate (either qualitatively or quantitatively) the accuracy or reliability of model predictions. This estimate of the model's accuracy will be an important factor in deciding how to use the model results in estimating the TMDL values.

An important step in the TMDL process is to evaluate the relative significance of the various source-loading estimates on model results. For example, potential sources of fecal coliform contributing to the impairment of the water body include municipal treatment plants, failing septic systems, livestock operations, and urban runoff. It will be important to evaluate the sensitivity of the model to loadings from each of these sources. For example, there is no known relationship that can be used to predict the contribution of failing septic systems to a stream. If the analysis indicates that the model is especially sensitive to this source, it might be necessary to revise the loading estimates to a daily or seasonal basis.

7.0 IDENTIFICATION OF DATA GAPS

TMDL development relies on pollutant- and site-specific data and sometimes it can become data intensive. Sufficient flow and water quality data are required to evaluate current water conditions and calibrate model parameters. To a certain degree, data availability dictates the modeling approach used for the North Fork Vermilion River watershed. Five types of data are crucial for the TMDL development:

- Flow data
- Meteorological data
- Water quality data
- Watershed and water body physical parameters
- Sources characteristic data

A considerable amount of climatic, hydrologic, and water quality data is available for the North Fork Vermilion River watershed (BPG09 and BPG05). Climate Stations at Danville and Hoopeston, Illinois provide continuous precipitation and climatic data needed for developing a calibrated, predictive hydrologic model, which is essential to a water quality model. The regional evaporation, wind speed, solar radiation, dew point, and cloud cover can be obtained form Midwest Climate Center. The listed North Fork Vermilion River segment has one USGS station (03338780) located at the middle of the segment, which provides daily flow and the monthly water quality records of DO, ammonia-nitrogen, TP, fecal coliform, and TSS from 1997 to 2000. The daily spillway discharge records of Lake Vermilion are available for water balance in the lake. Lake Vermilion has monthly data (one record per month) for DO, ammonia-nitrogen, and phosphorus, TSS, Chl-a from 1977 to 2002 from five locations (see Figure 4-1).

In summary, available flow and water quality data for both the North Fork Vermilion River (BPG09 and BPG05) and Lake Vermilion appear to meet the basic needs for this TMDL. IEPA, however, may consider collecting some current fecal coliform data at a temporal interval of five-samples-per-month (as stated in Illinois Water Quality Standards) during the months of May to October in North Fork Vermilion River to further verify the exceedance.

Based on a review of data collected for this Stage I report and discussion in previous chapters, the following information and data gaps have been identified in order to facilitate the TMDL development for two water bodies.

- Flow data and water quality data in Hoopeston Branch (BPGD)
- Septic tank investigation (distribution, upgrade, failure incidents)
- Drain tile data (existing condition, distribution, and density)
- Groundwater discharge and quality data
- Live stock assessment
- Wildlife assessment
- Channel geometry
- Point Sources Discharge Monitory Record
- Livestock operations and feedlot permits
- Danville Storm and Sanitary Sewer information

Stage 2 – Sampling and Data Collection is recommended for BPGD to further verify the exceedance of DO standards and support the development of TMDL. The water quality sampling events (with flow measurement) may be considered at a frequency of two-sample-per-month in dry months from May to November at the confluences of Hoopeston STP outfall ditch with Hoopeston Branch and the mouth of Hoopeston Branch. Table 7-1 summarizes the sampling events and parameters at the two locations. If funding is available, IEPA may also consider collecting continuous daily flow data at the mouth of Hoopeston Branch.

TABLE 7-1 SAMPING EVENTS AND PARAMETERS FOR HOOPESTON BRANCHES

Parameters	**Sample Events (two locations)**						
	May	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**
Flow	4	4	4	4	4	4	4
DO, Nutrient, BOD, and Chl-a	4	4	4	4	4	4	4
Sediment Oxygen Demand (SOD)			2	2			

The other data gaps are mainly related to sources characteristics. Obtaining these data does not always require on-site sampling; instead, coordination with local governments, agencies, and watershed groups may help the gathering of the needed data. In consultation with IEPA, Tetra Tech will determine the efforts to be included as part of actual TMDL Development. Illinois 303(d) list has not identified the sources for pathogen impairment in the listed North Fork Vermillion River segment. The preliminary assessment in this characterization report shows that failing septic systems could be the major source, especially under low flow conditions. Therefore, it is important to collect site-specific septic information. If possible, water samples should be collected at outfalls where subsurface drain tiles could possibly be connected to septic systems.

8.0 REFERENCES

Carlson, R.E. 1977. A trophic state index for lakes. *Limnology and Oceanography* 22:361-369.

City-Data.Com. 2004. On-Line Database with Climate Data for Danville, Illinois. On-Line Address: http://www.city-data.com/city/Danville-Illinois.html. Accessed on February 27.

Illinois Department of Agriculture. 2004 Illinois Soil Conservation Transect Survey Summary, September.

IEPA, 2003. ILLINOIS EPA - BOW - DWPC – Monitoring and Assessment Facility-Related Stream Survey Report for Hoopeston STP, June.

IEPA, 2004. Illinois Water Quality Report – Clean Water Act Section 305(b), Bureau of Water. May

Illinois State Water Survey (ISWS). 1998. Annual Summary of Illinois Agricultural Statistics. On-Line Address: http://www.nass.usda.gov/il/1998/9816.htm.

ISWS. 1999. “Sedimentation Survey of Lake Vermilion, Vermilion County, Illinois.” Prepared by William C. Bogner and K. Erin Hessler. May.

ISWS. 2003. “Sediment and Water Quality Monitoring for the Vermilion River and Little Vermilion River Watersheds.” Prepared by Laura Keefer. April.

Lin, S.D. and W. Bogner, 2004, Phase I: Diagnostic Study of Lake Vermilion, Vermilion County, Illinois. Prepared for the Consumers Illinois Water Company and IEPA (draft under review).

Miller-McClellan, J. 2003. A Comparative Study of the Total Maximum Daily Load (TMDL) Program and Process in Virginia and Kansas: Possible Outcomes and Effects upon Stakeholders, Master Thesis. Virginia Polytechnic Institute and State University, April.

Tetra Tech EM, Inc. (Tetra Tech). 2004a. Record of Telephone Conversation Regarding Characteristics of Lake Vermilion. Between Kelly Hirsch and David Cronk, Consumers Illinois Water Company. January 29.

Tetra Tech. 2004b. Record of Telephone Conservation Regarding Animal Feedlots and Agricultural Land in the North Fork Vermilion River Watershed. Between Kelly Hirsch and Glen O. Frank, Natural Resources Conservation Service, District Conservationist, Danville Field Office. February 4.

Tetra Tech. 2004c. Record of Telephone Conversation Regarding Septic System Use in Vermilion County. Between Kelly Hirsch and Doug Toole, Vermilion County Health Department. February 20.

Tetra Tech. 2004d. Record of Telephone Conversation Regarding Septic System Use in Warren County. Between Kelly Hirsch and Dr. Fred Martin, Warren County Health Department. February 23.

Tetra Tech. 2004e. Record of Telephone Conversation Regarding Tile Drainage Monitory Data in Vermilion County, Between Dr. Bin Zhang and Dr. Mike Hirschi, Department of Agricultural Engineering, University of Illinois-Urbana Champion.

U.S. Environmental Protection Agency (EPA) 2003. Search Engine for Permit Compliance System (PCS) database in Envirofacts. On-Line Address: http://www.epa.gov/enviro/html/pcs/pcs_query_java.html. November 24.

EPA. 2000. "Better Assessment Science Integration Point and Nonpoint Sources" (BASINS). Version 3.0. User's Manual. Office of Water, Parts I and II. EPA-823-C-98-007. November

U.S. Census Bureau. 1990. 1990 Census of Population and Housing Public Law 94-171 Data (Official) Age by Race and Hispanic Origin. On-Line Address: http://censtats.census.gov/pl94/pl94.shtml.

U.S. Census Bureau. 2000. Census 2000 Redistricting Data (Public Law 94-171) Summary File, Matrices PL1, PL2, PL3, PL4. On-Line Address: http://www.census.gov/Press-Release/www/2003/SF4.html.

U.S. Department of Agriculture (USDA). 1995. State Soil Geographic (STATSGO) Database Data Use Information Miscellaneous Publication Number 1492. U.S. Department of Agriculture, Natural Resources Conservation Service. Fort Worth, TX.

Weischmeier, W.H. and D.D. Smith. 1978 "Predicting Rainfall Erosion Losses – A Guide to Conservation Planning" USDA Agriculture Handbook 537.

Verma, A, R. Cooke, and L. Wendt. 1996 Mapping Subsurface Drainage Systems With Color Infrared Aerial Photographs, American Water Resources Association Symposium On GIS And Water Resources, Ft. Lauderdale, FL. Sept 22 to 26.

APPENDIX A. LIST OF CONTACTS

Organization	**Contact Name**	**Phone Number**
City of Danville, Public Works	Doug Ahrens	(217)431-2382
Consumers Illinois Water Company	David Cronk	(217)442-3063, ext. 123
Danville NRCS Field Office	Glen O. Franke	(217)442-8511
Illinois State Water Survey	Bill Saylor	(217)333-0447
Illinois State Water Survey	Bill Bogner	(217)333-9546
Louisville District Corps of Engineers	Jamie, receptionist	(502)315-6487
Purdue Extension	Kelly Pearson	(765)762-3231
USGS, Illinois Water Division	Bill Morrow	(217)344-0037
Vermilion County Health Department	Doug Toule	(217)431-2662
Warren County Health Department	Dr. Fred Martin	(765)762-3035
Warren County NRCS	Susan Meadows	(765)762-2443
Univerity of Illinois	Dr. Mike Hirschi	(217)333-9410

APPENDIX B. PHOTOS

APPENDIX B. PHOTOS

Lake Vermilion Dam and Spillway

Water Plant Intake

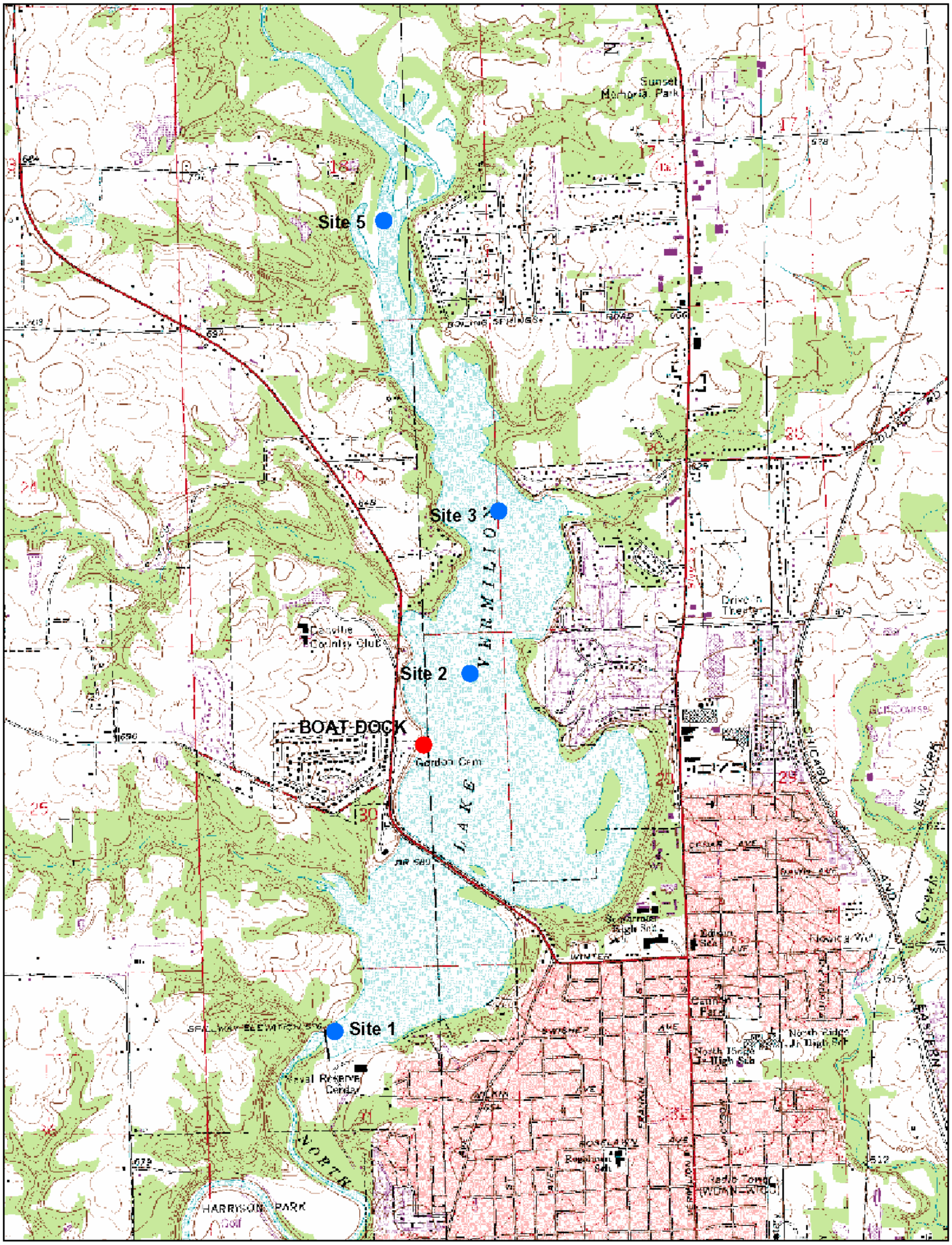
Lake Vermilion Bank Erosion

North Fork Vermilion River near Lake Vermilion

APPENDIX C: WATER QUALITY DATA

(See Appendix A of the Stage 3 Report)

APPENDIX D. WATER QUALITY SITE MAP IN LAKE VERMILION



(Source: IEPA; Site 1,2,3, and 5 stand for RBD-1,-2,-3, and -5)

STAGE 2 – WATER QUALITY SAMPLING REPORT

For TMDLs in North Fork Vermilion River, Salt Fork Vermilion River,
Sugar Creek, and Walnut Point Lake

Final Report

Prepared for

ILLINOIS ENVIRONMENTAL PROTECTION AGENCY
BUREAU OF WATER

Prepared by

TETRA TECH, INC.

February 22, 2007

CONTENTS

1.0 INTRODUCTION

Tetra Tech, Inc (Tetra Tech), has been tasked by the Illinois Environmental Protection Agency (IEPA) to conduct Stage 2 water quality sampling to support the development of total maximum daily loads (TMDL) for the Hoopeston Branch of the North Fork Vermilion River, Salt Fork Vermilion River, Sugar Creek, and Walnut Point Lake watersheds in Champaign, Edgar, Douglas, and Vermilion Counties. This report discusses Stage 2 data collection (Section 2.0), preliminary data analysis of listed impairments (Section 3.0), and recommendations for Stage 3 based on collected water quality data (Section 4.0).

2.0 DATA COLLECTION

This section (1) summarizes data collection activities, including the preparation of the quality assurance project plan (QAPP), identification of sampling sites, field sampling procedures, and laboratory sample analysis; (2) presents a data summary, and (3) discusses problems that occurred.

2.1 QAPP PREPARATION

Tetra Tech prepared a detailed QAPP, including a sampling analysis plan (SAP), for the Stage 2 water quality sampling in September 2005. The QAPP describes sampling objectives, sampling sites, sampling events and frequency, water quality parameters, and field and laboratory procedures and standards. The QAPP, which was approved by IEPA, has been used as a guideline for both field work and laboratory analysis (see Appendix A). After the approval of the initial QAPP, an addendum to the QAPP added four additional sampling locations to the sampling effort in the Salt Fork Vermilion River in March 2006 (see Appendix B).

2.2 SAMPLING SITE IDENTIFICATION

Sampling sites were identified for each watershed based on data needs discussed in the Stage 1 reports and through consultation with IEPA. A total of 15 sites were identified for the Stage 2 sampling effort, four of which were not included in the initial QAPP (see Appendix A). These sites were added in March 2006 as requested by IEPA (see Appendix B). Table 1 summarizes the listed segments, impairment causes, sampling sites, number of events, and field and laboratory parameters. Figures 1 through 4 show the final sampling sites identified in the field. Each site reflects the coordinates and description described in the QAPP or QAPP addendum except BPJ-08, which was relocated to the bridge near the confluence of Salt Fork Vermilion River and Stony Creek (see Figure 2) because of access problems in the field. BPJA-03 was also relocated on Jordan Creek, a tributary to the Salt Fork Vermillion River, because of access problems along the main stream (see Figure 2).

TABLE 1
SUMMARY OF IMPAIRED SEGMENTS, SAMPLING SITES, AND PARAMETERS

Watershed	Water Body	Impairment Cause(s) of Concern	Segment	Sampling Sites	No. of Events	Field Parameters	Laboratory Parameters
North Fork Vermilion River	Hoopeston Branch	DO	BPGD	BPGD-H-A1, BPGD-H-C1	14	pH, conductivity, DO, turbidity, Secchi disk, temperature, flow	TKN, NO_2 + NO_3, TP, TDP, chlorophyll- *a*, BOD5
Salt Fork Vermilion River	Salt Fork Vermillion River	pH, Nitrate	BPJ10	BPJ-10^{a}, BPJ-16^{a}	14	pH, conductivity, DO, turbidity, Secchi disk, temperature, flow	TKN, NO_2 + NO_3, TP, TDP, BOD5, NH_3, TSS
	Salt Fork Vermillion River	pH, Nitrate	BPJ08	BPJ-08	14	pH, conductivity, DO, turbidity, Secchi disk, temperature, flow	TKN, NO_2 + NO_3, TP, TDP, chlorophyll- *a* , BOD5, fecal coliform
	Jordan Creek	Fecal Coliform	Tributary to Salt Fork Vermilion River	BPJA-03^{a}	14	pH, conductivity, DO, turbidity, Secchi disk, temperature, flow	TKN, NO_2 + NO_3, TP, TDP, BOD5, NH_3, TSS, fecal coliform
	Salt Fork Vermillion River	Fecal Coliform	BPJ03	BPJ-03^{a}	14	pH, conductivity, DO, turbidity, Secchi disk, temperature, flow	TKN, NO_2 + NO_3, TP, TDP, BOD5, NH_3, TSS, fecal coliform
	Saline Branch	DO	BPJC08	BPJC-08, BPJC-UC-A2	14	pH, conductivity, DO, turbidity, Secchi disk, temperature, flow	TKN, NO_2 + NO_3, TP, TDP, chlorophyll-*a* , BOD5
	Spoon Branch	DO	BPJD02	BPJD-01, BPJD-02	14	pH, conductivity, DO, turbidity, Secchi disk, temperature, flow	TKN, NO_2 + NO_3, TP, TDP, chlorophyll- *a* , BOD5
Sugar Creek	Sugar Creek	DO	BMC2	BMC-2	14	pH, conductivity, DO, turbidity, Secchi disk, temperature, flow	TKN, NO_2 + NO_3, TP, TDP, chlorophyll- *a* , BOD5
Walnut Point Lake	Walnut Point Lake	TP, DO, NO_3	RBK	RBK-1, RBK-2, RBK-3	14	pH, conductivity, DO, turbidity, Secchi disk, temperature	TKN, NO_2 + NO_3, TP, TDP, chlorophyll- *a*
	Walnut Point Lake	TP, DO, NO_3	BEX1	BEX-1	14	pH, conductivity, DO, turbidity, Secchi disk, temperature, flow	TP and TDP

Notes:

BOD5	5-Day biological oxygen demand	TKN	Total Kjehldahl nitrogen
DO	Dissolved oxygen	TDP	Total dissolved phosphorus
NH_3	Ammonia	TP	Total phosphorus
NO_2	Nitrate	TSS	Total suspended solids
NO_3	Nitrite		
a	Sampling site added in March 2006		

FIGURE 1
HOOPESTON BRANCH SAMPLING SITES

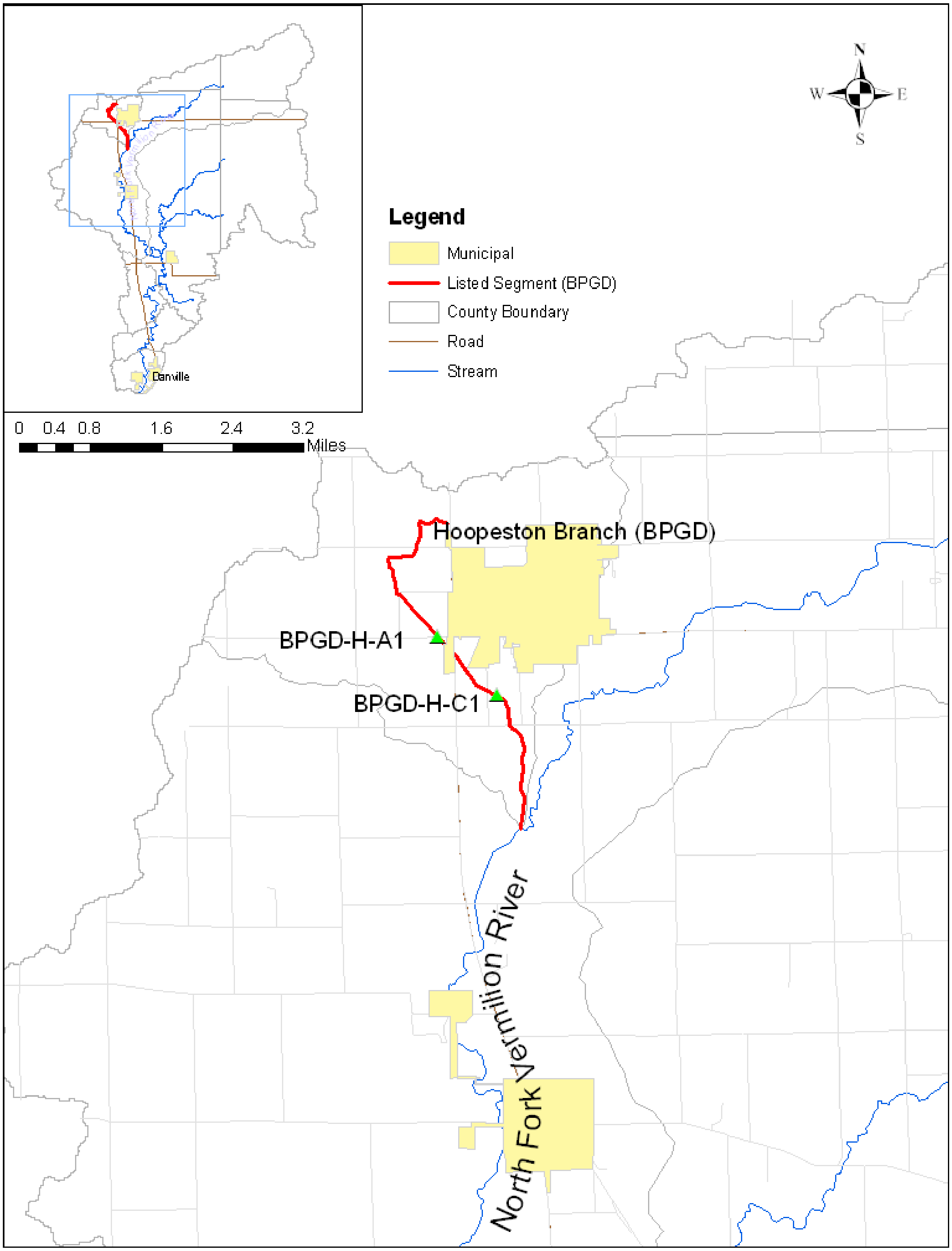


FIGURE 2
SALT FORK VERMILION RIVER AND TRIBUTARY SAMPLING SITES

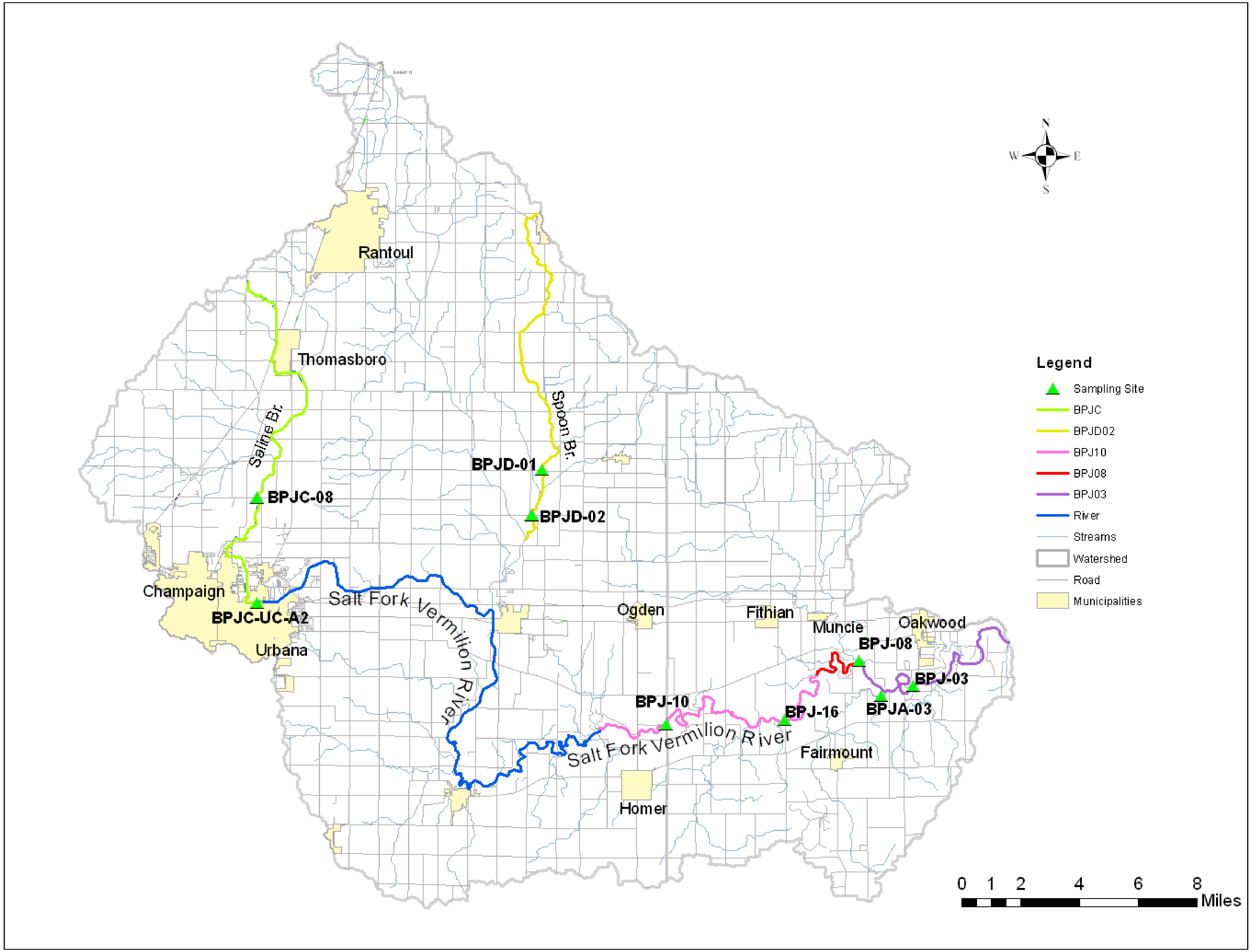


FIGURE 3
SUGAR CREEK SAMPLING SITE

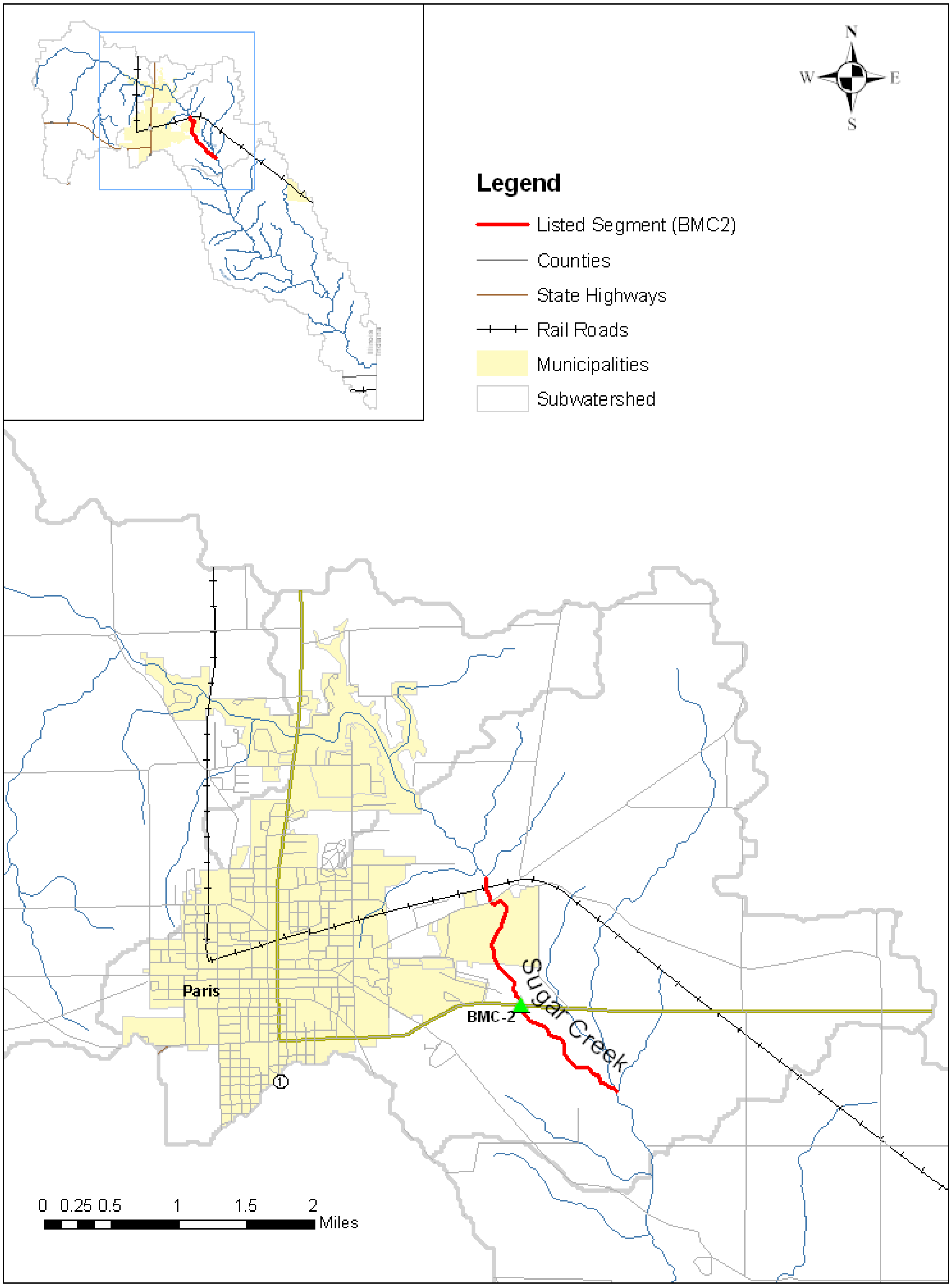
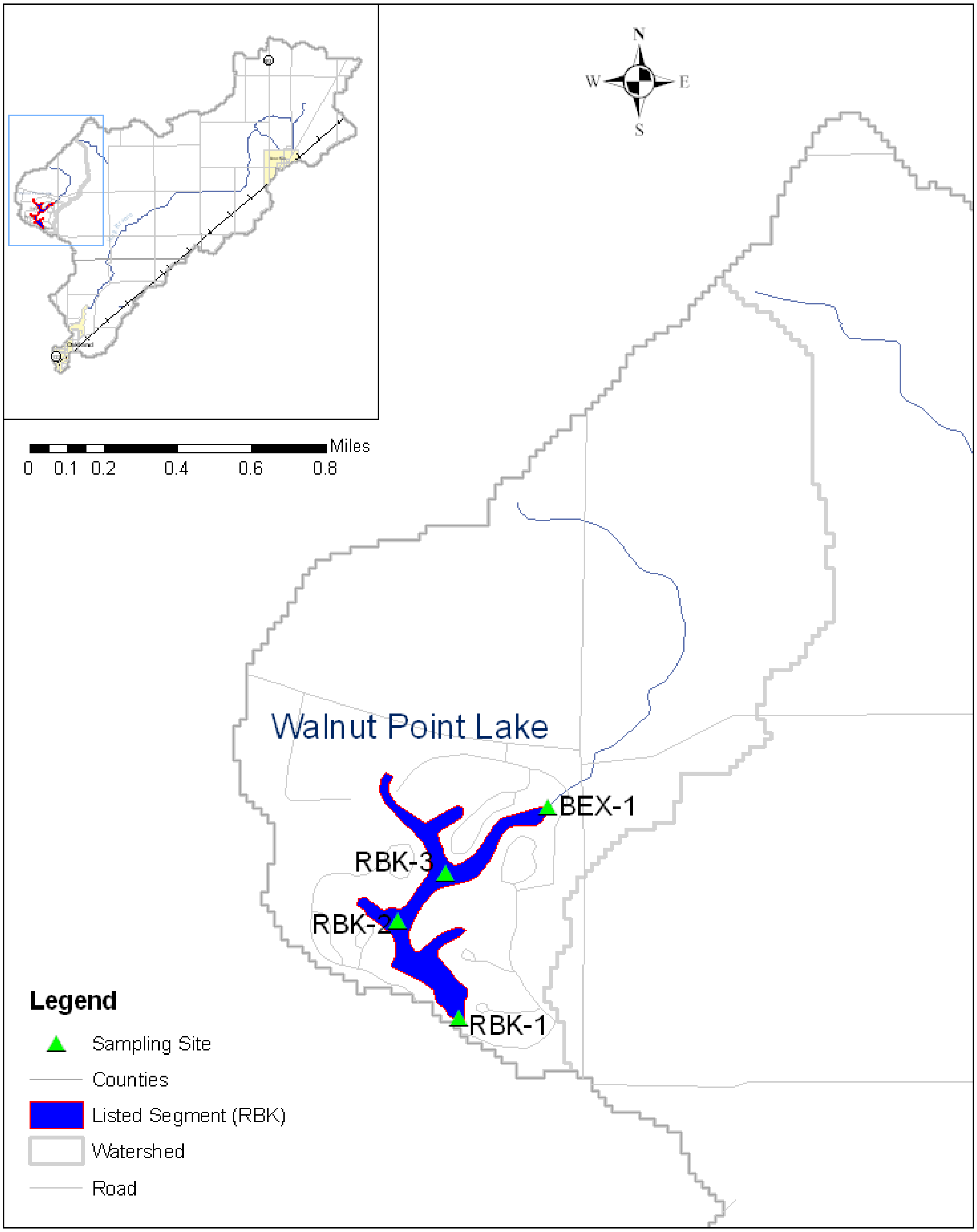


FIGURE 4
WALNUT POINT LAKE SAMPLING SITES



2.3 FIELD SAMPLING PROCEDURES

Water quality sampling was conducted from October 6 through November 1, 2005; resumed on April 11, 2006; and ended on October 27, 2006. Sampling at BPJ-10, BPJ-16, BPJA-03, and BPJ-03 began on April 11, 2006. The samples were collected from each site twice a month, generally 2 weeks apart. The first sampling event approximately occurred during the second week of the month, and the second sampling event occurred during the fourth week of the month.

During each sampling event, two to three field technicians and environmental scientists conducted field measurements and collected grab samples. The staff was required to be familiar with the QAPP and follow the sampling protocol. The sampling usually began in early morning and ended during mid-afternoon to allow enough time to deliver the samples to the laboratory. For each sampling event, field staff implemented standard procedures (as described in QAPP) for field sampling, chain of custody, laboratory analysis, and data reporting to produce well-documented data of known quality. The field staff maintained detailed logbooks and chain-of-custody forms that contain all information pertaining to sample collection. Information recorded for each sample included sample identification number, location (including latitude and longitude), sampling depth, date, time, sampler, and sample matrix.

Duplicate field quality control (QC) samples (one every other sampling event) were collected for laboratory analysis to check sampling and analytical precision, accuracy, and representativeness. Field duplicate samples are independent samples collected as close as possible in space and time to the original investigative sample. Field duplicate samples were collected immediately after collection of the original sample using the same collection method.

At each sampling site within a river or stream, water quality measurements for pH, temperature, dissolved oxygen (DO), conductivity, and turbidity were taken using a Horiba U-10 water quality meter; flow measurements (as field conditions allowed) were recorded using a flow meter; and Secchi depth was recorded using a Secchi disk. Water quality readings were recorded near both banks and in the center of each river or stream.

After water quality readings were taken, composite samples from the three water quality measurement reading locations were collected at the water surface. For samples collected in the streams, laboratory analysis included total Kjehldahl nitrogen (TKN), nitrates + nitrites ($NO_2 + NO_3$), total phosphorus (TP), total dissolved phosphorus (TDP), chlorophyll-*a*, and 5-day biological oxygen demand (BOD5). In addition, the samples from BPJ-08, BPJA-03, and BPJ-03 were delivered to the IEPA laboratory in Champaign for total fecal coliform analysis.

In Walnut Point Lake, water quality readings and samples for laboratory analysis were collected from three different depths at each of the three sampling locations so that the vertical profile of the water column could be characterized during Stage 3. At each location, the water depth was recorded. One sampling depth was just above the bottom of the lake, one was between the bottom of the lake and the surface, and one was near the surface. One Secchi disk reading was collected at each sampling location, and conductivity, pH, DO, turbidity, and temperature readings were collected at all three depths at each location. Samples for laboratory analysis were also collected at all three depths at each sampling location and analyzed for TKN, $NO_2 + NO_3$, TP, TDP, and chlorophyll-*a*. In addition, one sediment sample was collected using an Eckman dredge from the deepest sampling location and sent to the laboratory for TP and TDP analysis. One water sample was collected from a tributary to Walnut Point Lake during the first sampling event and analyzed for the same water quality parameters as for the other streams sampled; however, the water sample collected for laboratory analysis was analyzed for TP and TDP only as recommended in the Stage 1 report.

Each sampling event was photologged (see Appendix C). After sampling was completed at each location, the sampling location was recorded using global positioning system (GPS).

All samples were packed in coolers on ice immediately after collection from water and hand-delivered to Severn Trent Laboratory (STL) in University Park, Illinois, at the end of each sampling event. STL provided sample analytical results in the form of a Level II data package within a 2-week turnaround time. The Level II data package is provided in Appendix D in an Excel data file in an Illinois EPA water quality data submittal format.

2.4 LABORATORY SAMPLE ANALYSIS

STL was subcontracted to conduct all the laboratory analysis except the total fecal coliform analysis, which was conducted by the IEPA laboratory. The laboratories followed their internal QA procedures and any additional QA procedures specific to the analytical methods. All laboratory internal QC checks were conducted in accordance with the laboratories' QA manuals and SOPs and in accordance with the requirements of the QAPP.

During the sampling period, 160 samples were submitted for laboratory analysis, plus QC/quality assurance (QA) samples. A total of 168 water samples collected from rivers and streams were submitted for TKN, NO_2 + NO_3, TP, TDP, chlorophyll-*a*, and BOD5 analysis. In addition, 126 samples collected from Walnut Point Lake were submitted for TKN, NO_2 + NO_3, TP, TDP, and chlorophyll-*a* analysis. Seven water samples were collected from the tributary to Walnut Point Lake and submitted for TP and TDP analysis, and fourteen sediment samples collected from Walnut Point Lake were submitted for TP and total organic carbon (TOC) analysis. Seven duplicate samples and seven matrix spike duplicates were submitted for TKN, NO_2 + NO_3, TP, TDP, chlorophyll-*a*, and BOD5 analysis. The following methods were used by the laboratory to conduct these analyses:

- TKN – Method E 351.3; A 4500NorgC
- NO_2 + NO_3 – Method E 353.2; A 4500NO3F
- TP – Method E 365.2; A 4500PE
- TDP (ortho) – Method E 365.2; A 4500PE
- Chlorophyll-*a* – Method 10200H
- BOD5 – Method E 405.1; A 5210B
- TP (sediment) – A 4500PB4E; E 365.2M
- TOC – TOC analysis
- TSS – EPA Method 160.2
- NH_3 –EPA Method 350.2

In addition, fecal coliform was added to the laboratory analysis for samples collected from BPJ-08 so that the results at BPJ-08 and BPJA-03 can be used to characterize the fecal coliform concentration in the upstream of segment BPJ-03.

2.5 DATA SUMMARY

Tetra Tech received the data report from STL in both electronic and hard-copy formats. The data were checked for quality and accuracy and then formatted in an Excel spreadsheet for reporting. Appendix D presents the Excel spreadsheet of water quality data results for the Stage 2 sampling. The spreadsheet includes a total of 3,263 data points for various water quality parameters, including both field measurements and laboratory results.

2.6 PROBLEMS

During the shipment of samples collected on October 31, 2005, for chlorophyll-*a* analysis from STL in University Park, Illinois, to Pensacola, Florida, three water samples (RBK-1-Bottom, RBK-3-Bottom, and BPJC-08) were damaged and could not be analyzed by the laboratory.

In addition, the samples from RBK-1 collected from a 26-foot depth on October 31, 2005, and RBK-2 collected from an 11-foot depth on October 7, 2005, contained higher TDP concentrations than TP concentrations. This situation is attributed to the detection error of the standard analysis approach. During Stage 3, these data points should not be used.

3.0 DATA ANALYSIS

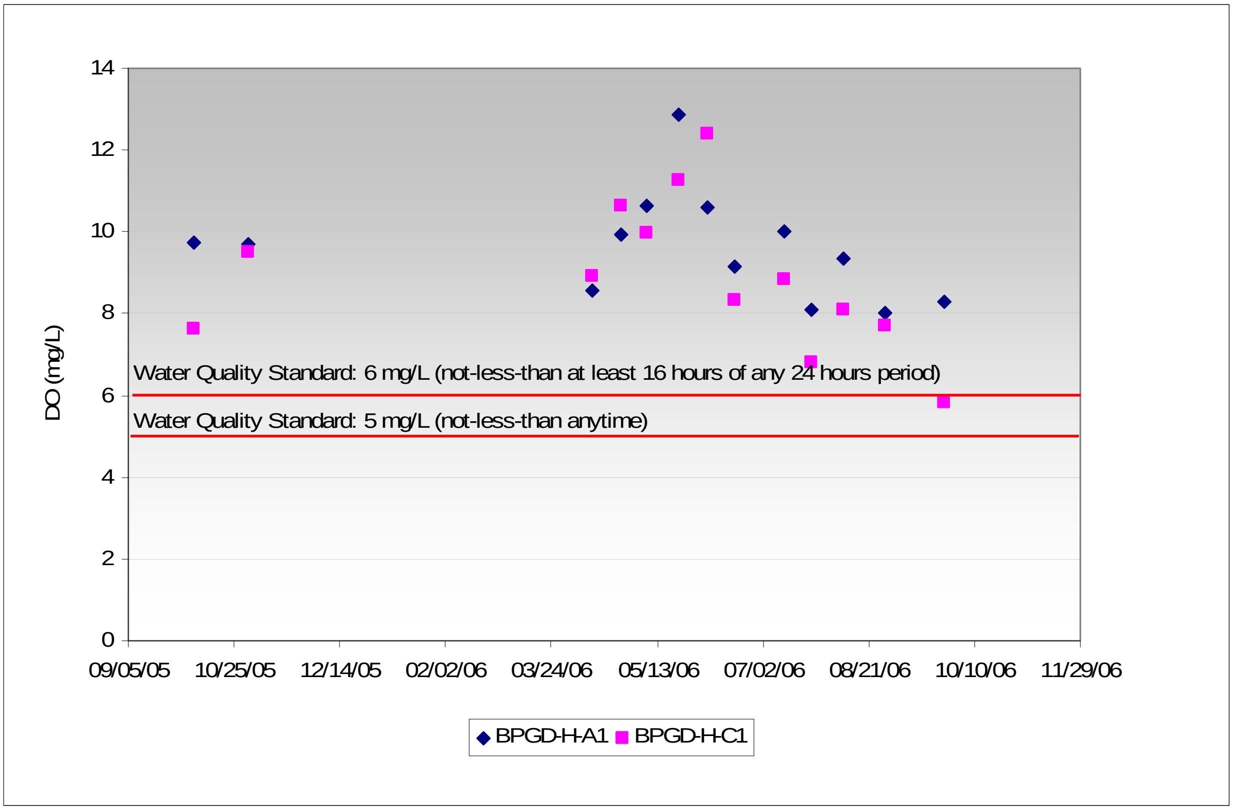
This section discusses the preliminary data analysis for each water body sampled, with a focus on the listed impairments.

3.1 HOOPESTON BRANCH IN NORTH FORK VERMILION RIVER

Sampling sites BPGD-H-A1 and BPGD-H-C1 are located on the Hoopeston Branch of North Fork Vermilion River. BPGD-H-A1 is located upstream of the confluence of the Hoopeston Sewage Treatment Plant (STP) outfall ditch with the stream, and BPGD-H-C1 is located downstream from this confluence. BOD and DO data collected from these two locations were analyzed. A detection limit of 2 milligrams per liter (mg/L) was used for data points when the BOD concentration was below the detect limit.

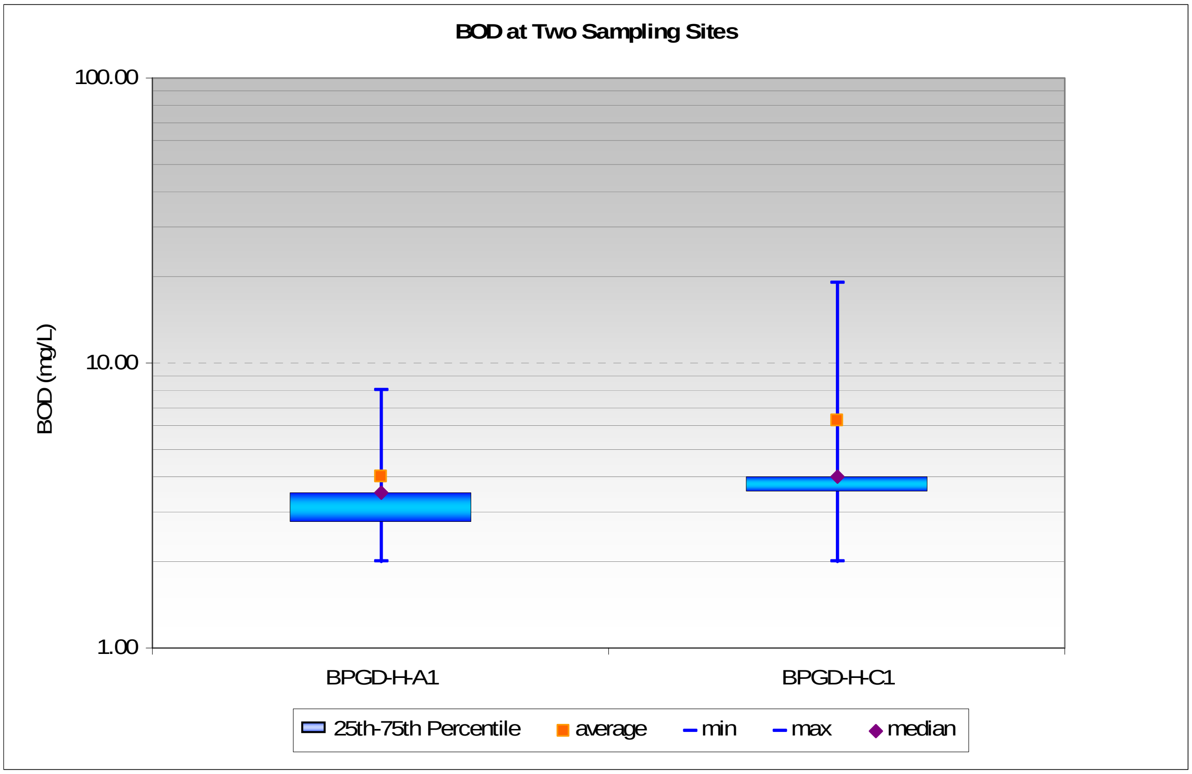
Figure 5 compares the DO measurements at the two sites during the sampling period. All data points met the DO standard of not-less-than 5.0 mg/L at any time. It is evident that BPGD-H-A1 contained higher average DO concentrations than BPGD-H-C1.

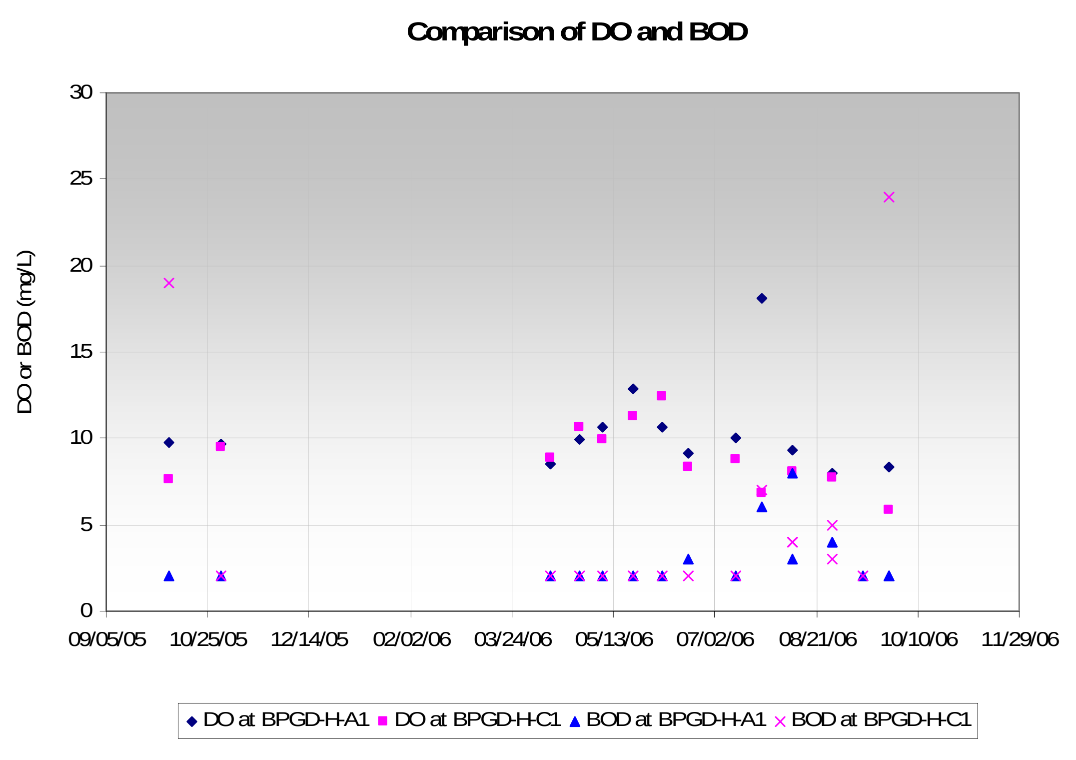
FIGURE 5
DO CONCENTRATIONS IN HOOPESTON BRANCH



A total of 15 BOD data points (data points below the detective limit were removed) were analyzed for the two sites in Hoopeston Branch. The measured BOD values ranged from 2 to 19 mg/L. For most of the sampling period, BOD concentrations were below 8 mg/L, with highest of 19 mg/L observed in October. In general, BOD concentrations in BPGD-H-C1 were relatively higher than those at BPGD-H-A1, a situation potentially attributable to effluent from the Hoopeston STP (see Figure 6). The comparison of BOD and DO data points in Figure 6 indicates a noticeable correlation between BOD and DO data. Increased BOD concentrations decrease DO concentrations in Hoopeston Branch as shown by the data points for August and September in Figure 6.

FIGURE 6
BOD CONCENTRATIONS IN HOOPESTON BRANCH

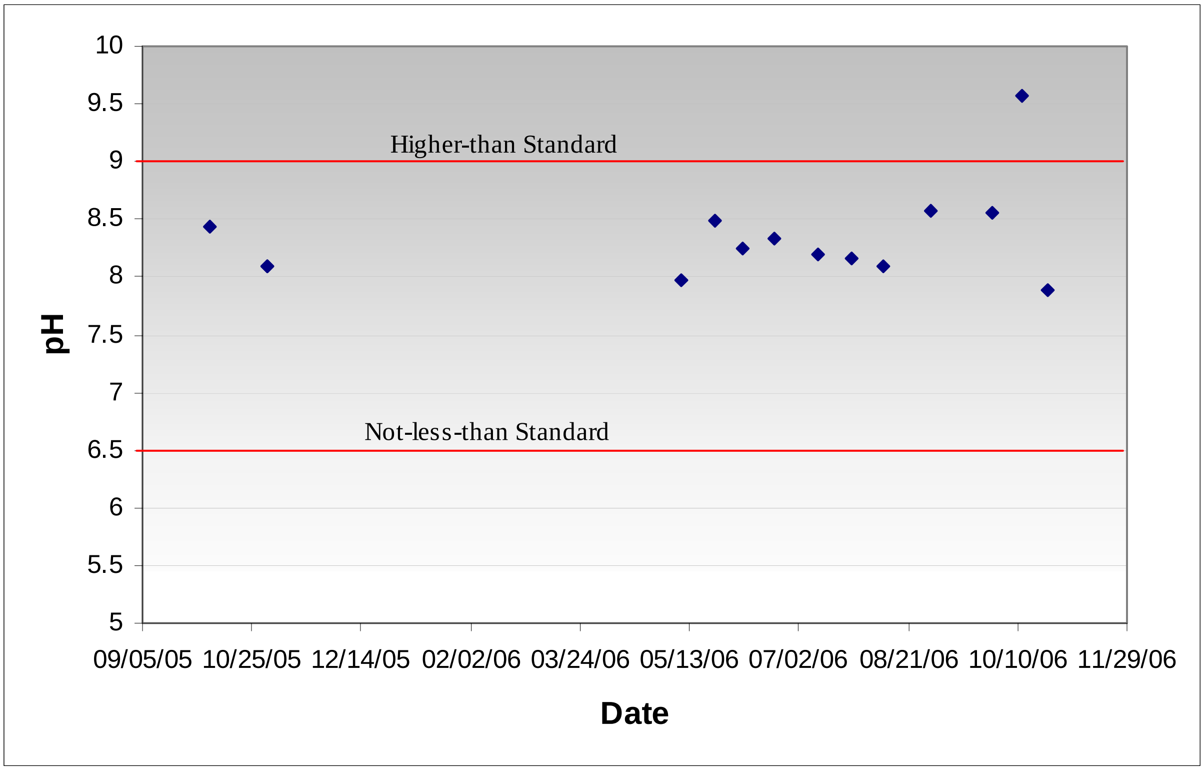




3.2 SALT FORK VERMILION RIVER

pH data were recorded at sampling site BPJ-08 between October 2005 and October 2006. A total of 14 measurements were taken at this sampling station and only 1 exceeded the pH water quality standard of 9 (see Figure 7). At BPJ-08, pH values ranged from 7.88 to 9.57, with an average value of 8.34. A pattern is not apparent over the period of time that measurements were taken.

FIGURE 7
pH AT BPJ-08 IN SALT FORK VERMILLION RIVER



pH data were also recorded at sampling sites BPJ-10 and BPJ-16 between May and October of 2006. A total of 11 measurements were taken at BPJ-10 and one of the measurements exceeded the pH water quality standard of 9 (see Figure 8). At BPJ-10, pH values ranged from 7.85 to 9.90, with an average value of 8.40. A total of 10 measurements were taken at BPJ-16 and one value barely exceeded the pH water quality standard of 9 (see Figure 9). At BPJ-16, pH values ranged from 7.53 to 9.05, with an average value of 8.30.

FIGURE 8
pH AT BPJ-10 IN SALT FORK VERMILLION RIVER

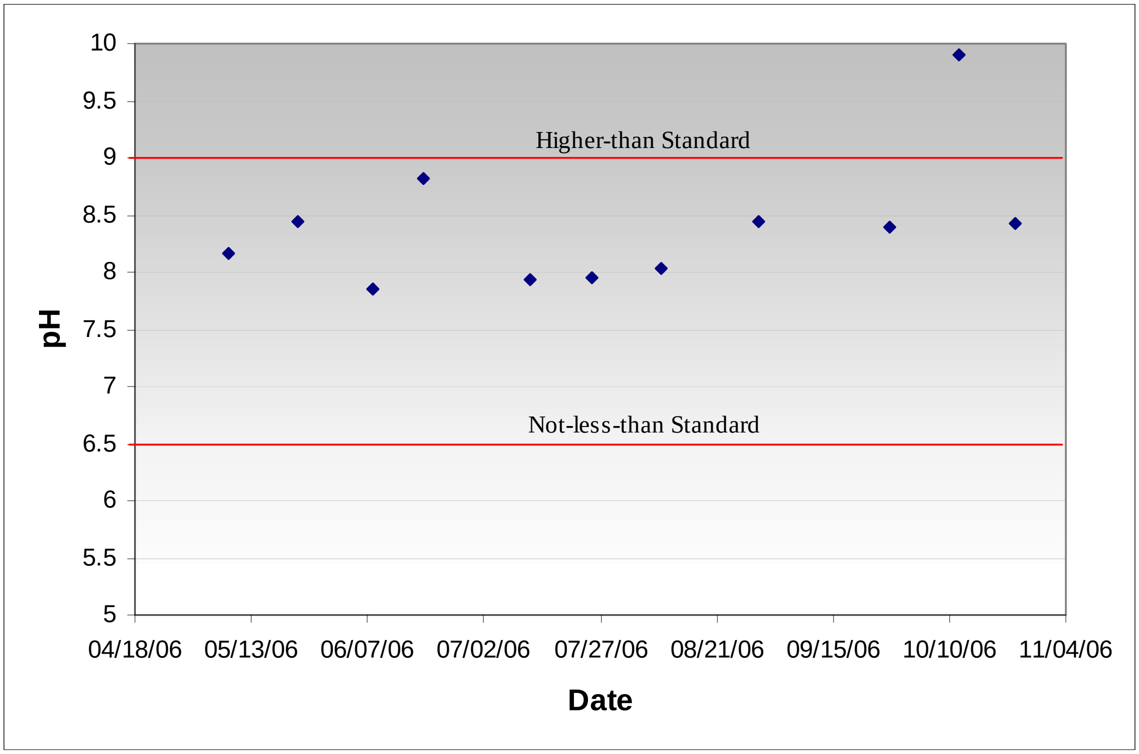
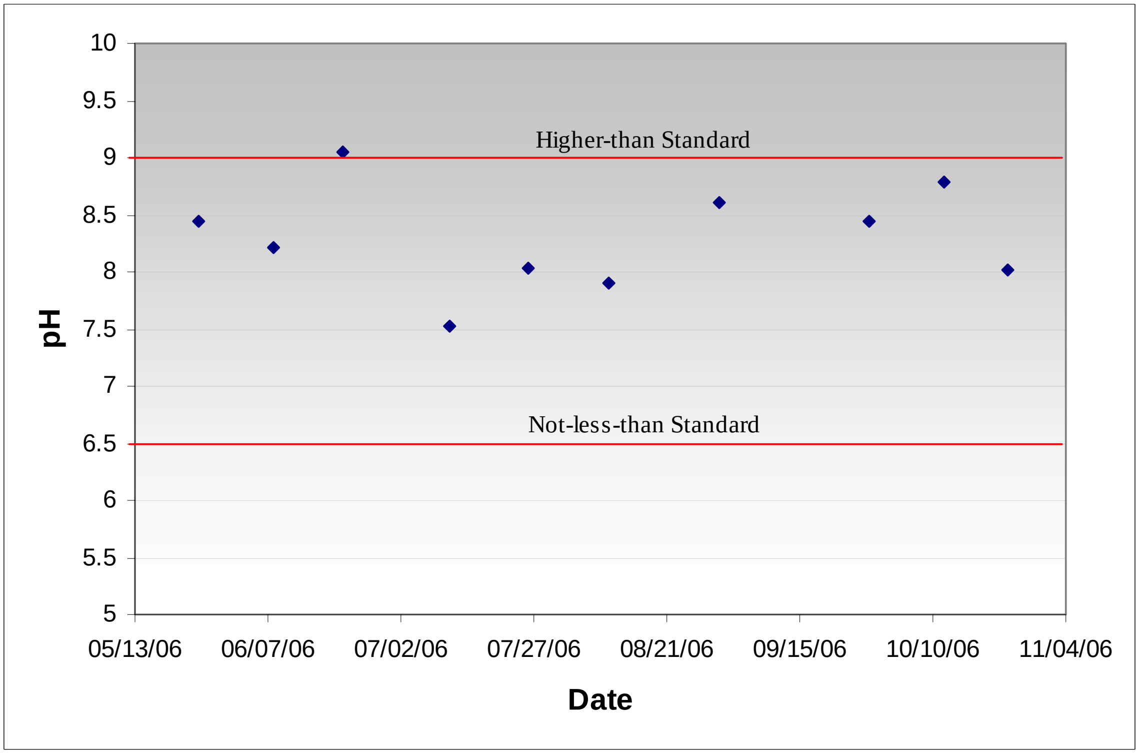
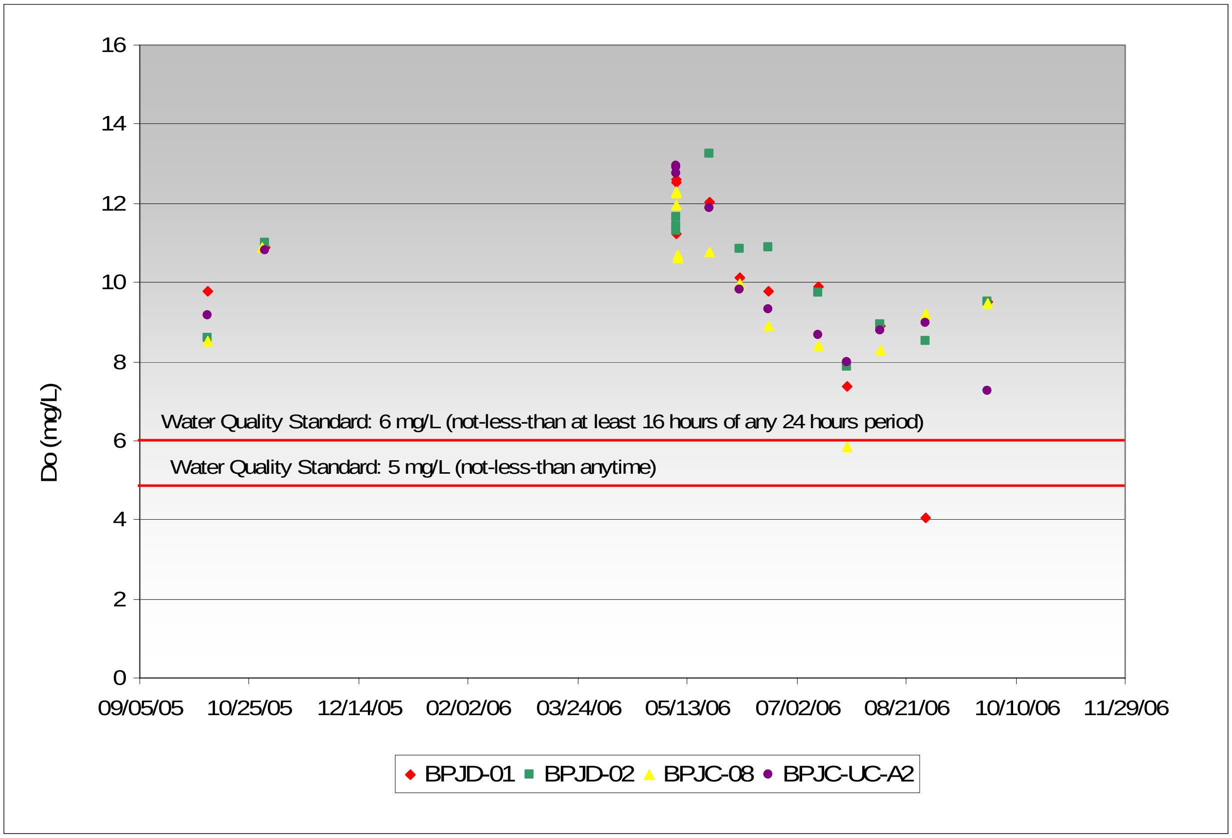


FIGURE 9
pH AT BPJ-16 IN SALT FORK VERMILLION RIVER



DO data from BPJD-01, BPJD-02, BPJC-08, and BPJC-UC-A2 were analyzed. A total of 54 DO measurements were taken, and only one collected from BPJD-01 fell below the water quality standard of 6 mg/L (see Figure 10). DO measurements at all four sites were similar, with averages ranging from 9.87 to 10.27 mg/L. DO levels are higher in the spring and decrease as the year progresses.

FIGURE 10
DO CONCENTRATIONS AT SEGMENTS BPJC-08 AND BPJD-02
IN SALT FORK VERMILLION RIVER



Fecal coliform data were collected between May and October 2006 from BPJ-03, BPJ-08, and BPJA-03. A total of 36 measurements were taken, and 19 exceeded the water quality standard of 200 colony-forming units per 100 milliliters (cfu/100 mL) (see Figure 11). The geometric mean of fecal coliform concentrations exceeded the water quality standard at all three sites. The fecal coliform concentrations at the upstream side of segment BPJ-03 (as shown by combining BPJ-08 and BPJA-03 data) are similar to those at the downstream end (as shown by BPJ-03 data). The elevated fecal coliform concentrations mostly occurred in July and August (see Figure 12).

FIGURE 11
FECAL COLIFORM CONCENTRATIONS AT BPJ-03, BPJ-08, AND BPJA-03 IN SALT FORK VERMILLION RIVER

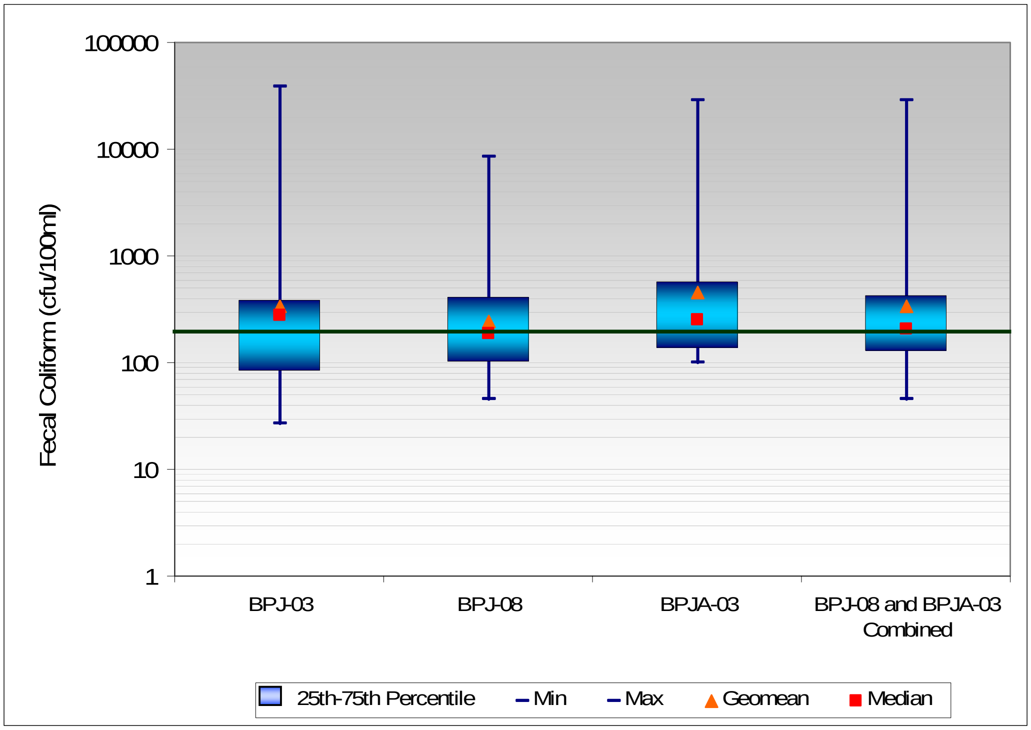
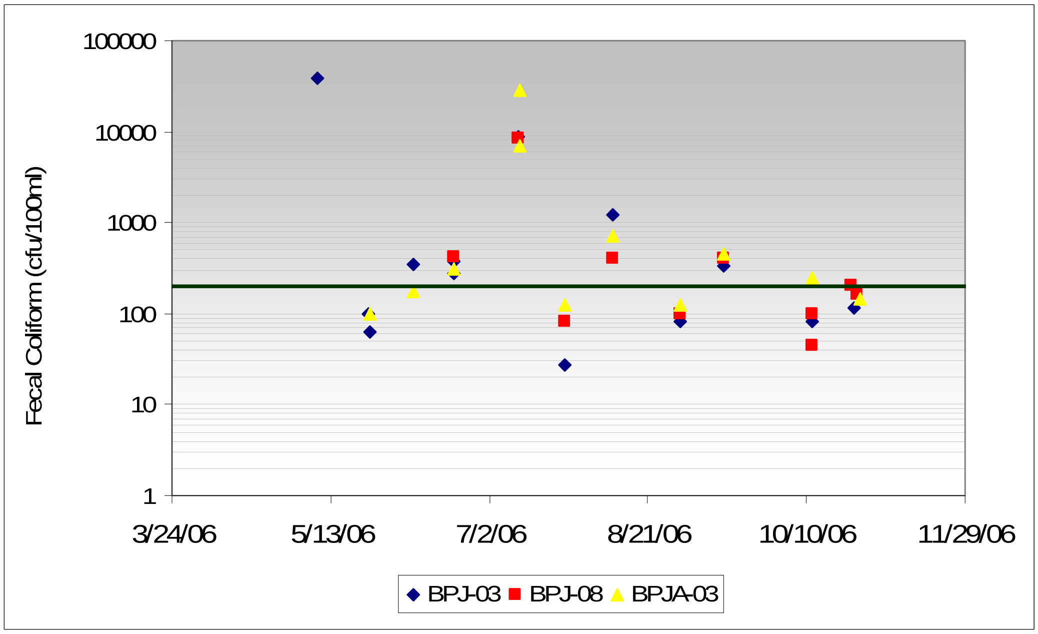


FIGURE 12
MONTHLY VARIATIONS IN FECAL COLIFORM CONCENTRATIONS AT BPJ-03, BPJ-08, AND BPJA-03 IN SALT FORK VERMILLION RIVER



3.3 SUGAR CREEK

The bi-weekly DO data collected from Sugar Creek during the sampling period never violated the IEPA DO standard of not less than 5 mg/L at any time. A total of 15 measurements were taken that ranged from 7.48 to 12.92 mg/L (see Figure 13). DO concentrations were highest in May and gradually decreased with time after May. The IEPA surface water section independently conducted continuous DO sampling every 30 minutes in July and September 2006, and data indicate that DO concentrations violated the standard of no less than 5 mg/L DO at any time (see Figure 14). In addition, the DO concentrations violated the standard of not less than 6 mg/L for at least 16 hours out of a 24-hour period.

FIGURE 13
DO CONCENTRATIONS IN SUGAR CREEK

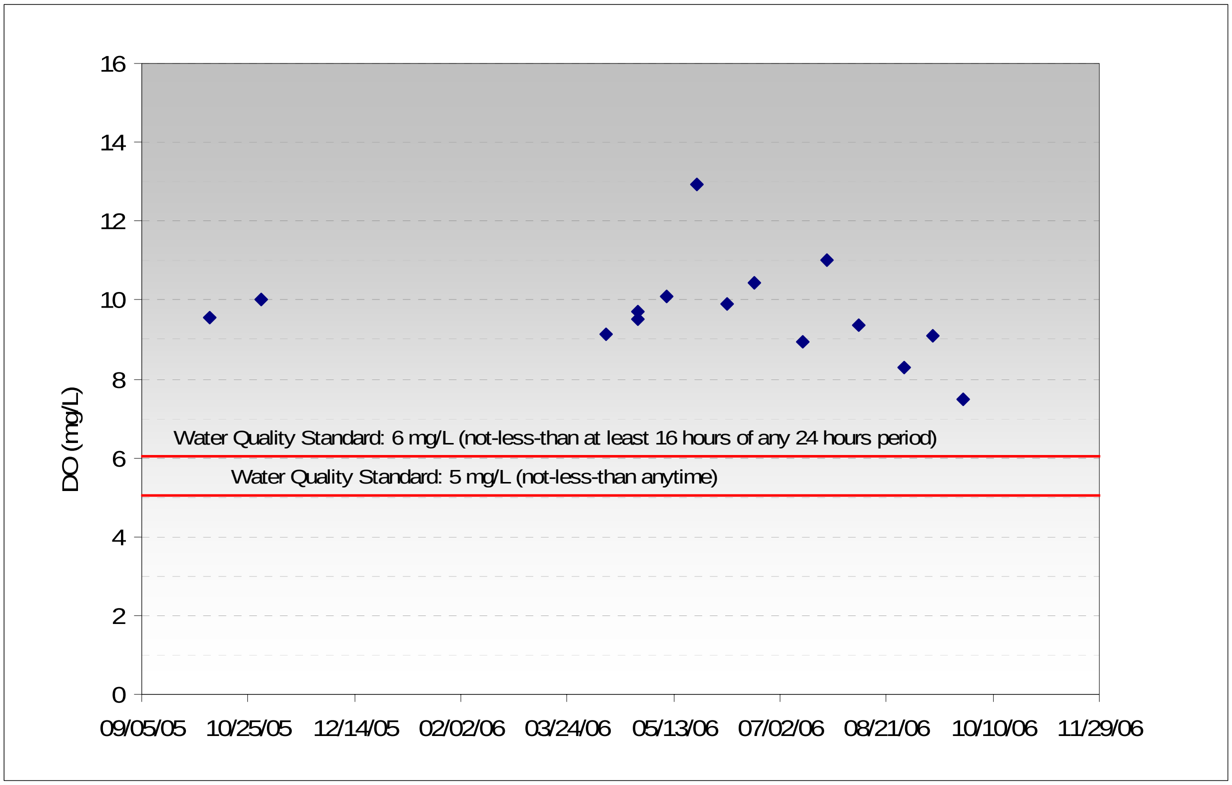
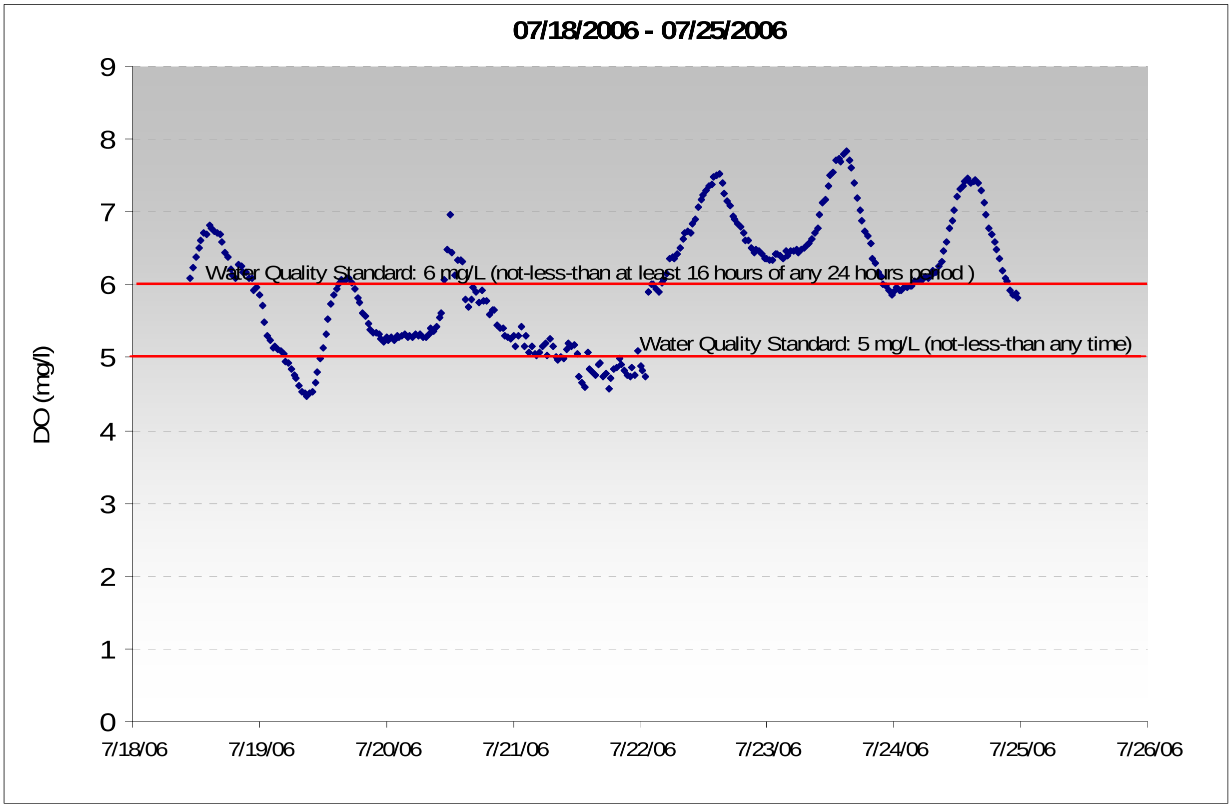
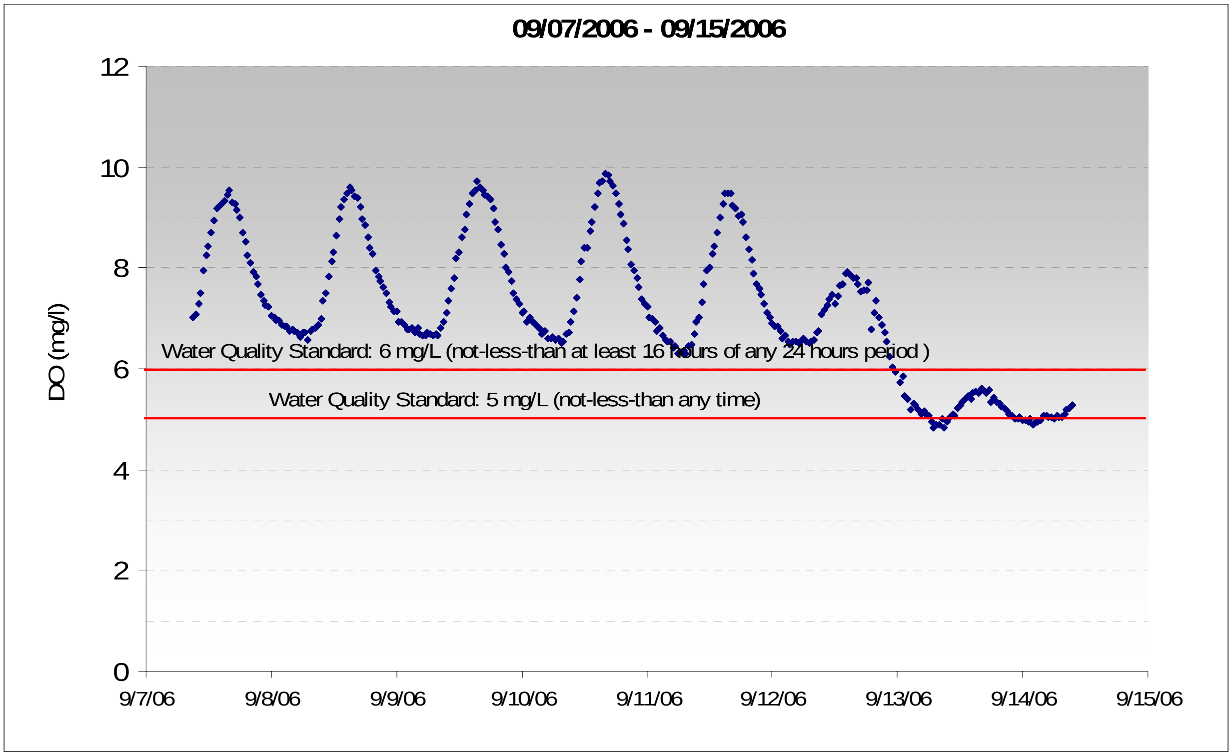


FIGURE 14
CONTINUOUS DO CONCENTRATIONS IN SUGAR CREEK
(Collected by IEPA)





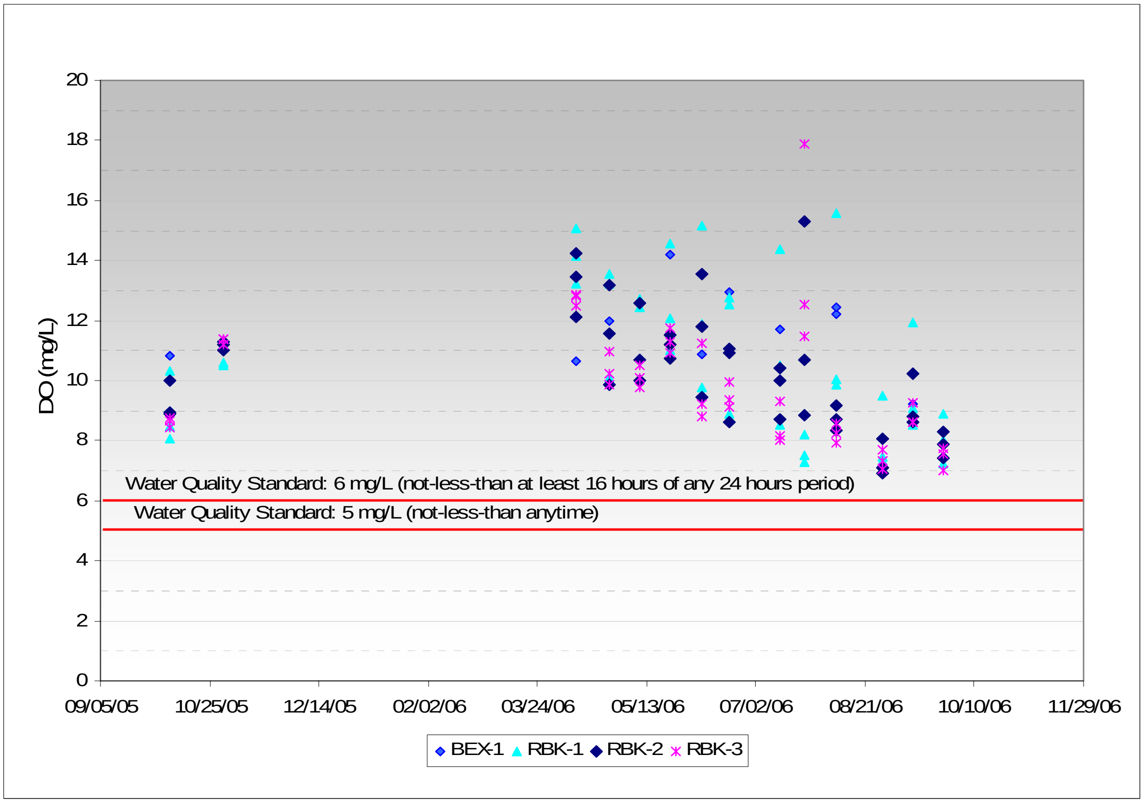
3.4 WALNUT POINT LAKE

Walnut Point Lake has four sampling sites: BEX-1, RBK-1, RBK-2, and RBK-3. BEX-1 is located at the inflow point from a tributary to the north end of the lake. The flow path starts from BEX-1 to RBK-3, RBK-2, and finally RBK-1 which is located near the dam at the southern end of the lake. DO, TP, NO_2 + NO_3, and chlorophyll-*a* measurements were analyzed to characterize the water quality in the lake as discussed below.

DO

A total of 96 DO data points were collected from BEX-1, RBK-1, RBK-2, and RBK-3 during the sampling period. The average and minimum DO concentrations at all four locations exceeded the water quality standard of not less than 6.0 mg/L (see Figure 15). The average DO concentration at the tributary (12 mg/L) appears higher than concentrations in the lake. In general, DO concentrations are stable in the lake and gradually decrease in August and September. DO concentrations are measured 1 foot below the water surface, 2 feet above the lake bottom, and at a middle point. Figure 15 shows data from all three depths.

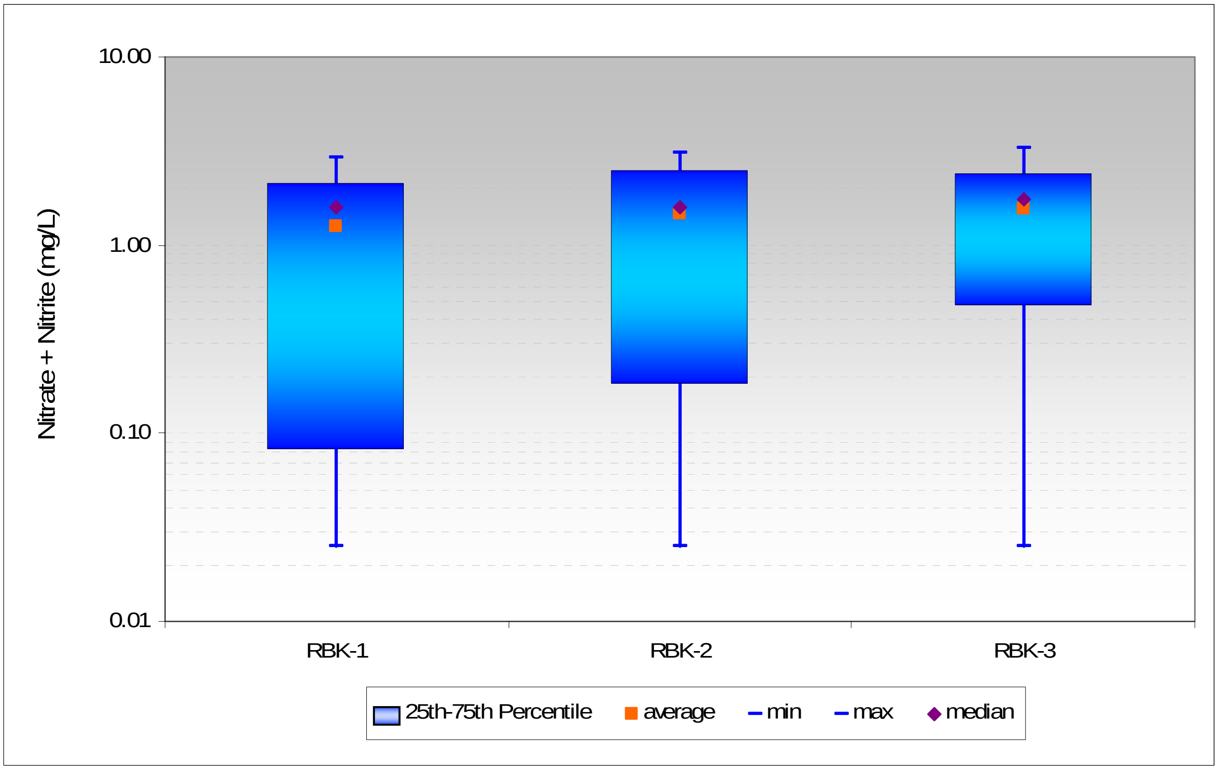
FIGURE 15
DO CONCENTRATIONS IN WALNUT POINT LAKE



$NO_2 + NO_3$

A total of 70 $NO_2 + NO_3$ data points were collected from RBK-1, RBK-2, and RBK-3 during the sampling period. Concentrations at all three locations are below the IEPA water quality standard of 10 mg/L (see Figure 16). The data range from a minimum concentration of 0.03 mg/L to a maximum concentration of 3.30 mg/L at RBK-3. The average total nitrogen concentration is highest at RBK-3 and lowest at RBK-1. A high range of the 25th to 75th quartile at RBK-1 indicates a diverse range of total nitrogen values.

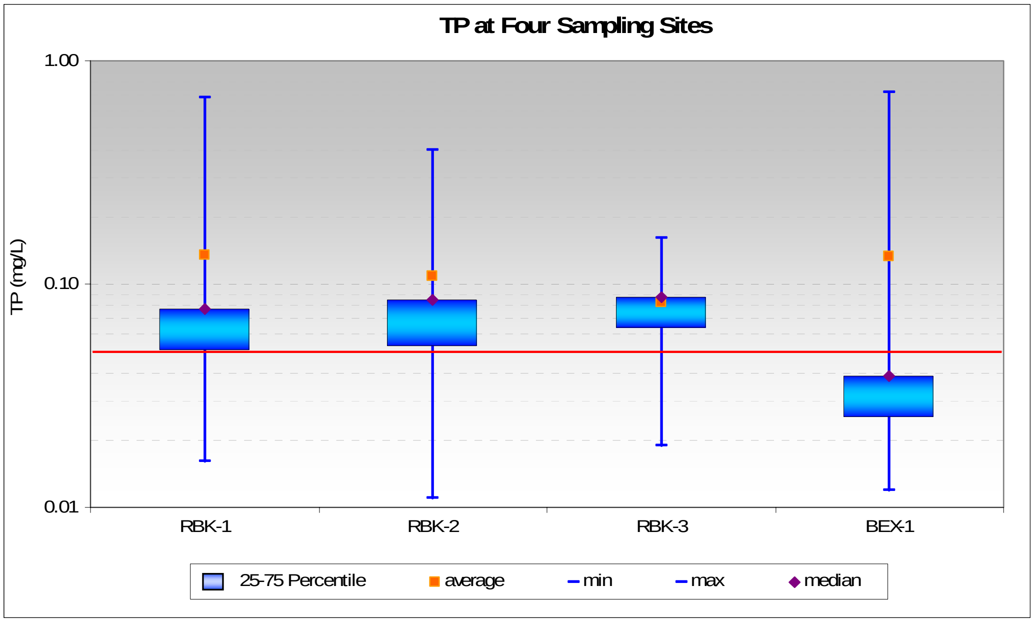
FIGURE 16
$NO_2 + NO_3$ CONCENTRATIONS IN WALNUT POINT LAKE



TP

A total of 139 TP data points were collected from all four location Walnut Point Lake sites (RBK-1, RBK-2, RBK-3, and BEX-1). TP values ranged from 0.01 to 0.72 mg/L (see Figure 17). The average TP concentrations at all sites exceeded the IEPA water quality standard of 0.05 mg/L. High concentrations were detected at BEX-1 and RBK-1. Out of the 139 total data points, 106 (76 percent) violated the standard. These low values were mostly seen from April through July. The 25th to 75th quartile of TP concentrations at BEX-1 is below the average concentration, indicating that most values are below the water quality standard. TP concentrations are measured at 1 foot below the water surface, 2 feet above the lake bottom, and at a middle point. The second graph in Figure 17 indicates lower average concentrations at the surface and gradually increasing concentrations with an increase in depth. High concentrations at the bottom indicate historic TP accumulation at RBK-1.

FIGURE 17
TP CONCENTRATIONS IN WALNUT POINT LAKE



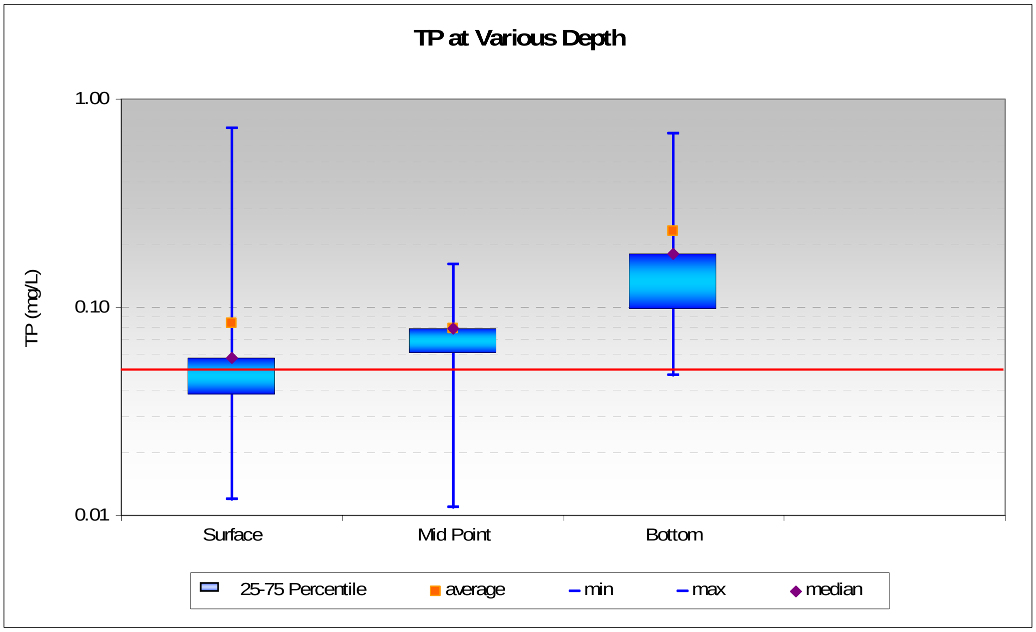
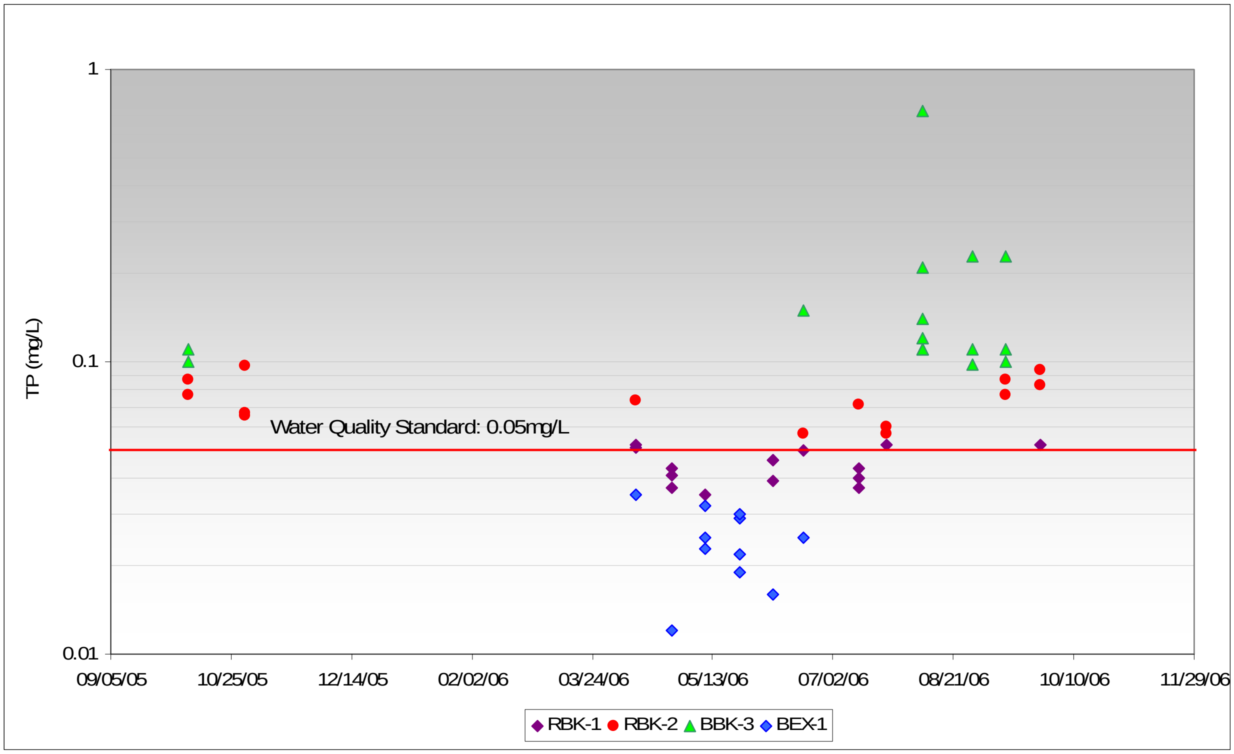


Figure 18 presents the TP data points for 1 foot below the water surface in Walnut Point Lake at all four sampling sites. Out of the 55 data points, 34 violated the 0.05-mg/L standard. The highest TP concentrations occurred in August and September.

FIGURE 18
SCATTER PLOT OF TP CONCENTRATIONS WITHIN 1 FOOT OF WATER SURFACE IN WALNUT POINT LAKE



Chlorophyll-*a*

A total of 111 chlorophyll-*a* measurements were taken at RBK-1, RBK-2, and RBK-3. The minimum concentration of 0.53 milligrams per cubic meter (mg/m^3) was detected at RBK-1, and the maximum concentration of 170 mg/m^3 was detected at RBK-3 (see Figure 19). The average concentration ranges from 21.27 to 29.74 mg/m^3. The chlorophyll-*a* concentration at RBK-3 varied from 0.8 to 170 mg/m^3. Higher chlorophyll-*a* concentrations were detected at the surface and gradually decreased with depth. The elevated chlorophyll-*a* concentrations are apparently closely related to high TP concentrations (see Figure 20).

FIGURE 19
CHLOROPHYLL-*a* CONCENTRATIONS IN WALNUT POINT LAKE

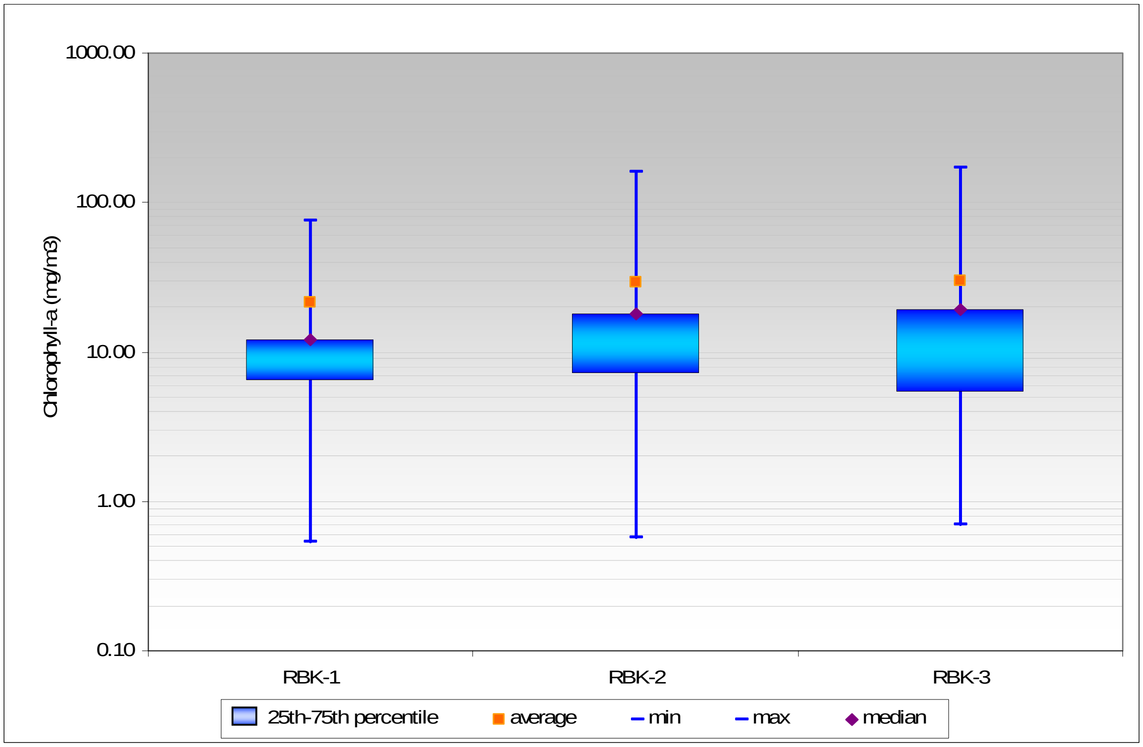
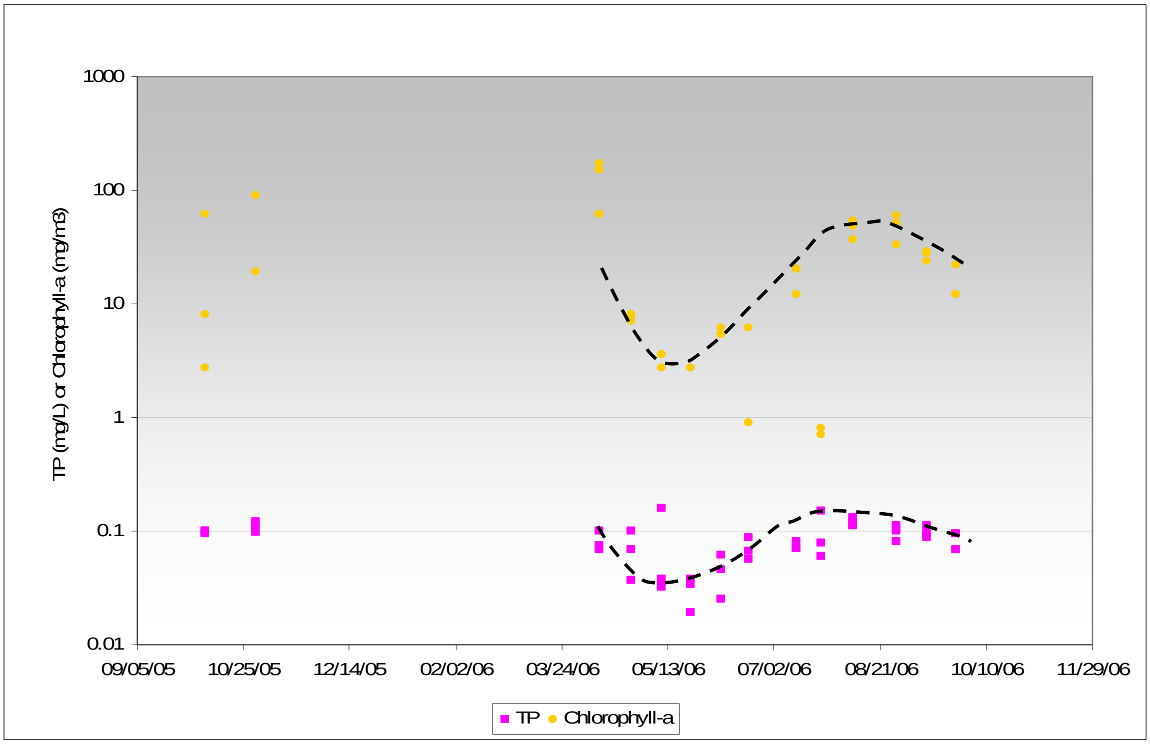


FIGURE 20
TP AND CHLOROPHYLL-*a* CONCENTRATIONS AT RBK-3
IN WALNUT POINT LAKE



4.0 RECOMMENDATIONS

Based on the data analysis, the recommendations below should be considered.

NORTH FORK VERMILLION RIVER WATERSHED

- Segment BPGD (Hoopeston Branch): Previously, the BPGD segment was assessed based on 2002 facility-related stream survey (FRSS) data, when a DO concentration of 4.7 mg/L was recorded, which violated the standard of not less than 5 mg/L at any time. This standard was never violated based on Stage 2 sampling data. It is recommended that DO be delisted from 2006 303(d) list.

SALT FORK VERMILION RIVER WATERSHED

- Segment BPJ10 (Salt Fork Vermilion River): It is recommended that the segment be listed for pH impairment because two violations of the pH water quality standard of no more than 9 were recorded during the sampling period. These violations occurred on October 12, 2006 with a pH value of 9.90 and June 21, 2006 with a pH value of 9.05. In addition, BPJ10 should also be listed for nitrate impairment because eight violations were recorded during the sampling period.

- Segment BPJ08 (Salt Fork Vermilion River): It is recommended that the segment be listed for pH impairment because one violation of the pH water quality standard of no more than 9 was recorded during the sampling period. The violation occurred on October 12, 2006 with a pH value of 9.57. It is also recommended that BPJ08 be listed for nitrates because three violations were recorded during the sampling period. In addition, BPJ08 should also be listed for fecal coliform impairment.

- Segment BPJ03 (Salt Fork Vermilion River and Jordan Creek): It is recommended that the segment be listed for fecal coliform impairment because 6 violations on Jordan Creek and 7 violations on Salt Fork Vermilion River of fecal coliform water quality standard of 200 colony-forming units per 100 milliliters (cfu/100 mL) were recorded during the sampling period.

- Segment BPJC08 (Saline Brach): The DO standard of not less than 5 mg/L at any time was not violated based on Stage 2 sampling data. It is recommended that the segment be delisted for DO impairment.

- Segment BPJD02 (Spoon Branch): One DO data point, 4.04 mg/L on August 30, 2006, was below the IEPA standard of no less than 5 mg/L at any time. It is recommended that a DO TMDL be developed for the segment.

SUGAR CREEK WATERSHED

- Segment BMC2: Based on DO data that violated the IEPA standard of no less than 5 mg/L at any time, it is recommended that a DO TMDL be developed for the segment.

WALNUT POINT LAKE WATERSHED

- Segment RBK: It is recommended that Walnut Point Lake be delisted for low DO impairment because no violation of applicable water quality standard was recorded during the sampling period; however, a TP TMDL should be developed for the segment. The Walnut Point Lake is not designated for the use of public and food processing water supply. The nitrate standard is not applicable to the segment.

Table 2 summarizes the number of water quality violations for each segment based on Stage 2 results compared to Stage 1 findings. The final decision on Stage 3 will be made through consultation with IEPA.

TABLE 2
SUMMARY OF IMPAIRED SEGMENTS, PARAMETERS, AND NUMBER OF VIOLATIONS

Segment ID	Segment Name	Station ID	Parameters	No. of Violations/No. of Data Points Based on Stage 1 Report	Date of Last Violation	No. of Violations/No. of Data Points Based on Stage 2 Data Collection	Recommendation
BPGD	Hoopeston Branch	BPGD-H-A1	DO[a]	1/1 (FRSS data)	9/23/2002	0/13	Delisting
		BPGD-H-C1		1/3 (FRSS data)	No Violation	0/13	
BPJ10	Salt Fork Vermilion River	BPJ-10	pH	0/16	10/12/2006	1/11	TMDL development
			NO_2[b]	0/4	6/19/2006	4/11	TMDL development
		BPJ-16	pH	No Data	6/21/2006	1/10	TMDL development
			NO_2 [b]		6/21/2006	4/13	TMDL development
BPJ08	Salt Fork Vermilion River	BPJ-08	pH	2/7	10/12/2006	1/14	TMDL development
			NO_2 [b]	0/6	6/21/2006	3/15	TMDL development
BPJ03	Jordan Creek	BPJA-03	Fecal Coliform	No Data	10/12/2006	6/11	TMDL development
	Salt Fork Vermilion River	BPJ-03			9/14/2006	7/13	
BPJC08	Saline Branch	BPJC-08	DO[a]	3/23 (including FRSS data)	8/13/2001	0/12	Delisting
		BPJC-UC-A2				0/11	
BPJD02	Spoon Branch	BPJD-01	DO[a]	1/6	8/30/2006	1/11	TMDL development
		BPJD-02			No Violation	0/11	

TABLE 2 (Continued)
SUMMARY OF IMPAIRED SEGMENTS, PARAMETERS, NUMBER OF VIOLATIONS

Segment ID	Segment Name	Station ID	Parameters	No. of Violations/No. of Data Points Based on Stage 1 Report	Date of Last Violation	No. of Violations/No. of Data Points Based on Stage 2 Data Collection	Recommendation
BMC2	Sugar Creek	BMC-2	DO[a]	1/224 (including FRSS data)	9/14/2006	53/687[c]	TMDL development
RBK	Walnut Point Lake	BEX-1	TP[d]	No data	9/12/2006	4/11	TMDL development
			DO[a]		No Violation	0/11	Delisting
		RBK-1	TP[d]	19/25	9/26/2006	7/14	TMDL development
			NO_2[b, d]	0/20	No Violation	0/14	Delisting
			DO[a]	59/107	10/13/1987	0/14	Delisting
		RBK-2	TP[d]	11/15	9/26/2006	9/14	TMDL development
			NO_2[b, d]	0/15	No Violation	0/14	Delisting
			DO[a]	49/101	10/4/1995	0/14	Delisting
		RBK-3	TP[d]	11/15	9/26/2006	10/14	TMDL development
			NO_2[b, d]	0/15	No Violation	0/14	Delisting
			DO[a]	30/80	No Violation	0/14	Delisting

Notes:

DO	Dissolved oxygen
FRSS	2002 Facility-related stream survey
ID	Identification
NO_2	Nitrate
NO_3	Nitrite
TMDL	Total maximum daily load
TP	Total phosphorus

a	Based on DO standard of not-less-than 5 mg/L at any time; only data points within 1-foot of water surface considered
b	NO_2 + NO_3 data used as surrogate
c	Continuous samples collected taken at 30-minute intervals
d	Data points within 1 foot of water surface

APPENDIX A

QAPP

Available Upon Request

Contact Illinois EPA at 217-782-3362

APPENDIX B

QAPP ADDENDUM

Available Upon Request

Contact Illinois EPA at 217-782-3362

APPENDIX C

FIELD PHOTOGRAPHS

Photograph No. 1 Location: BPJC-UC-A2
Orientation: West Date: October 6, 2005
Description: Tetra Tech collected composite samples from the south bank, center, and north banks. (Field book Photo # 01)

Photograph No. 2 Location: BPJ-UC-A2
Orientation: North Date: October 6, 2005
Description: Overview of BPJ-UC-A2 (Field book photo # 02)

Photograph No. 3 Location: BPJC-08
Orientation: East Date: October 6, 2005
Description: Tetra Tech measuring width of stream (Field book photo # 3)

Photograph No. 4 Location: BPJD-08
Orientation: East Date: October 6, 2005
Description: Tetra Tech collecting surface samples (Field book photo # 4)

Photograph No. 5 Location: BPJD-01
Orientation: East Date: October 6, 2005
Description: Tetra Tech collecting water from center of river for field parameters (Field book photo # 5)

Photograph No. 6 Location: BPJD-02
Orientation: East Date: October 6, 2005
Description: Tetra Tech collecting water for Horiba field parameters (Field book photo # 6)

Photograph No. 7 Location: BPJ-08
Orientation: Northeast Date: October 6, 2005
Description: Failed silt fencing along east bank of Salt Fork Creek (Field book photo # 7)

Photograph No. 8 Location: BPJ-08
Orientation: Northeast Date: October 6, 2005
Description: Tetra Tech measuring width of Salt Fork Creek (Field book photo # 8)

Photograph No. 9 Location: BPGD-H-A1
Orientation: North Date: October 6, 2005
Description: Tetra Tech using Secchi disk for field measurements (Field book photo # 9)

Photograph No. 10 Location: BPGD-H-C1
Orientation: Southwest Date: October 6, 2005
Description: Tetra Tech collecting water for Horiba field measurements (Field book photo # 10)

Photograph No. 11 Location: RBK-3
Orientation: Southwest Date: October 7, 2005
Description: Tetra Tech collecting sample from RBK–3 bottom (Field book photo # 9)

Photograph No. 12 Location: RBK-2
Orientation: West Date: October 7, 2005
Description: Tetra Tech collecting surface sample for RBK-2-surface (Field book photo # 10)

Photograph No. 13 Location: RBK-2
Orientation: West Date: October 7, 2005
Description: Tetra Tech preparing the Kemmerer sampler at RBK-2 for a middle sample (Field book photo #11)

Photograph No. 14 Location: RBK-2
Orientation: West Date: October 7, 2005
Description: Tetra Tech wrapping foil around sample to protect from sunlight (No reference in field book)

Photograph No. 15 Location: BEX-1
Orientation: North Date: October 7,2005
Description: Tetra Tech collecting water for Horiba field measurements (Field book photo # 12)

Photograph No. 16 Location: BEX-1
Orientation: Northwest Date: October 7, 2005
Description: Tetra Tech collecting surface water sample from southeast bank (Field book photo # 13)

Photograph No. 17 Location: BMC-2
Orientation: Southwest Date: October 7, 2005
Description: Tetra Tech checking field measurements using Horiba along east bank (Field book photo # 14)

Photograph No. 18 Location: BMC-2
Orientation: West Date: October 7, 2005
Description: Tetra Tech collecting samples from west bank (Field book photo # 15)

APPENDIX D

STAGE 2 WATER QUALITY DATA

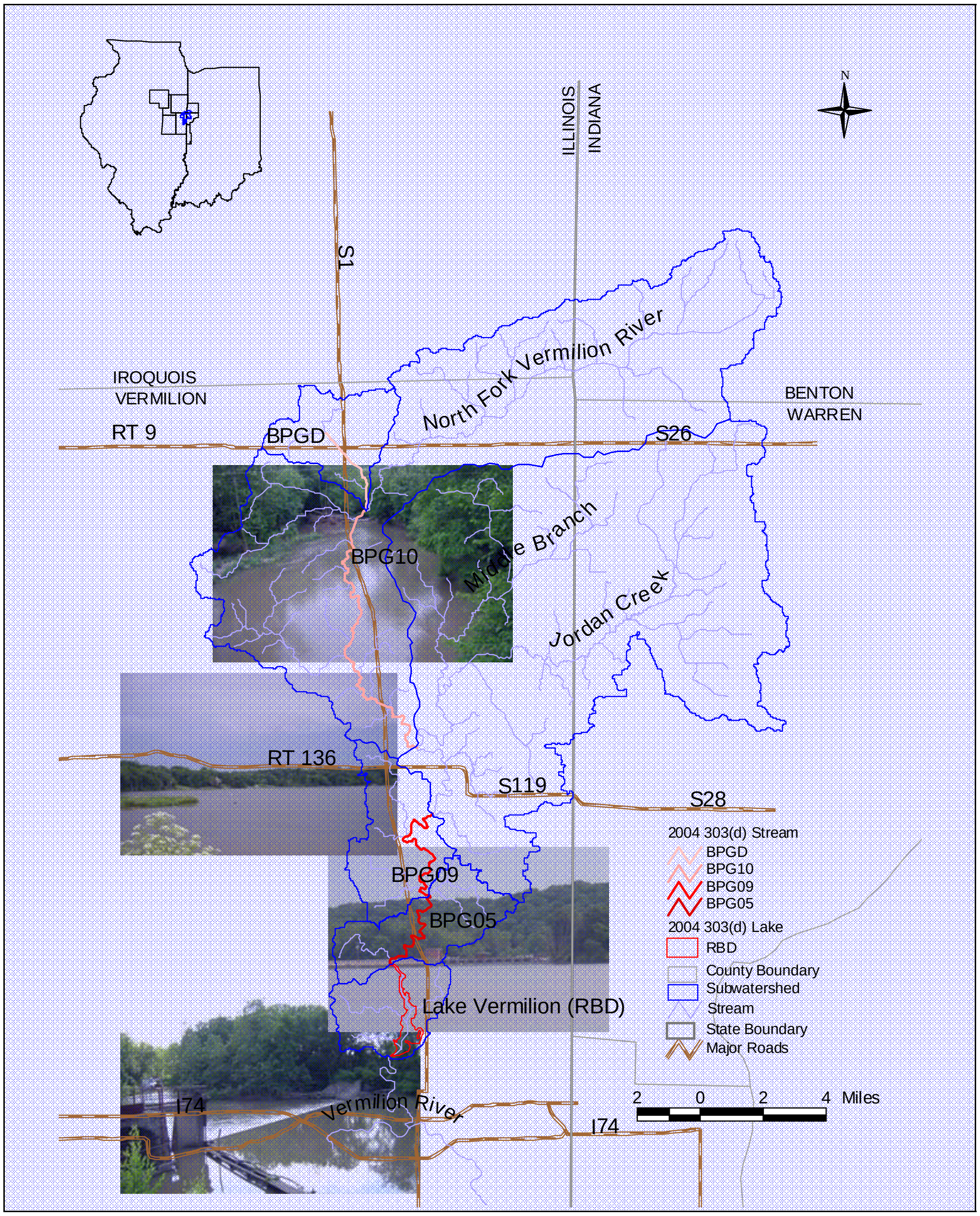
Available Upon Request

Contact Illinois EPA at 217-782-3362

North Fork Vermilion River and Lake Vermilion TMDL

FINAL REPORT

Prepared for
Illinois Environmental Protection Agency



TETRA TECH, INC

September 6, 2006

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1.0 INTRODUCTION

Section 303(d) of the Clean Water Act (CWA) and the U.S. Environmental Protection Agency (USEPA) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to identify water bodies that do not meet water quality standards and to determine the Total Maximum Daily Load (TMDL) for pollutants causing the impairment. A TMDL is the total amount of pollutant load that a water body can receive and still meet the water quality standards. It is the sum of the individual waste load allocation for point sources and load allocations for nonpoint sources and natural background with a margin of safety. The CWA establishes the process for completing TMDLs to provide more stringent, water-quality based controls when technology-based controls are not sufficient to achieve state water quality standards. 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 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.

Under Section 303(d) of the CWA, the State of Illinois prepared a list of waters that are not meeting state water quality standards (hereafter referred to as the “303(d) list”) in each 2-year cycle. The most recent list was reviewed and approved by USEPA in 2004. The 303(d) list identifies five water bodies as impaired:

- North Fork Vermilion River (BPG05)
- North Fork Vermilion River (BPG09)
- North Fork Vermilion River (BPG10)
- Hoopeston Branch (BPGD)
- Lake Vermilion (RBD)

This report documents the analysis and findings of a characterization of the overall hydrology and water quality for the North Fork Vermilion River watershed; the TMDL development for Segments BPG05, BPG09, and RBD; and the implementation plan. The Stage 2 sampling of segment BPGD showed that the DO standard was no longer being violated, so a TMDL was not developed for Hoopeston Branch. No TMDL will be developed for BPG10 because there is no numeric water quality standard for total nitrogen in streams. The focus of this TMDL is on the portion of the North Fork Vermilion River watershed that drains into Lake Vermilion. In this report, “North Fork Vermilion River watershed” refers to the watershed area upstream of Lake Vermilion dam, unless otherwise specified.

This chapter discusses the rationale for beneficial use designations and impairments for waters of the State of Illinois, and specifically, for the listed North Fork Vermilion River segments and Lake Vermilion in eastern Illinois. Chapter 2 describes the characteristics of the watershed and water bodies, and Chapter 3 addresses the climate and hydrology conditions. Chapter 4 describes the water quality standards and water quality assessment. Chapter 5 discusses the potential nonpoint and point sources that may cause the impairment. Chapter 6 describes the technical analysis for hydrology, loading, and linkage of sources and water quality. Chapter 7 presents the TMDL for Segments BPG05, BPG09, and RBD.

All waters of Illinois are assigned one of the following four designations: general use waters, public and food processing water supplies, Lake Michigan, and secondary contact and indigenous aquatic life waters. All Illinois waters must meet general use water quality standards unless they are subject to another specific designation (CWA Section 302.201). The general use standards protect the state’s water for aquatic life (except as provided in Illinois Water Quality Standard Section 302.213), wildlife, agricultural use, secondary contact use, and most industrial uses, and they ensure the aesthetic quality of the state’s aquatic environment. Primary contact uses are protected for all general use waters where the physical configuration permits such use. Unless otherwise specifically provided for and in addition to the general use standards, waters of the state must meet the public and food processing water quality standards at the points of water withdrawal for treatment and distribution as a potable supply or for food processing.

The designated uses and the causes of impairment addressed in this TMDL are summarized in Table 1-1. When a waterbody is assessed as partial support for a designated use, one violation of an applicable Illinois water quality standard at an Intensive Basin Surveys (IBS) or Facility-Related Stream Surveys (FRSS) site or one violation over three years at an Ambient Water Quality Monitoring Network (AWQMN) station is considered a basis for listing the violating parameter as a potential cause.

TABLE 1-1 DESIGNATED USES OF IMPAIRED SEGMENTS

Segment	Designated Use (Support Status)	Causes of Impairment	Impairments addressed in TMDL
North Fork Vermilion River (BPG05)	Aquatic life (full) Drinking water supply (partial)	Nitrogen Nitrate	Nitrogen Nitrate
North Fork Vermilion River (BPG09)	Aquatic life (full) Primary contact (not supporting)	Pathogen	Fecal Coliform
North Fork Vermilion River (BPG10)	Aquatic life (partial) Fish Consumption (not assessed)	Total Nitrogen (TN)	None
Hoopeston Branch (BPGD)	Aquatic life (partial)	Total Nitrogen (TN) Dissolved Oxygen (DO)	DO
Lake Vermilion (RBD)	Overall use (partial) Aquatic life support (full) Fish consumption (full) Primary contact (partial) Secondary contact (partial) Drinking water supply (partial)	Total Phosphorus (TP) and Nitrate	TP and Nitrate

Source: IEPA 2004 303(d) list

The North Fork Vermilion River and Hoopeston Branch segments addressed in this report are designated as a general use water body. As specified under Title 35 of the Illinois Administrative Code, Subtitle C, Part 302, waters of the state shall be free from sludge or bottom deposits (narrative standard for siltation), visible oil, odor, plant or algal growth (narrative standards for nutrients, eutrophication, or noxious aquatic plants), and color or turbidity of other than natural origin. Aquatic life is fully supported in segments BPG05, BPG09, and RBD while partially supported in segments BPG10 and BPGD. The primary contact use of the river is listed as non-support in segment BPG09 due to violation of the fecal coliform standard. Lake Vermilion (RBD) is the drinking water supply for the City of Danville. Drinking water supply use of Lake Vermilion is listed as partial support due to nitrate concentrations in excess of the 10 mg/L Public and Food Processing Standard. This standard applies to raw (untreated) source water at any point at which water is withdrawn from the waterbody for treatment and distribution as a potable water supply or for food processing. BPG05 is also assessed as partial support segment for drinking water supply use because it is located immediately upstream of RBD. In Lake Vermilion, aquatic life and fish consumption are fully supported, while its uses as a drinking water supply and for primary and secondary contact are partially supported, resulting in partial support of overall use. One purpose of this report is to verify the causes of impairment by comparing the available data to water quality standards.

In the 2004 Illinois Water Quality Report (IEPA, 2004), dissolved oxygen, total nitrogen, nitrate nitrogen, total suspended solids, sedimentation/siltation, and excessive algal growth were listed as potential causes of impairment for Lake Vermilion. The determination of these potential causes was based on applying the 2002 assessment methodology to the data collected from Lake Vermilion in 2000. As a result of the 2004 assessment update for Lake Vermilion, dissolved oxygen, sedimentation/siltation, and total nitrogen no longer apply as potential causes of impairment because Aquatic Life Use is not impaired. Therefore, since dissolved oxygen is not considered a potential cause of Aquatic Life Use impairment, a TMDL will not be developed for dissolved oxygen at this time. Furthermore, data show that the numeric general use water quality standard for total phosphorus (0.05 mg/L) was exceeded during the 2000 monitoring season and therefore, total phosphorus will be added as a potential cause of impairment for Secondary Contact Use and a TMDL will be developed for total phosphorus.

2.0 WATERSHED AND WATER BODY CHARACTERISTICS

This chapter describes the general hydrological characteristics of the North Fork Vermilion River watershed and water bodies, including their location, population, land use and cover topography and geology, and soils. The discussion of general watershed characteristics is followed by specific information for the listed segments of the river and the lake.

2.1 LOCATION

The North Fork Vermillion River Watershed is located in central Illinois along the Illinois-Indiana border, as shown on Figure 2-1. Most of the watershed is located in Vermilion County, Illinois, with portions extending to Iroquois County in Illinois, and to Warren and Benton Counties in Indiana. The watershed drains about 295 square miles, with about 200 square miles in Illinois and 95 square miles in Indiana. The distribution of watershed area by county is shown in Table 2-1.

TABLE 2-1 WATERSHED AREA DISTRIBUTION BY COUNTY

County, State	Area of Watershed in County (Square Miles)	Percent of Watershed in County (Percent)
Vermilion County, Illinois	190	64
Iroquois County, Illinois	10	3
Warren County, Indiana	66	23
Benton County, Indiana	29	10

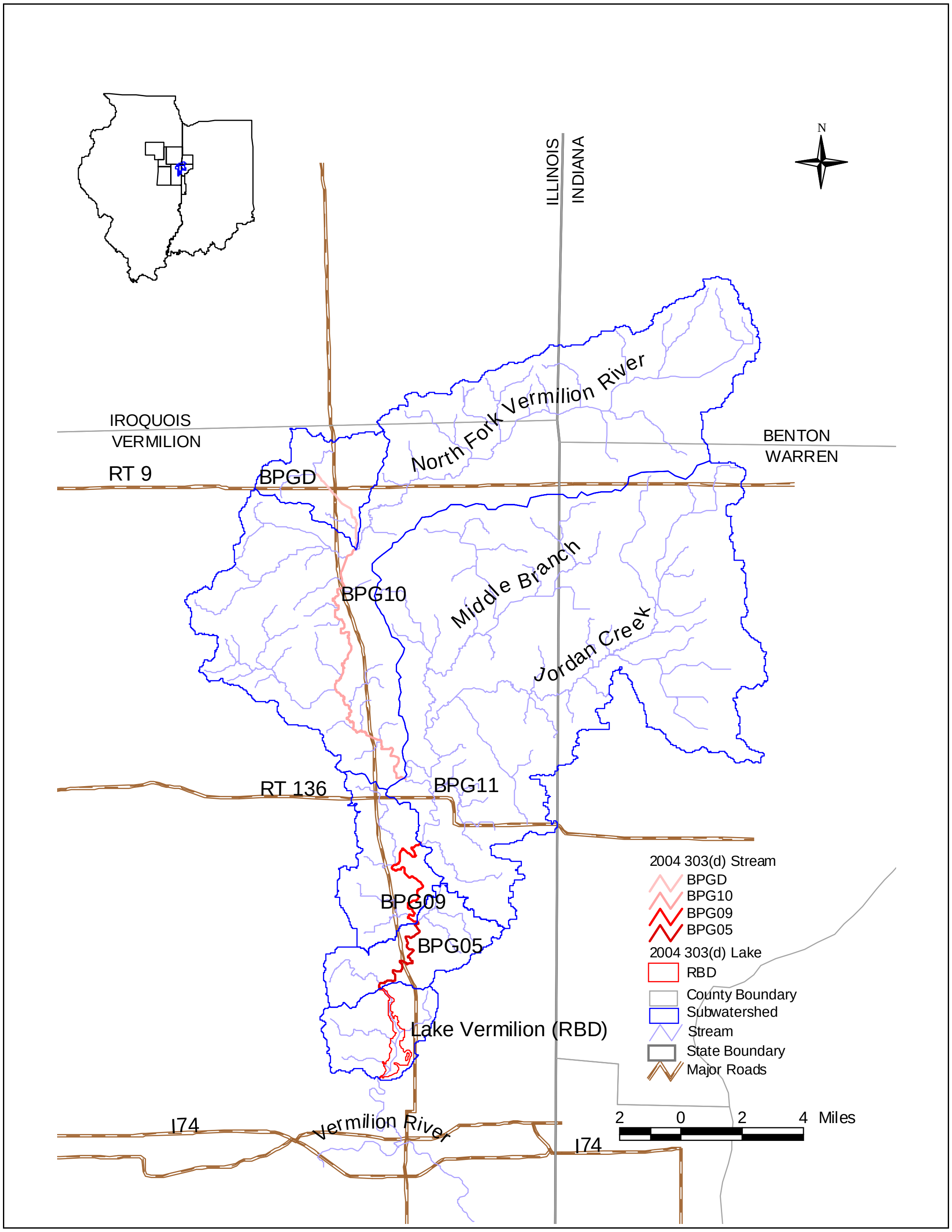
Lake Vermilion (RBD) is located in the southern portion of the watershed, 1 mile northwest of the City of Danville, about 5.2 miles upstream of the confluence of the North Fork Vermilion River with Vermilion River. BPG05 is located immediately upstream of Lake Vermilion, and extends about 9.82 miles. BPG09 starts at the confluence with Painter Creek and extends downstream 5.91 miles, directly flowing into BPG05. BPG10 starts at the confluence of Middle Branch and extends upstream 24.1 miles. BPGD is 4.72 mile Hoopeston Branch, extending from the confluence with North Fork Vermilion to the source water. The North Fork Vermilion River watershed is delineated into six subwatersheds, including the one draining to BPG11 (Figure 2-1). This TMDL focuses on the subwatersheds that drain to the listed North Fork Vermilion River segments (except BPG10), Hoopeston Branch, and Lake Vermilion segments. The watershed area between the dam and the confluence with the Vermilion River is not included in the TMDL. The characteristics of subwatersheds will be used for the load allocation for each segment in the TMDL development. The load allocation from the river segment (BPG05) can be treated as a lumped point source load to Lake Vermilion.

2.2 POPULATION

Total watershed population data is not directly available but population estimates may be calculated from the 2000 U.S. Census data. The census data were downloaded for all towns, cities, and counties with boundaries that were fully or partially within the watershed (U.S. Census Bureau 2000). Urban and nonurban populations were estimated for the watershed area and were summed to obtain the total watershed population. This section describes how urban and nonurban population estimates were determined from town, city, and county census data.

The urban watershed population is the sum of the populations for all municipalities located entirely in the watershed. For Danville, which is located partially in the watershed, a population weighting method was used to estimate its contribution to the urban watershed population. A geographic information system (GIS) spatial overlay of the town and city boundaries was used to determine that 27 percent of Danville is located in the Lake Vermilion subwatershed. Assuming a uniform distribution of population throughout

FIGURE 2-1 NORTH FORK VERMILION RIVER WATERSHED



Danville, the population of Danville was multiplied by 27 percent to estimate its contribution to the urban population. Table 2-2 lists the populations of each municipality in the watershed. The contributing population for each area was summed to obtain total urban watershed population for the two subwatersheds.

TABLE 2-2 MUNICIPALITY POPULATION IN THE NORTH FORK VERMILION RIVER WATERSHED

Subwatershed	Municipality/County	Urban population
BPGD	Hoopeston/Vermilion	5,965
BPG10	Ambia/Benton Rossville/Vermilion	197 1,217
BPG09	Alvin/Vermilion Bismarck/Vermilion Henning/Vermilion	316 542 241
BPG05	NA	NA
RBD	Danville/Vermilion	9,154[a]
Total		**17,632**

Notes:
NA Not applicable (no municipalities located in the subwatershed)
a Represents 27 percent of the total Danville population of 33,904; 27 percent of Danville is located in the watershed.
Source: U.S. Census Bureau 2000

The first step in calculating the nonurban watershed population was to subtract the county urban population from the total county population. The portion of nonurban population in each subwatershed was then calculated by multiplying the percent area of the county in the subwatershed by the nonurban population of the county. For example, the nonurban population of Vermilion County is 23,263. 2.51 percent of Vermilion County is in the Lake Vermilion subwatershed, and 18.7 percent of Vermilion County is in the North Fork Vermilion River subwatershed. Therefore, 2.51 percent of 23,263 (584) is assumed to be in the Lake Vermilion subwatershed, and 18.7 percent of 23,263 (4,350) is assumed to be in the North Fork Vermilion River subwatershed. The results from these calculations for each subwatershed and county are shown in Table 2-3. These results are based on the assumption that nonurban populations are uniformly distributed throughout each county.

TABLE 2-3 WATERSHED POPULATION SUMMARIZED BY WATER BODY SEGMENT

Waterbody Segment	County	Watershed Population	Percent Watershed Population	Urban population	Percent Urban Population	Nonurban Population	Percent Nonurban Population
North Fork Vermilion River[a]	Benton	424	2.99	197	1.39	227	1.60
	Iroquois	102	0.73	0	0.00	102	0.73
	Vermilion	12,631	89.21	8,281	58.49	4,350	30.72
	Warren	1,001	7.07	0	0.00	1,001	7.07
	Total	**14,158**	**100**	**8,478**	**59.88**	**5,680**	**40.12**
Lake (RBD)	Vermilion	**9,738**	**100**	**9,154**	**94.00**	**584**	**6.00**

[a] Include BPGD, BPG05, BPG09, and BPG10 subwatersheds

Source: U.S Census Bureau 2000 and USEPA 1998

Table 2-4 shows the population change between 1990 and 2000 for each county in the watershed. Detailed population data by county and town were not available for 1990, so percent urban and nonurban population change in each watershed could not be calculated. However, data indicate that the population in the watershed is likely decreasing. Between 1990 and 2000, the population of Danville decreased from

37,025 to 33,904, which further supports a decreasing population trend in the watershed (U.S. Census Bureau 1990 and 2000).

TABLE 2-4 POPULATION CHANGE

County in the Watershed	1990 Population	2000 Population	Absolute Change	Percent Change
Benton	**9,441**	**9,421**	**-20**	**-0.21%**
Iroquois	**30,787**	**31,334**	**547**	**1.78%**
Vermilion	**88,254**	**83,919**	**-4,335**	**-5.17%**
Warren	**8,176**	**8,419**	**243**	**2.97%**
Weighted Average				**-2.61%**

Sources: U.S Census Bureau 1990 and 2000

2.3 LAND USE AND LAND COVER

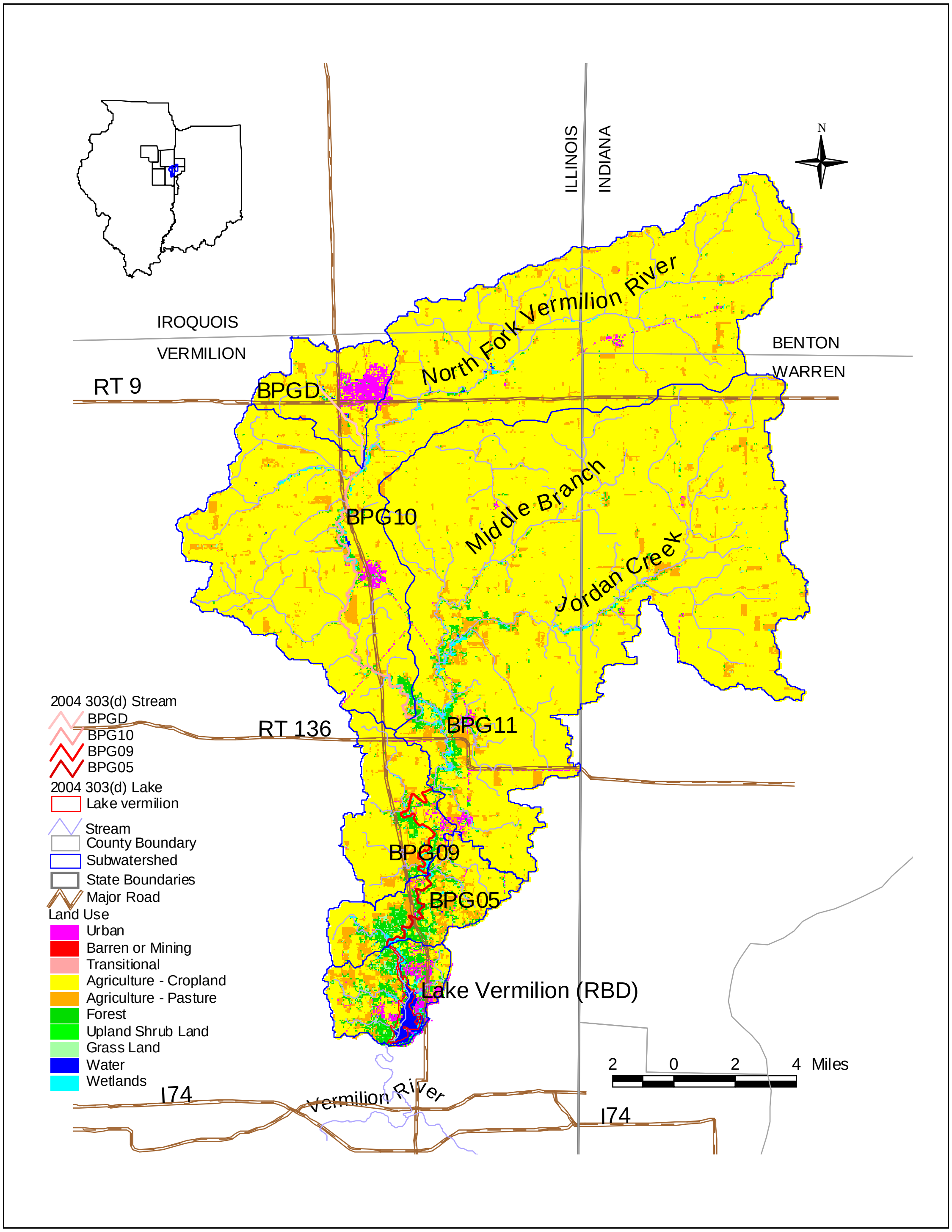
Figure 2-2 presents land use and land cover in the North Fork Vermilion River watershed. Land use data for the North Fork Vermilion River Watershed was obtained from the U.S. Geological Survey (USGS) Geographic Information Retrieval and Analysis (GIRAS) data files. The files consist of 1993 land use/land cover digital data collected by USGS and converted to ARC/INFO by USEPA (EPA 2000). The data can be used for environmental assessment of land use patterns with respect to water quality analysis, growth management, and other types of environmental impact assessment. Illinois Gap Analysis Program (GAP) land use and land cover data provides detailed classification of agriculture land. However, the State of Indiana does not have land classification compatible to Illinois. The GAP data is not used for land use analysis. Land use is calculated for subwatersheds contributing to each listed segment.

Table 2-5 summarizes the land use for the BPGD subwatershed and shows that the agriculture cropland accounts for about 75 percent of the 6,926 acre subwatershed area. The urban land accounts for 14 percent, mainly attributed to the City of Hoopeston. The other land uses account for less than 1 percent each. BPGD subwatershed drains to North Fork Vermilion River BPG10. Pasture land (8.3 percent) is considered rural grassland with possible grazing activities.

TABLE 2-5 LAND USES IN SUBWATERSHED OF BPGD

Land Use	Area (acre)	Percentage of Upstream Watershed Area
Cropland	5,230.2	75.52
Pasture	575.9	8.31
Forest	68.1	0.98
Urban	979.1	14.14
Wetland	16.7	0.24
Grass Land	41.3	0.60
Water	13.1	0.19
Barren or Mining	1.6	0.02
Total	**6,925.9**	**100.00**

FIGURE 2-2 LAND USE AND LAND COVER MAP



The BPG10 subwatershed consists of predominantly agricultural land, over 90 percent, as shown in Table 2-6. Pasture land is about 6 percent, followed by urban land 1.8 percent, and forestland 1.2 percent. No TMDL will be developed for BPG10 because there is no existing numeric water quality standard for total nitrogen, which is the cause for listing.

TABLE 2-6 LAND USES IN SUBWATERSHEDS (CUMULATIVE) OF BPG10

Land Use	**Area (acre)**	**Percentage of Upstream Watershed Area**
Cropland	72,865.3	90.25
Pasture	4,706.3	5.83
Forest	960.5	1.19
Urban	1,464.4	1.81
Wetland	408.5	0.51
Grass Land	254.7	0.32
Water	73.4	0.09
Barren or Mining	2.3	0.003
Total	**80,735.5**	**100.00**

Table 2-7 summarizes land use for the BPG09 subwatershed of North Fork Vermilion River. It is predominantly agricultural crop land, accounting for 89.6 percent of the total watershed area. Pasture land accounts for about 6.5 percent, and forest land accounts for 1.8 percent. Agricultural lands are mostly located upstream near the headwater area. Major crops are corn, small grains, and soybeans.

TABLE 2-7 LAND USES IN SUBWATERSHEDS (CUMULATIVE) OF BPG09

Land Use	**Area (acre)**	**Percentage of Upstream Watershed Area**
Cropland	156,359.1	89.56
Pasture	11,293.4	6.47
Forest	3,215.1	1.84
Urban	1,896.3	1.09
Wetland	969.7	0.56
Grass Land	752.8	0.43
Water	93.5	0.05
Barren or Mining	3.0	0.002
Total	**174,583.0**	**100.00**

The BPG05 subwatershed represents the drainage area upstream of Lake Vermilion, which includes BPG09 subwatershed plus the lateral contributing area along the BPG05 segment. The land use distribution is similar to BPG09 subwatershed, with cropland at 88 percent, pasture at 7 percent, forest at 2.5 percent, and urban at 1.1 percent. Wetland, grassland, water, and barren or mining together account for about 1.4 percent (Table 2-8).

TABLE 2-8 LAND USES IN SUBWATERSHED (CUMULATIVE) OF BPG05

Land Use	**Area (acre)**	**Percentage of Upstream Watershed Area**
Cropland	160,803.2	88.10
Pasture	12,925.4	7.08
Forest	4,541.8	2.49
Urban	1,984.6	1.09
Wetland	1,132.7	0.62
Grass Land	1,037.3	0.57
Water	105.0	0.06
Barren or Mining	3.0	0.002
Total	**182,532.9**	**100.00**

The RBD subwatershed is the portion of the Vermilion River Watershed upstream of Lake Vermilion, including BPG05 watershed and the area that drains directly to the lake. Table 2-9 summarizes the land use for the RBD subwatershed that drains directly to the lake. The area surrounding Lake Vermilion is also predominately agricultural land and urban land.

TABLE 2-9 LAND USE IN RBD SUBWATERSHED (CUMULATIVE)

Land Use	**Area (acre)**	**Percentage of Upstream Watershed Area**
Cropland	162,868.9	86.20
Pasture	14,102.5	7.46
Forest	5,981.2	3.17
Urban	2,604.2	1.38
Wetland	1,344.7	0.71
Grass Land	1,307.4	0.69
Water	708.8	0.38
Upland Shrub Land	27.5	0.01
Barren or Mining	3.0	0.002
Transitional	1.6	0.001
Total	**188,949.9**	**100.00**

2.4 TOPOGRAPHY AND GEOLOGY

The North Fork Vermilion River watershed has rough topography resulting from fluvial erosion through glacial drift. The rivers have broad floodplains formed by glacial lakes. The highest point in the watershed is at an elevation of about 820 feet and the lowest point is at about 520 feet (NGVD 1929). The rivers have incised through a relatively thin cover of unconsolidated materials overlying the La Salle Anticlinorium, and their drainage patterns are largely controlled by joint patterns associated with the La Salle Anticlinorium. Sedimentary rocks of Ordovician and Pennsylvanian age are exposed along the waterways throughout the area. Two geological time periods are well represented: the Pennsylvanian (the age of coal) and the Quaternary (the age of glaciers).

The bedrock strata that immediately underlie most of the surface materials in the Vermilion River area are Pennsylvanian age. They were formed from sediments deposited some 290 million years ago when what is now Illinois was covered by shallow seas with large swamps near the shore. These wet, swampy areas supported a lush forest of large trees, tree and seed ferns, and giant scouring rushes. As the plants fell into the swampy waters, they were partially preserved, buried by later sediments and eventually converted into coal. Pennsylvanian-age bedrock is classified by cyclothems, which are based on this cyclical sedimentation.

Other landscape features resulted from the multiple glacial advances across the region. The glaciers left moraines, terraces, kames, an entrenched meander, and sand dunes. A succession of moraines (deposits that mark where a glacier melted and advanced at the same rate) are present across the land surface. These moraine ridges generally trend northwest to southeast, then continue to loop around to the east. The Bloomington Moraine, a prominent feature of the Oakwood area, is one of the largest in Illinois and represents the southernmost extent of a re-advance of a glacier some 15,000 years ago.

As the glaciers melted, water poured down the Wabash Valley, rapidly deepening it. In addition, glacial Lake Watseka, located to the north, breached the Chatsworth Moraine. Its outwash material flowed south following what is now the course of the North Fork Vermilion River. The valley of the Vermilion River, including the Salt Fork, became entrenched below the upland. The Vermilion River cut its channel 60 feet below the upland into the Pennsylvanian bedrock.

East of Rossville is an area of sand 2 miles wide and 3 miles long that has been blown into dunes. The sand dunes are the result of glacial ice. They were deposited when the valley of the North Fork Vermilion River filled with outwash from a melting glacier or with valley train deposits (outwash that has been deposited in a stream valley) from the draining of ancient Lake Watseka.

2.5 SOILS

Soils data and GIS files from the Natural Resources Conservation Service (NRCS) were used to characterize soils in the North Fork 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 coverage 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. Identification fields in the GIS coverage can be linked to a database that provides information on chemical and physical soil characteristics. The STATSGO database contains many soil characteristics associated with each map unit. Of particular interest are the hydrologic soil group, the K-factor of the Universal Soil Loss Equation (USLE), and depth to water table.

The hydrologic soil group classification identifies soil groups with 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 2-10.

TABLE 2-10 NRCS HYDROLOGIC SOIL GROUP

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.

Dual hydrologic groups, A/D, B/D, and C/D, are given for certain wet soils that can be adequately drained. The first letter applies to the drained condition, the second to the undrained. Only soils that are rated D in their natural condition are assigned to dual classes. Soils may be assigned to dual groups if drainage is feasible and practical. Figure 2-3 displays the STATSGO hydrologic soil group map for the North Fork Vermillion River watershed. For the North Fork Vermilion River watershed, Hydrologic Soil Group C accounts for 30.2 percent and is mostly located along the river channel. Hydrologic Soil Group D (poorly drained) accounts for 42.7 percent and located in upper land of the watershed. Hydrologic Soil Group B covers about 27.1 percent in the northern portion of the watershed.

A commonly used soil attribute of interest is the K-factor, a coefficient used in the USLE (Wischmeier and Smith, 1978). The K-factor is a dimensionless measure of a soil's natural susceptibility to erosion. 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 potential soil erodibility. The distribution of K-factor values in the North Fork Vermilion River watershed is shown in Figure 2-4. The figure indicates K-Factors ranging from 0.28 to 0.43; 44 percent of watershed area has a K-factor of 0.32, 35 percent has a K-factor of 0.43, and 21 percent of the area has a K-factor of 0.28. A very small portion of the watershed in Indiana has a K-factor of 0.37. These more highly erodible soils are primarily distributed on both sides of North Fork Vermilion River in the central portion of the watershed.

FIGURE 2-3 HYDROLOGIC SOIL GROUP MAP

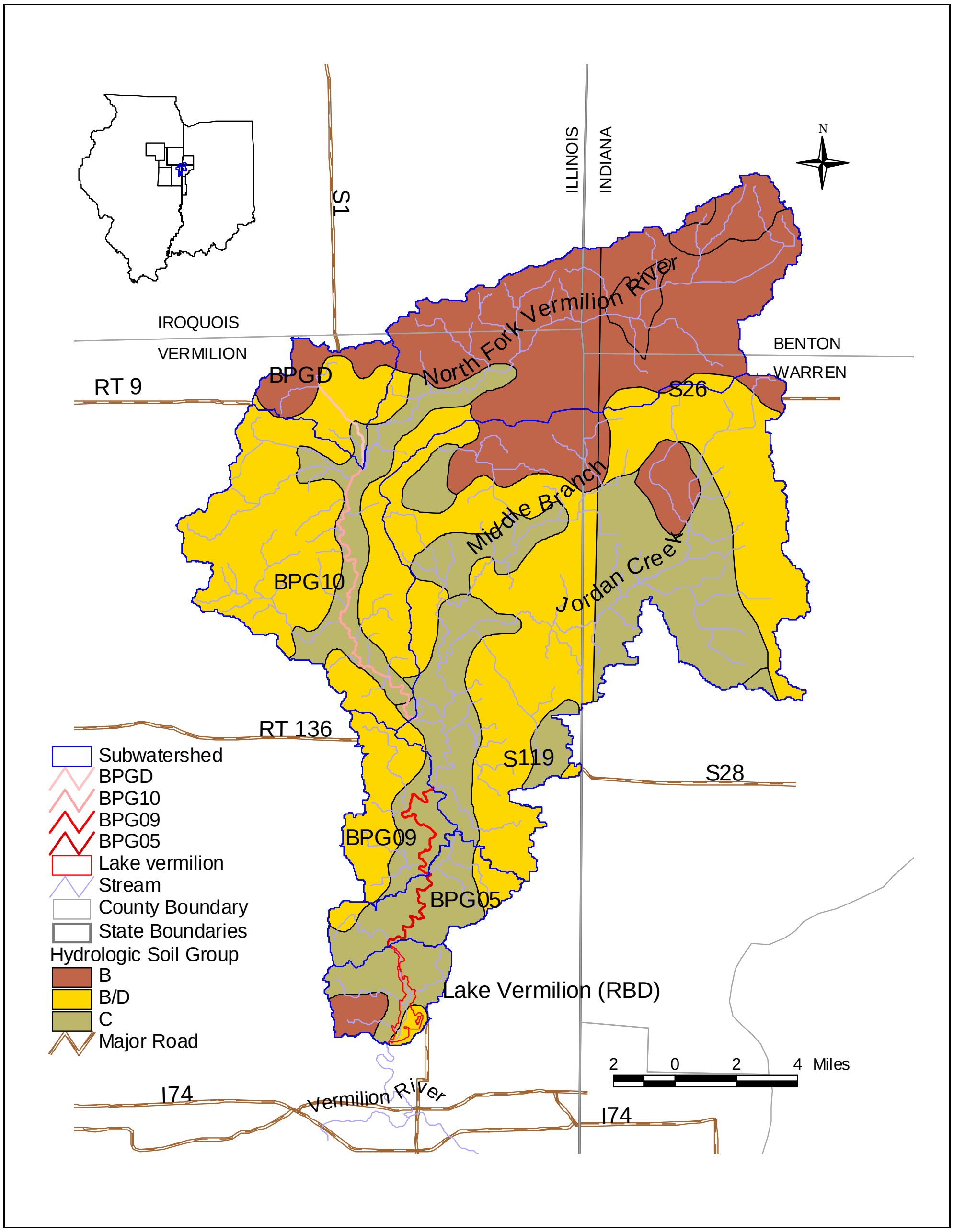
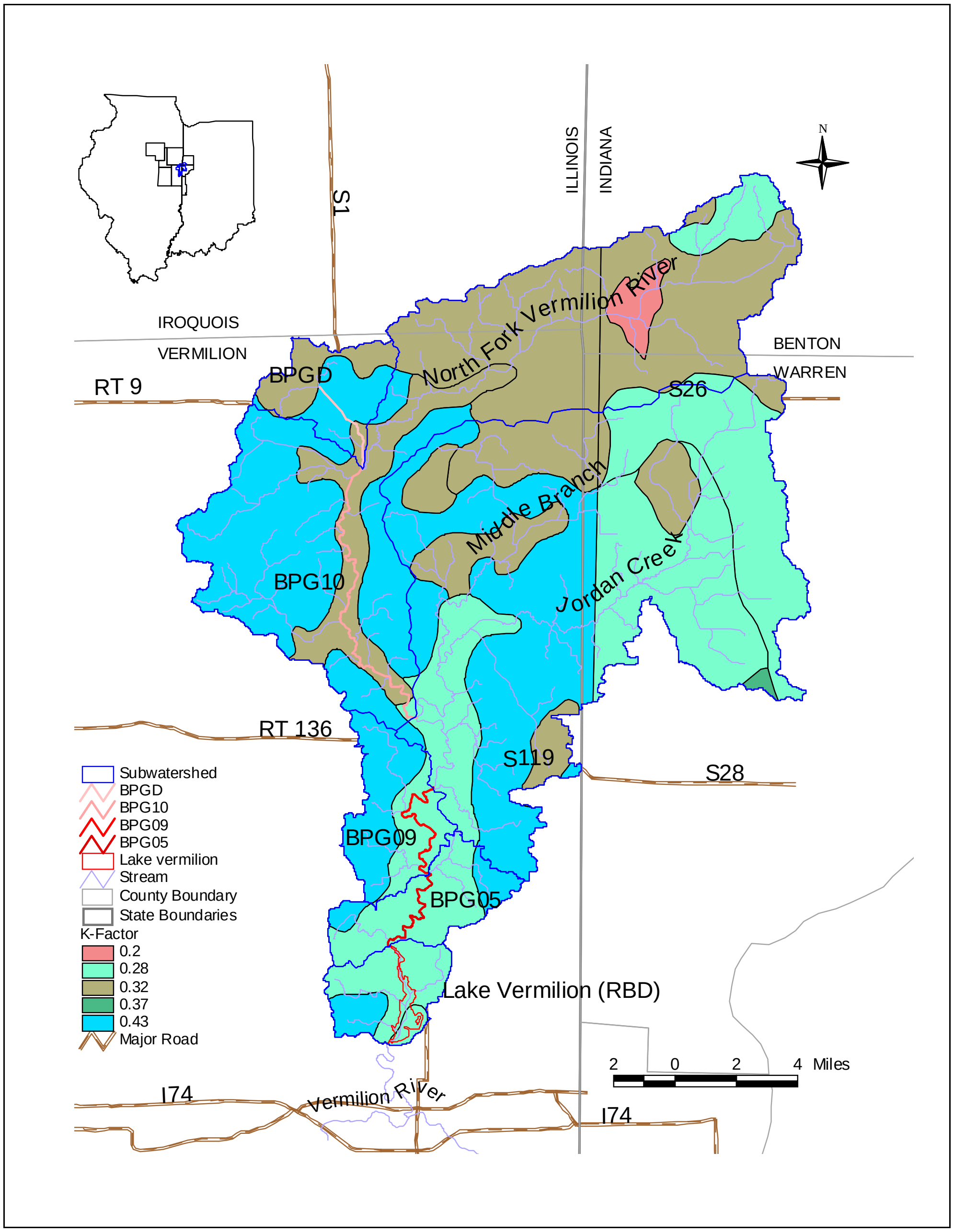
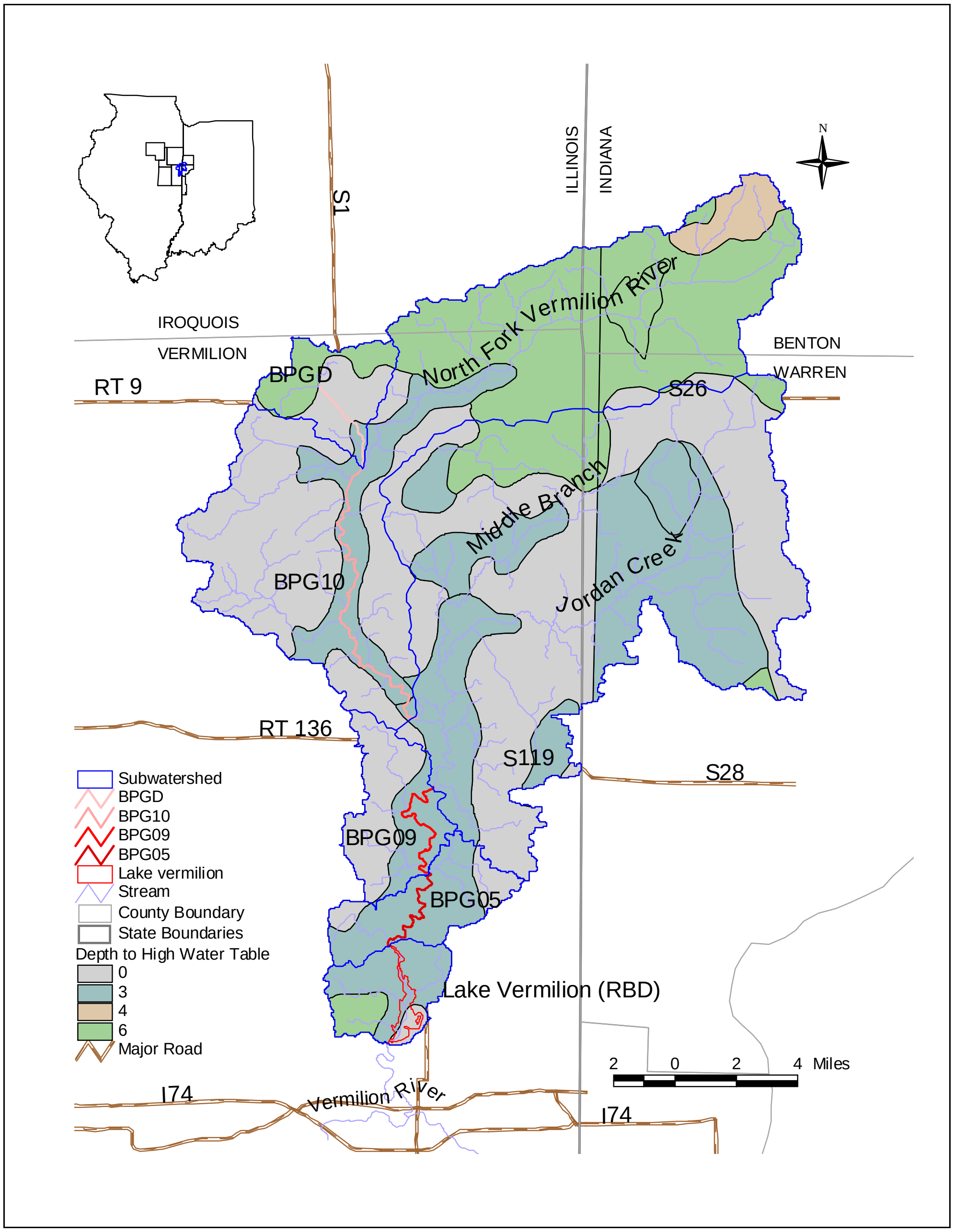


FIGURE 2-4 SOIL EROSION K-FACTOR MAP



The depth to the groundwater table determines the groundwater flow contribution to the North Fork Vermilion River. When the depth is shallower, there is a better chance for groundwater to discharge to the river and lake. The depth to the water table varies seasonally. The estimated depth to the water table is based on NRCS Soil Survey. Each soil unit has an estimated depth to the water table associated with it. Figure 2-5 presents the distribution of depth to the seasonal high water table in the watershed. The southern portion of the watershed and channel valley has a relatively shallow groundwater level, with the depth to water table ranging from 0 to 3 feet. The water table at the northern end of the watershed is deeper, with a depth of about 6 feet.

FIGURE 2-5 DEPTH TO SEASONAL HIGH WATER TABLE



2.6 WATERBODY CHARACTERISTICS

This section discusses waterbody characteristics for the North Fork Vermilion River and Lake Vermilion.

2.6.1 Hoopeston Branch

Hoopeston Branch is a 4.72 mile, second-order tributary to North Fork Vermilion River, flowing from northwest to southeast. Its headwater is located in the northwest corner of the North Fork Vermillion River watershed. The average slope of the branch is about 0.006%. The subwatershed area is 10.8 square miles. Based on USGS topography, the portion of Hoopeston Branch near Hoopeston is channelized. The estimated channel width is about 8 feet.

2.6.2 North Fork Vermilion River

The North Fork Vermilion River flows about 62 miles from its headwaters in Benton County, Indiana, to Lake Vermilion in Danville, Illinois, then into the Vermilion River. The river flows through the following towns from upstream to downstream: Ambia, Indiana; and Hoopeston, Rossville, Henning, Alvin, Bismarck, and Danville, Illinois. The North Fork Vermilion River has a sand, gravel, and rubble substrate. The listed segments include BPG10, BPG09, and BPG05 from upstream to downstream, as shown on Figure 2-1. Table 2-11 summarizes the characteristics of the North Fork Vermilion River including both listed and not listed segments.

TABLE 2-11 NORTH FORK VERMILION RIVER CHARACTERISTICS

Characteristic	Value[a]
Reach length	62 miles[b]
10-year, 7-day low flow	1.24 cubic feet per second (cfs)
Low flow mean velocity	0.22 fps
Mean flow	297 cfs
Mean velocity	1.01 fps
Bottom of reach elevation	520 feet above sea level[b]
Mean stream slope	0.071 percent[b]
Mean width	24.1 ft

Notes:

a Table includes characteristics for segments of North Fork Vermilion River upstream of Lake Vermilion.

b Source: Illinois State Water Survey 2003

Source: USEPA 1998 unless otherwise noted

2.6.3 Lake Vermilion

Lake Vermilion is a drinking water reservoir located northwest of Danville, Illinois. The lake is managed by Consumer Illinois Water Company (Tetra Tech, 2004a). In 1902, a dam was constructed near Jaycee's Park to increase storage for water supply. The dam was reconstructed in 1914 to augment flow to the pre-existing channel dam adjacent to the water treatment plant. A review of the lake bathymetry indicates that the old dam still exists, which may affect local hydrodynamic and lake circulation.

The present dam and spillway was constructed in 1925 south of the old dam. In 1991, it was further enhanced to increase reservoir capacity. The dam is located at 40°9’24” North latitude and 87°39’8” West longitude in Section 31, T 20N R 11W Township in Vermillion County, Illinois. The 1991 enhancements increased the pool level from 576 to 582.2 feet (NGVD 1929) using extensions that had been added to the original spillway gates (ISWS, 1999). The elongated lake has an average length-width ratio of about 18. County Highway 20 (Denmark Road) crosses the southern portion of the lake. The road embankment narrows the waterway, which separates the lake into two parts and may affect lake circulation. West Newell Road crosses the lake’s north end, where the North Fork Vermilion River flows in. More detailed information about the old dam and roads will be needed to model the lake’s hydrodynamic conditions and water quality. Consumer Illinois Water Company uses 13 cubic feet per second from the lake to meet water supply demands. Table 2-12 summarizes characteristics of Lake Vermilion.

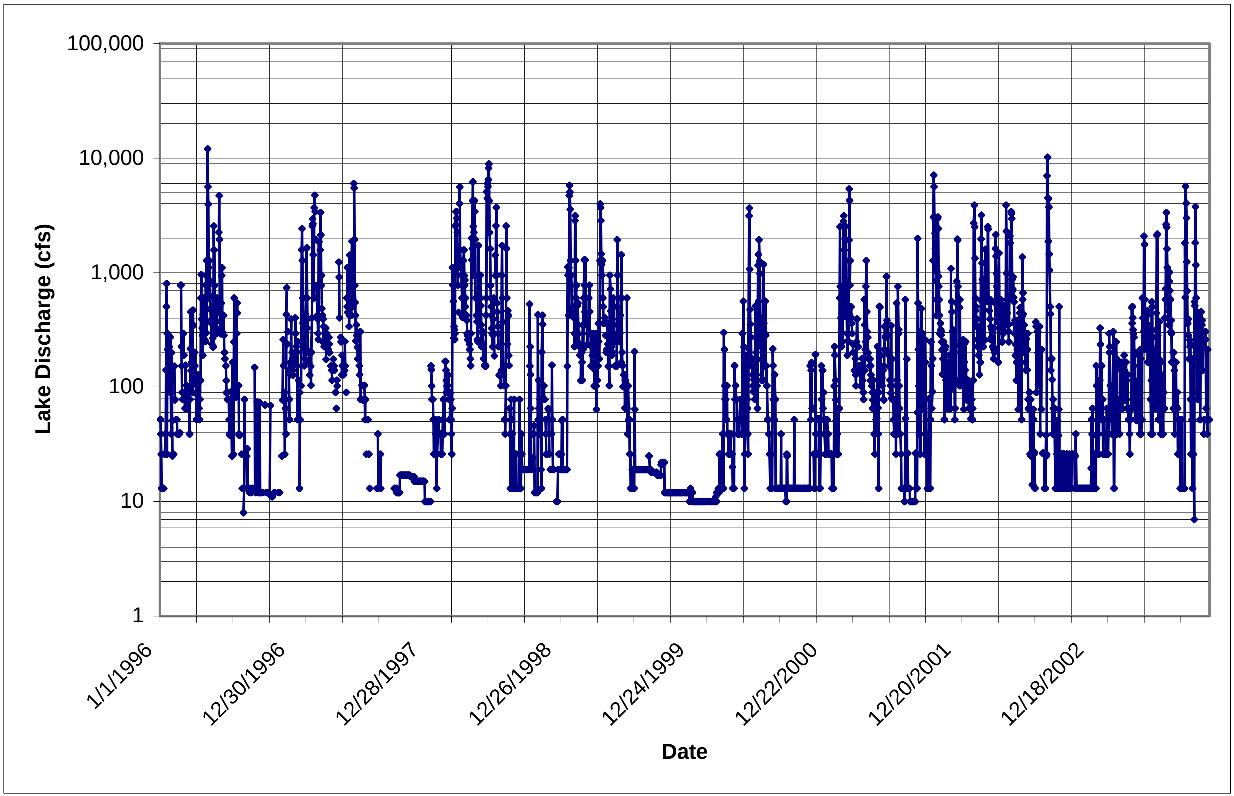
TABLE 2-12 LAKE VERMILION CHARACTERISTICS

Characteristic	Value
Drainage area	295 square miles
Water surface	880 acres[a]
Service spillway crest elevation	582.2 feet NGVD[a,b]
Emergency spillway elevation	582.7 feet NGVD[b]
Maximum storage	7,900 acre-feet[a]
Normal storage	7,900 acre-feet[a]
Maximum pool length	3.6 miles[a]
Shoreline length	22 miles[b]
Average depth	12 feet near center [a,b] 6 feet near northern end[a,b]
Maximum depth	22 feet (near dam)[b]
Dam length	600 feet[b]
Designed maximum discharge	38,220 cfs[b]
Average hydraulic retention time	15 days

Notes:
NGVD National Geodetic Vertical Datum
a Source: Illinois State Water Survey 1999
b Source: Tetra Tech 2004a
Source: USEPA 1998 unless otherwise noted

Discharge from the lake is controlled by the extended spillway gate. Figure 2-6 shows the lake discharge data for 1996 to 2002. The minimum discharge from the lake is 13 cfs, the average discharge from the lake is 100 cfs, and the maximum discharge of 16,000 cfs was recorded in 1994 (Tetra Tech, 2004a). The average annual lake evaporation rate observed at Urbana, Illinois, is 10.5 inches per year. The Consumers Illinois Water Company treatment plant is located near the downstream side of the new dam. There is no water intake structure in the lake; instead, water is released through the spillway to a holding basin 2.5 river miles downstream near the water treatment plant, then pumped in to the plant. The plant's design production capacity is 14 million gallons per day (MGD). The spillway gate is regulated to maintain the stable lake level. During low flows, the release is controlled to sustain the water yield of the plant. In 2002, the water treatment plant was improved to increase the nitrate removal efficiency, chloramine disinfection, and other performance enhancements (Lin and Bogner, 2004).

FIGURE 2-6   LAKE VERMILLION DISCHARGE



Source: Consumer Illinois Water Company (2004)

3.0 CLIMATE AND HYDROLOGY

This section discusses the climate of the watershed and its hydrology.

3.1 CLIMATE

The eastern portion of Illinois has a continental climate with cold, rather dry winters, and warm humid summers. Table 3-1 summarizes climate characteristic near Danville, Illinois. The average annual precipitation at Danville, Illinois is about 40.8 inches. Monthly average precipitation is about 3.4 inches. Months from March through August are wet months, with average precipitation between 3.2 and 4.7 inches per month. Months from September to February are relatively dry, with average precipitation of 2.5 inches for the normally driest months of October and February. On average, there are 122 days with precipitation. Severe droughts are infrequent, but prolonged dry periods during a part of the growing season are not unusual. Such periods usually cause reduced crop yields. A single thunderstorm often produces more than 1 inch of rain and occasionally is accompanied by hail and damaging winds. More than 4.5 inches of rain has fallen within a 24-hour period and nearly 15 inches during a month. Some fall and winter months have had less than 0.25 inch of precipitation. The average annual temperature at Danville, Illinois is approximately 52.5 °F. The maximum and minimum average temperatures are 65.9 and 42.9 °F, respectively.

TABLE 3-1 CLIMATE CHARACTERISTICS NEAR DANVILLE, ILLINOIS

Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Average temp. (°F)	25.8	31	41.9	52.8	63	71.8	75.3	73.4	66.6	55	42.7	30.9	52.5
High temperature (°F)	34.2	40	52	64.5	75.2	83.5	86.2	84.1	78.4	66.6	51.6	38.7	62.9
Low temperature (°F)	17.3	21.9	31.7	41	50.7	60	64.3	62.6	54.7	43.3	33.8	23	42.0
Precipitation (in)	2	2	3.2	3.8	4.5	4.7	4.4	3.9	3	3	3.5	2.8	40.8 (total)
Days with Precip	11	9	12	12	12	10	10	9	8	8	10	11	122 (total)
Average Wind speed (mph)	11.1	11.1	11.9	11.6	9.9	8.8	7.7	7.3	8.1	9.2	10.8	10.8	9.9
Morning humidity (%)	81	81	80	79	82	83	87	90	89	86	84	83	83.8
Afternoon humidity (%)	71	68	62	57	58	58	61	61	59	58	67	72	62.7
Sunshine (%)	42	50	50	54	61	66	67	68	65	61	43	40	55.6
Days clear of clouds	6	6	6	6	7	7	8	9	11	11	6	6	7.4
Partly cloudy days	6	6	7	7	9	11	12	11	9	8	7	6	8.3
Cloudy days	19	16	18	17	15	12	10	10	11	12	17	20	14.8
Snowfall (in)	6.6	5.4	3.7	0.6	0	0	0	0	0	0.2	1.9	5.4	2.0

Notes:

°F	Degrees Fahrenheit
in	Inch
mph	Miles per hour
%	Percent

Source: http://www.sws.uiuc.edu/atmos/statecli/Summary/112140.htm, Data Period: 1971-2000

The region has daily high temperatures greater than 90 °F about 45 days per year and subzero degree Fahrenheit temperatures on the average 1 day, or less, per year. Annual average snowfall is about 10 inches with large variations in snowfall occurring from year to year. Sunshine averages more than 70 percent during the three summer months, but only 45 percent during the winter months. Precipitation occurs an average of 10-days per month with snowfall occurring in October through April (ISWS, 1998).

3.2 HYDROLOGY

Hydrology in North Fork Vermilion River is mostly affected by glacial processes and deposits that cover the watershed. The principal source of surface runoff is precipitation that enters the stream as overland flow, which is rainwater or snowmelt that flows over the land surface toward stream channels. In agricultural areas, there is more infiltration and much less overland flow compared to urban areas. The average annual runoff is 15.43 inches (total annual runoff volume divided by watershed area), which accounts for about 38 percent of annual precipitation. Groundwater discharge to streams affects the flow and water quality of the stream. The actual groundwater contribution can be determined by a water balance in the river.

USGS station 03338780 is located in the North Fork Vermilion River near the bridge at the intersection of Vermilion County Road 2750 N, about 1.8 miles west of Bismarck, 1.9 miles downstream from the Painter Creek confluence, and 6.6 miles downstream from the confluence of the Middle Branch of the North Fork Vermilion River. The station measured flow from June 1970 to September 1974 partially and fully from October 1988 to present. Figure 3-1 shows the flows from 1988 to 2001. The mean flow is 297.4 cfs, and the median flow is 107 cfs. The maximum flow of 14,500 cfs was recorded on April 12, 1994. The minimum flow of 2.5 cfs was recorded in September 1991, which was a very dry month.

FIGURE 3-1 NORTH FORK VERMILION RIVER FLOW (1988 TO 2001)

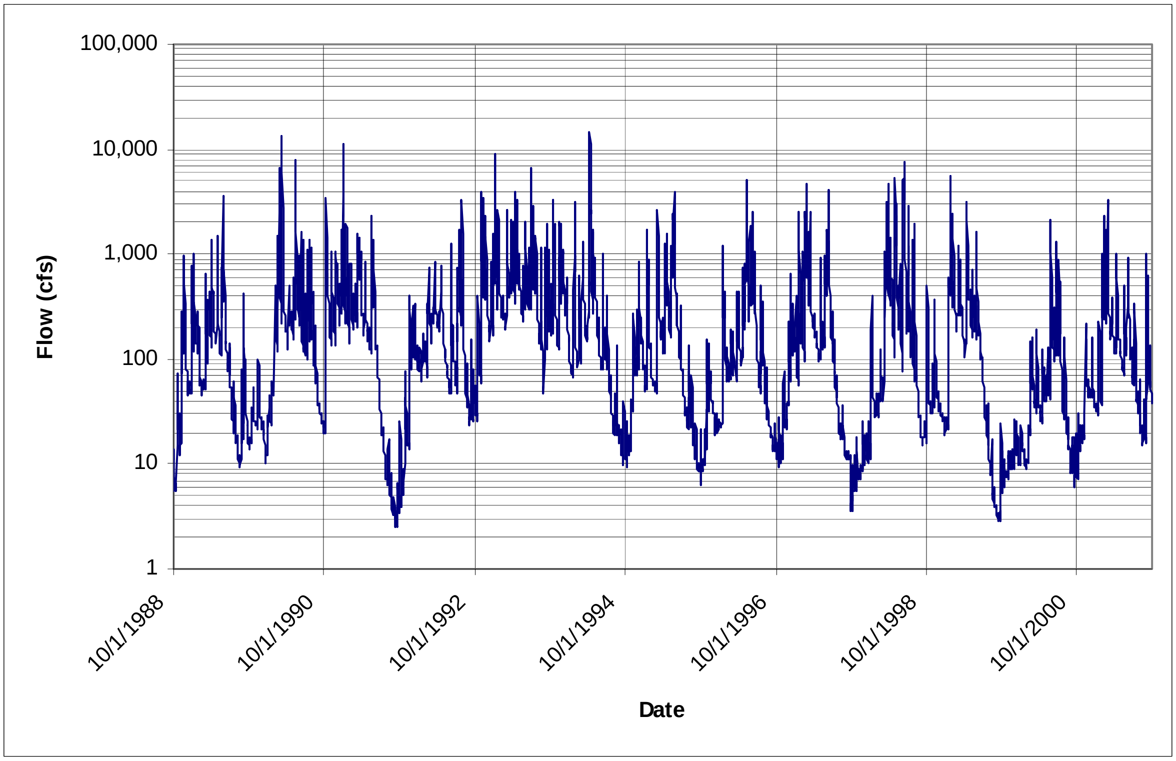


Figure 3-2 presents a flow frequency curve for the North Fork Vermilion River, based on flow data from 1988 to 2001. It shows the 25th percentile flow of 28 cfs and 75th percentile flow of 289 cfs. The flow in the river is greater than 100 cfs 50 percent of the time.

FIGURE 3-2 NORTH FORK VERMILION RIVER FLOW FREQUENCY CURVE

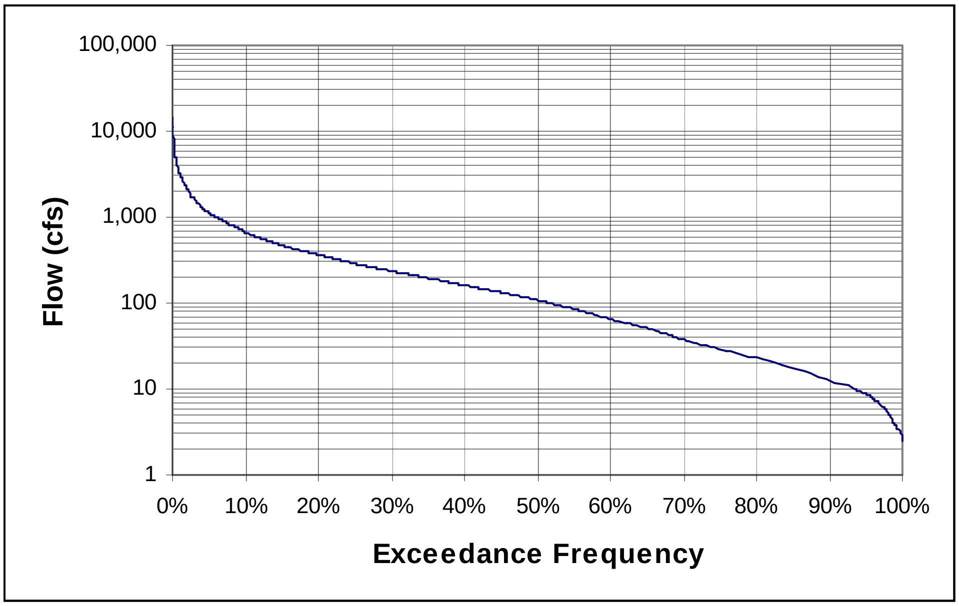
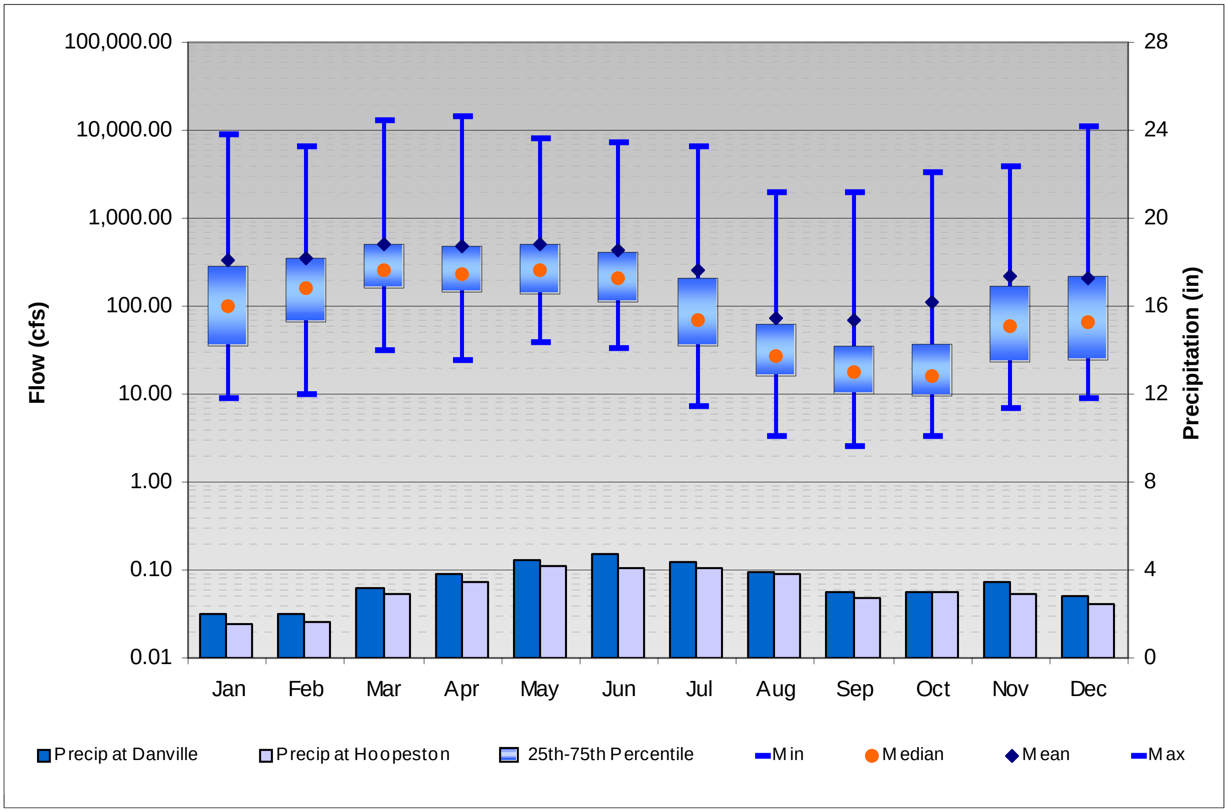


Figure 3-3 shows the monthly statistics of North Fork Vermilion River Flow and monthly average precipitation at Danville and Hoopeston, Illinois. The Hoopeston climate station is located near the northwest boundary of the watershed. The monthly variation of flow is somewhat different from precipitation in the watershed though both exhibit the yearly cycle. The monthly average flow starts to increase in January and peaks in May and decreases to reach the lowest in September. However, the monthly average rainfall starts to increase in March, reaches the highest in June, and then decreases. January and February have the lowest rainfall, but lowest monthly average flows occur in August and September. The yearly cycle of flow and precipitation differs by about 2 months. The phenomena may be attributed to snow melting, temperature trends, and vegetation growth throughout the year.

FIGURE 3-3 MONTHLY AVERAGE FLOW AND PRECIPITATION IN NORTH FORK VERMILION RIVER WATERSHED



The hydrology of the North Fork Vermilion River watershed is also affected by the channelization of streams and drainage ditches and extensive use of artificial drainage tiles. Subsurface tile drains predominantly drain agricultural fields in East-Central Illinois, as in many other regions of the central plains. Improved subsurface drainage not only improves crop production and farm income, but also reduces surface runoff. This results in reduced soil erosion and sediment load to streams and water bodies. The subsurface drainage system, however, results in increased flow through the soil profile, increasing leaching of nitrates and dissolved phosphorus to the streams. If private septic systems are connected to drain tile, the domestic wastewater moves faster to downstream water bodies.

4.0 WATER QUALITY

This chapter discusses applicable water quality standards and the pollutants of concern in the North Fork Vermilion River and Lake Vermilion. The available water quality data is evaluated to verify impairments in listed segments by comparing observed data with water quality standards or appropriate targets. The spatial and temporal water quality variation as well as the correlation among the constituents are assessed.

4.1 WATER QUALITY STANDARDS AND END POINTS

This section describes applicable water quality standards for the North Fork Vermilion River and Lake Vermilion. Based on the standards, TMDL endpoints were identified as numeric water quality targets.

4.1.1 River Water Quality Standards

The North Fork Vermilion River Segment BPG09 is listed on the Illinois 2004 303(d) list for pathogens. Fecal coliform will be used as the indicator of pathogens. The Illinois fecal coliform standards for general use requires that 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 (GM) of 200 colony forming units (cfu) per 100 mL (cfu/100 mL), nor shall more than 10 percent of the samples during any 30 days period exceed 400 cfu/100 mL in protected waters. Fecal coliform is the pollutant of concern in the North Fork Vermilion River Segment BPG09.

The North Fork Vermilion River Segment BPG05 is listed on the Illinois 2004 303(d) list for nitrate nitrogen, which caused the impairment of the designated use of public and food processing water supply. The not-to-exceed numeric standard for nitrate nitrogen is 10 mg/L.

Although they are not listed in North Fork Vermilion River, nutrients are listed as the causes for impairment in Lake Vermilion, which is the downstream receiving water. USEPA regulations at CFR Part 131.10(b) requires that in “designating uses of a waterbody and the appropriate criteria for those uses, the State shall take into consideration the water quality standards of downstream waters and shall ensure that its water quality standards provide for the attainment and maintenance of the water quality standards for downstream waters.” There is no phosphorus standard for rivers and streams in Illinois, but IEPA considers total phosphorus (TP) concentration of 0.61 mg/L as a guideline to protect aquatic life. The phosphorus standard for a lake states that TP shall not exceed 0.05 mg/L in any reservoir or lake with a surface area of 20 acres or more or in any stream at the point where it enters any such reservoir or lake.

Hoopeston Branch was listed for impairment caused by low DO. The applicable DO standard states that DO shall not be less than 6.0 mg/L during at least 16 hours of any 24 hour period, nor less than 5.0 mg/L at any time. However, Stage 2 sampling indicated that the DO standard was no longer violated, so a TMDL will not be developed for Hoopeston Branch at this time.

4.1.2 Lake Water Quality Standards

Lake Vermilion is listed on the Illinois 2004 303(d) list for use impairment caused by nutrients, siltation, organic enrichment, excessive algal growth, nitrates, and suspended solids. The water quality standards associated with the listing include TP, DO, total ammonia nitrogen, and nitrate. The total ammonia nitrogen must never exceed 15 mg/L in state waters. The total ammonia nitrogen acute, chronic, and sub-chronic standards are determined by temperature and pH in water. A review of total ammonia nitrogen in Lake Vermilion shows that there is no exceedance of the standard (including acute, chronic, and sub-chronic standards) at possible ranges of temperature and pH. Therefore, a total ammonia nitrogen TMDL will not be developed at this time.

Table 4-1 summarizes the applicable numeric water quality standards for Lake Vermilion. The State of Illinois does not have TSS or turbidity numeric standards that could be used as a surrogate for siltation impairment. Nevertheless, sedimentation appears to be a concern in Lake Vermilion because between 1976 and 1998, the lake lost 1,186 acre-feet of storage capacity. The storage loss rate is about 0.9 percent per year. Based on IEPA guidelines, the storage loss rate is classified as moderate. IEPA does not require the TMDL development for constituents without numeric standards. Therefore, a TMDL will not be developed for TSS at this time. Because phosphorus load is largely associated with TSS load, the measures implemented for phosphorus reduction may also reduce the sediment load to the lake and decrease the storage loss rate.

TABLE 4-1 WATER QUALITY STANDARDS FOR LAKE VERMILION

Parameter	Standard
Nitrate	Shall not exceed 10 mg/L
Total Phosphorus	Phosphorus as TP shall not exceed 0.05 mg/L in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more, or in any stream at the point where it enters any such reservoir or lake

Excessive algal growth is listed as a cause of impairment in Lake Vermilion. Algal biomass is commonly measured through a surrogate, Chlorophyll-a (Chl-a), which is a plant pigment. The abundance of Chl-a in water highly correlates with the amount of algae present. The State of Illinois does not have a numeric standard for Chl-a. The algal growth is directly related to excessive amounts of limiting nutrients and light availability for photosynthesis. Phosphorus is identified as a limiting nutrient in this report. Consequently, TP can be considered a surrogate indicator for excessive algal growth.

4.1.3 TMDL Endpoints

To meet all designated uses, a water body must meet the standards identified for its most sensitive use. TMDL endpoints are the numeric target values of pollutants and parameters for a water body that represent the conditions that will attain water quality standards and restore the water body to its designated uses. The most stringent standards are chosen as the endpoints for the TMDL analysis. Usually, if an applicable numeric water quality standard violation is the basis for 303(d) listing, the numeric criterion is selected as the TMDL endpoint. If the applicable water quality standard or guideline is narrative or is not protective of the designated use, a numeric water quality target must be established or adopted from site-specific water quality and biologic assessment. Table 4-2 summarizes the endpoints that will be used in the TMDL development for the North Fork Vermilion River and Lake Vermilion.

TABLE 4-2 TMDL ENDPOINTS

Parameter	TMDL Endpoint			Indicator
	North Fork Vermilion River	Hoopeston Branch	Lake Vermilion	
Total Phosphorus (mg/L)	N/A	N/A	<0.05	Direct measurement
Fecal Coliform (cfu/100 mL)	<200 (GM)	N/A	N/A	Indicator for Pathogen
Dissolved Oxygen (mg/L)	N/A	>5.0	N/A	Direct measurement
Nitrate (mg/L)	10	N/A	10	Direct measurement

4.2 DATA AVAILABILITY

From 1977 to 1998, USGS collected monthly water samples at Station 03338780 (see Figure 4-1) in the North Fork Vermilion River near Bismarck, Illinois. Continuous daily average flows are recorded at this site. Water quality constituents include TP, dissolved phosphorus (DP), ammonia nitrogen, DO, TSS, nitrite and nitrate, and fecal coliform. Data for the USGS site were retrieved from NWIS database and USEPA STORET database. IEPA collected and provided fecal coliform data at Station 03338780 from January 24, 2000 to November 04, 2003. Jordan Creek (BPGC) and Middle Branch (BPGE) are monitored during the 2001 IEPA Intensive Basin Survey. Both tributaries are listed as fully supporting aquatic life. The data is not included in this report.

As many as 26 sampling sites are located in Lake Vermillion. Only five of them monitored water quality on a regular basis since 1978. The rest of the sites either have few water quality data points or the data point is prior to 1977 so that they are not included in the analysis. The five sampling sites are RBD-1, RBD-2, RBD-3, RBD-4, and RBD-5, as shown in Figure 4-2. A topographic map is also included in Appendix C to show the site locations and surrounding areas. RBD-1 is located in the area of deep water near the Lake Vermilion dam. RBD-2 is located in the middle of the lake, 50 feet south of the old dam. RBD-3 is located in the upper portion of the lake, 500 feet north of the old dam. RBD-4 is located at the north side of the old dam. RBD-5 is located near the southeast overbank of the lake. Water quality constituents from the five sites include TP, ammonia nitrogen, nitrate and nitrites, total Kjeldahl nitrogen, DO, and Chlorophyll-a. Data up to 1998 were retrieved from the USEPA STORET site. Data after 1998 were provided by IEPA. Illinois State Water Survey (Lin and Bogner, 2004) collected water quality data from May 8, 2000, through April 19, 2001, as part of a diagnostic study. In that report, RBD-5 was located at the upstream end of the lake. Both IEPA and Illinois State Water Survey (ISWS) collected water samples at a site near USGS site (03338780) in the North Fork Vermillion River inflow (RBD-T2) and the lake spillway (RBD-T1) to assess the water quality inflow and outflows. Collectively, water quality data is available for Lake Vermilion from 1978 to 2002.

In addition, the IEPA Facility-Related Stream Survey event collected microvertebrate and water quality data at 8 locations at the vicinity of the Hoopeston STP. The data resulted in the listing of Hoopeston Branch and BPG10 for impairment.

FIGURE 4-1 WATER QUALITY SAMPLING SITES

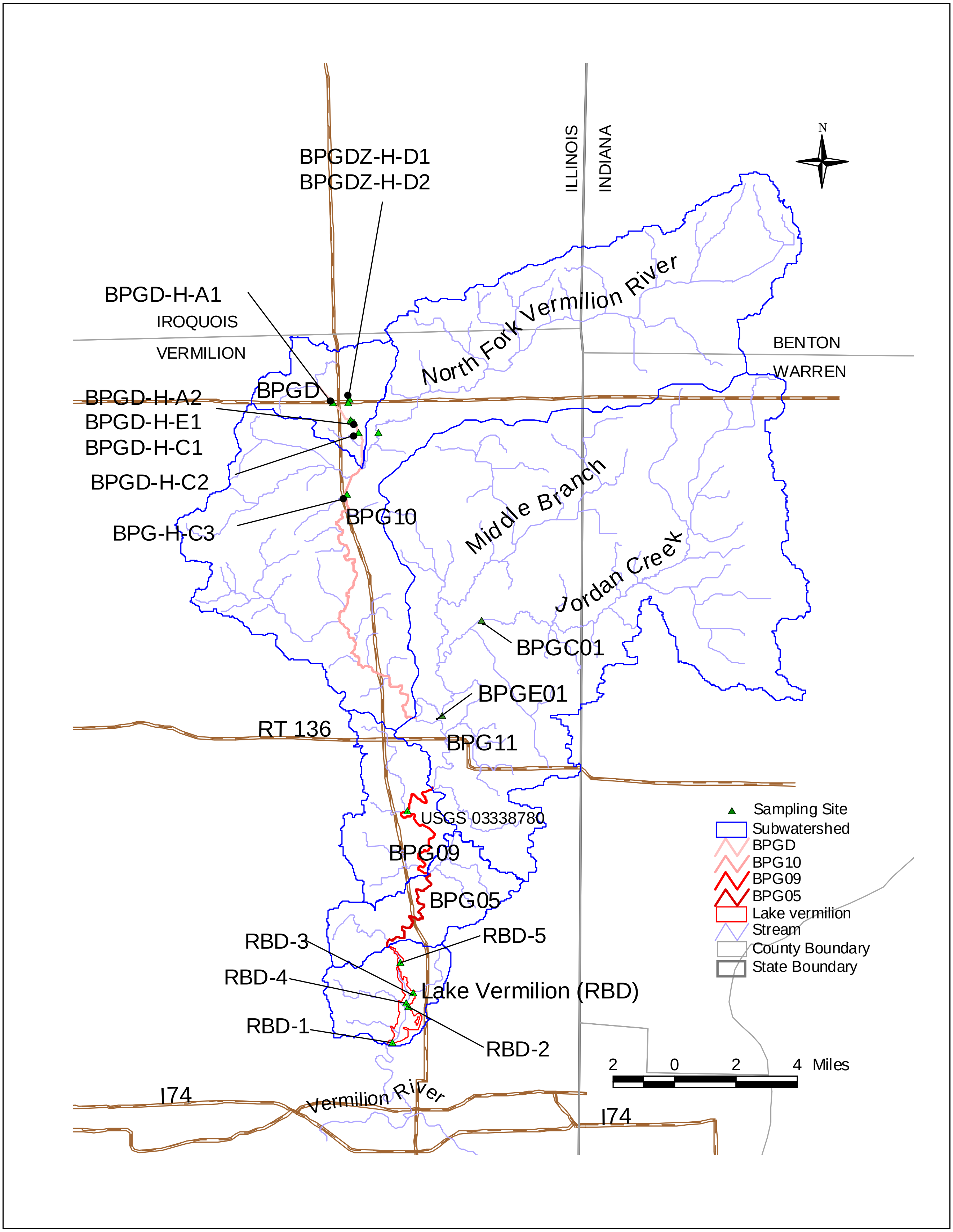
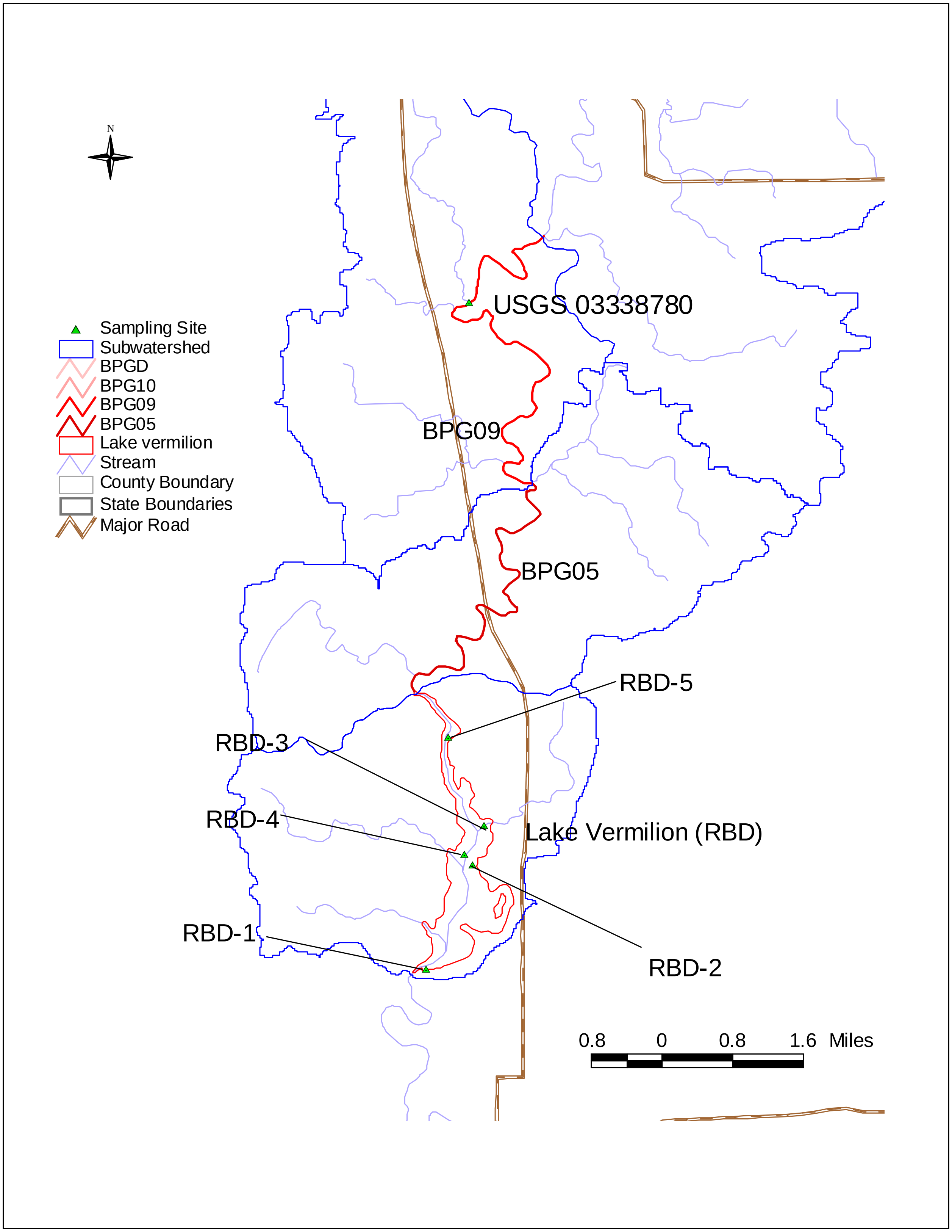


FIGURE 4-2 LOCATIONS OF SAMPLING SITES IN LAKE VERMILION



4.3 ASSESSMENT OF WATER QUALITY DATA

This section discusses the pollutants of concern for the listed segments: BPGD, BPG09, BPG05, and RBD. The available water quality data is analyzed and assessed to verify the impairments of the listed segments by comparing observed data with water quality standards or appropriate targets. The potential spatial and temporal variation of water quality conditions is evaluated for the river segment and the lake.

4.3.1 Hoopeston Branch (BPGD)

The BPGD segment is assessed based on 2002 Facility-Related Stream Survey (FRSS) data. Results from the 2002 survey indicated slightly impaired conditions within Hoopeston Branch upstream and downstream of the STP. Severely impaired conditions to the biotic communities were also recorded for Hoopeston Ditch (IEPA, 2003). General use water quality standards were not met for dissolved oxygen on Hoopeston Branch, according to FRSS data collected in September 2002. A DO concentration of 4.7 mg/L was recorded, violating the Illinois DO standards for general use.

The Stage 2 water quality sampling in BPGD indicated that the DO standard was no longer violated, so a TMDL will not be developed for this segment at this time.

4.3.2 North Fork Vermilion River

This section assesses nutrient and fecal coliform in North Fork Vermilion River based on data from the USGS sampling site at Bismarck, Illinois (03338780), located in BPG09. BPG05 is assessed based on extrapolation of data from the upstream site in BPG09 and the downstream site in RBD. No TMDL is developed for BPG10 because no numeric water quality standard is available for total nitrogen. Phosphorus is assessed in the North Fork Vermilion River because of the TP listing for Lake Vermilion.

4.3.2.1 Phosphorus

Phosphorus is an important component of organic matter. As a constituent of nucleic acids in all cells, it is vital for all organisms. In streams and rivers, phosphorus is usually the limiting nutrient of photosynthetic production of algae. Phosphorus enters streams and rivers not only through stormwater runoff, but also through natural mineralization of phosphates in the soil and rock and man-made sources. Phosphorus is measured in two ways: as total phosphorus (TP) and as dissolved phosphorus (DP). Streams with high TP and low DP levels usually have the most phosphorus input from nonpoint source pollution, such as agricultural runoff. Since phosphorus can be bound to sediments such as clay, phosphorus is measured through the suspended solids potency. DP measurements provide insights into how much of the phosphorus entering a stream is from point sources and diffusive sources such as livestock operations and animal feedlots or septic systems. Untreated wastewater can have phosphorus concentrations as high as 10 mg/L and feedlot overflow can contribute up to 4 or 5 mg/L.

The Illinois water quality standard requires that TP not exceed the 0.05 mg/L in any stream at the point where it enters any reservoir or lake with a surface area of 20 acres or more. Although the listed North Fork Vermilion River segment is about 3 miles upstream of the entrance to the lake, it seems reasonable to set the segment's phosphorus target at the 0.05 mg/L because there is not likely to be any dramatic deposition of particulate and dissolved phosphorus in the short distance from the listed river segment to the entrance. Figure 4-3 presents the TP data at Bismarck, Illinois (03338780). It shows that TP is frequently higher than the lake standard.

Figure 4-4 shows the interannual variation in TP concentration. There is no noticeable increasing or decreasing trend from 1978 to present. The average annual concentration goes up and down, likely attributed to the precipitation change. The average annual concentrations exceed the lake phosphorus standard in almost every year.

Figure 4-5 presents the monthly descriptive statistics for TP in the North Fork Vermilion River. The month of April has the overall lowest TP during the spring season, and then TP starts to increase through the summer growing season reaching a higher level. TP decreases slightly in late fall and early winter. Phosphorus is fairly high in January through March, with a large deviation as indicated by the range between the 25th and 75th percentiles, while flow in the river is near the annual average (see Figure 3-3). A possible explanation is that the phosphorus sources may include steady sources other than precipitation induced overland runoff. This explanation seems appropriate based on a review of the ratio of DP to TP in Table 4-3.

FIGURE 4-3 PHOSPHORUS CONCENTRATIONS IN NORTH FORK VERMILION RIVER AT BISMARCK (1978-2002)

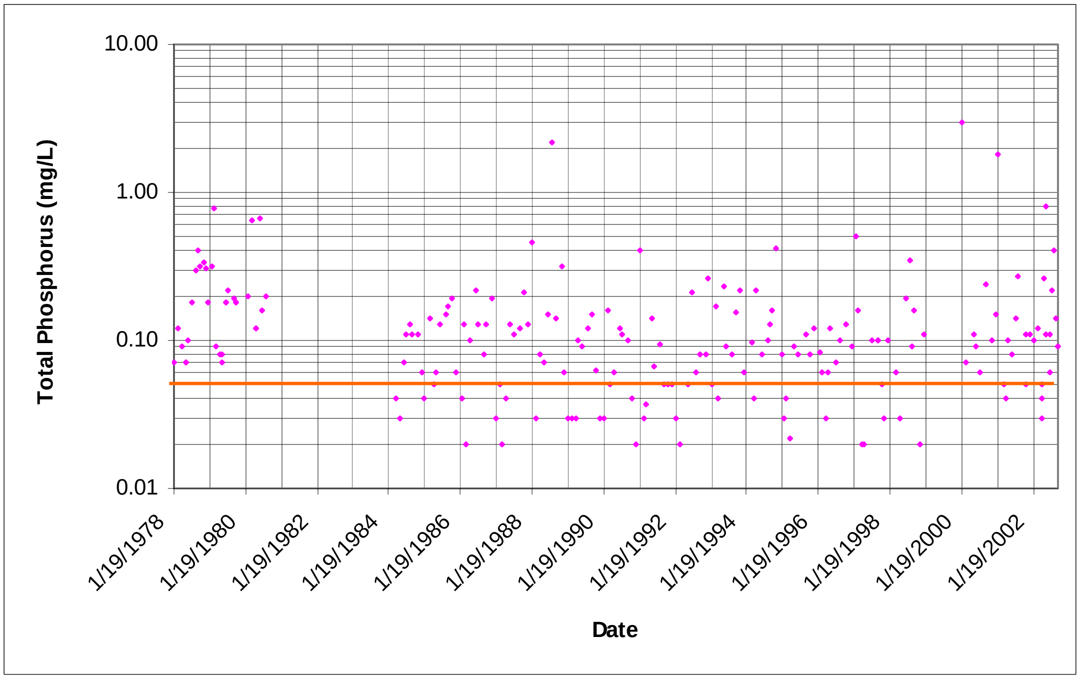


FIGURE 4-4 INTERANNUAL VARIATION IN TOTAL PHOSPHORUS CONCENTRATIONS NORTH FORK VERMILION RIVER (BPG09)

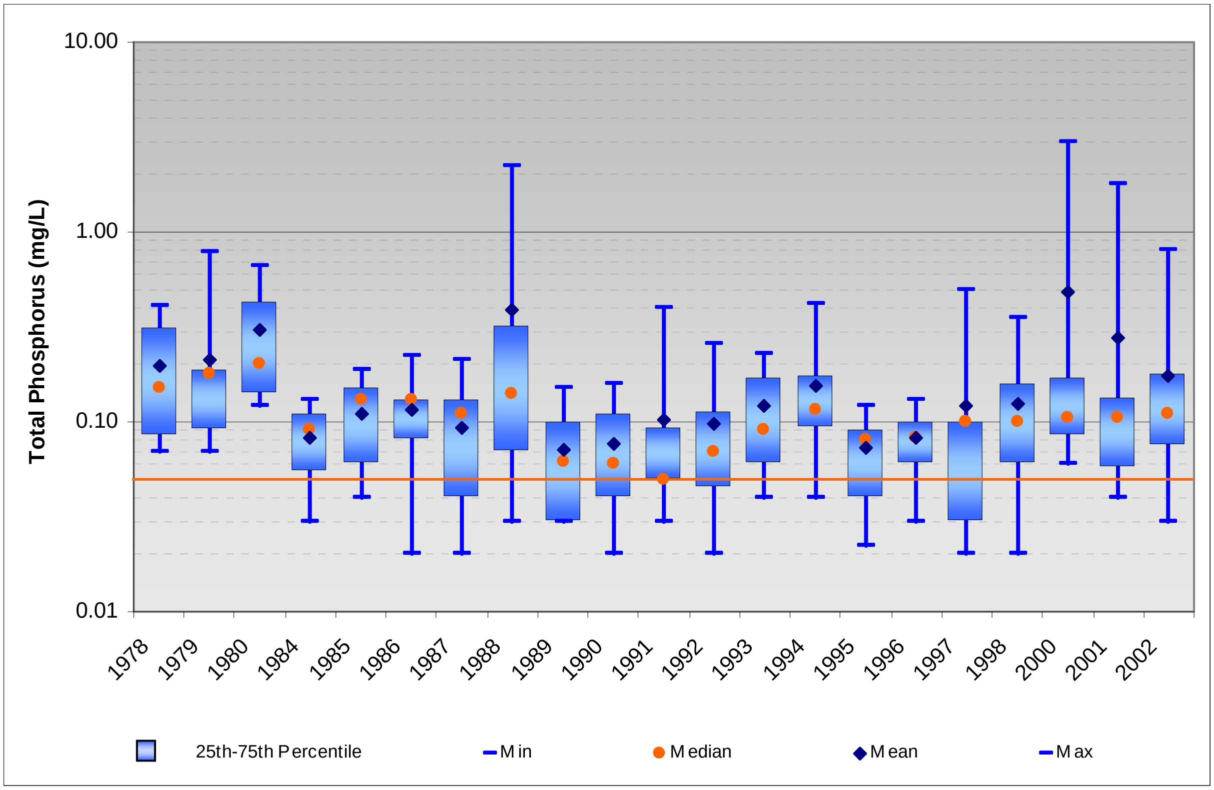
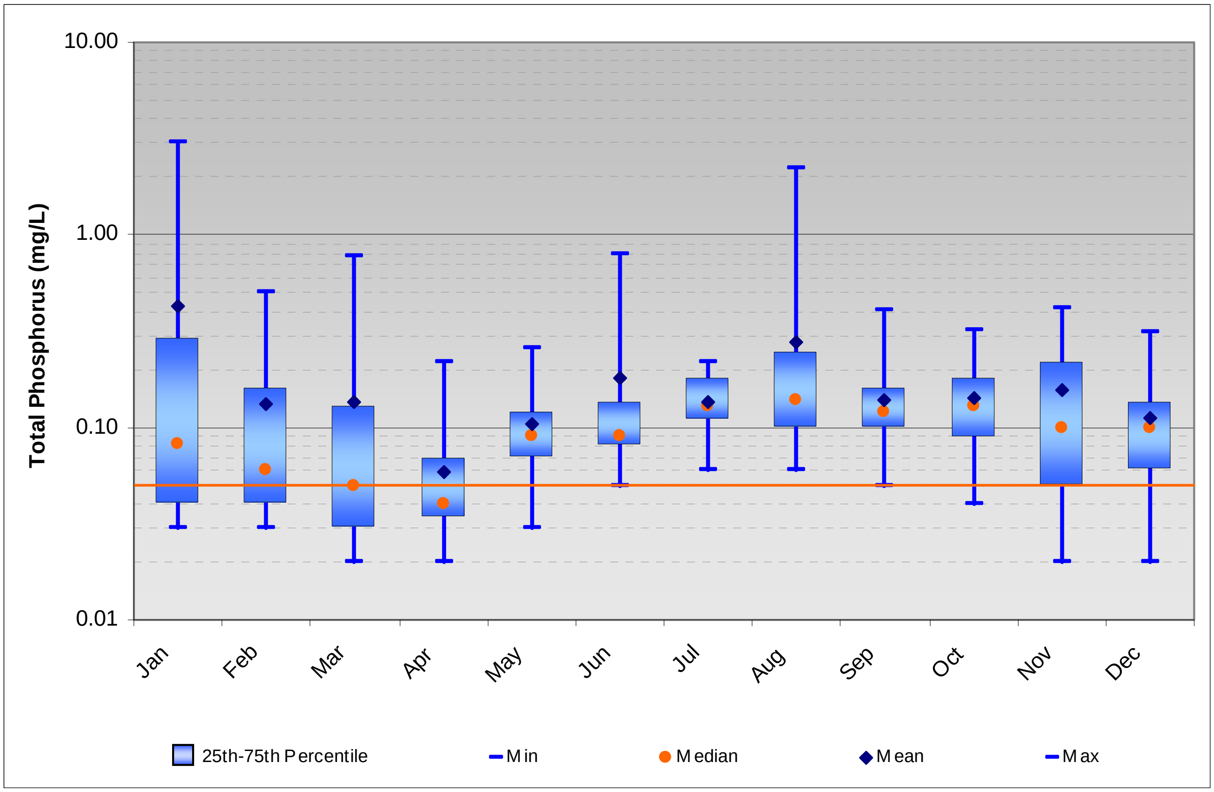


FIGURE 4-5 MONTHLY TOTAL PHOSPHORUS CONCENTRATIONS NORTH FORK VERMILLION RIVER (BPG09)



DP is the portion of TP that is biologically available for plant uptake. It is the soluble form of phosphorus that is not absorbed to soil particles. In rivers and lakes with short retention time, DP concentration is crucial for plant growth. Table 4-3 summarizes the monthly DP and TP concentrations at Bismarck. The average monthly DP is about 0.08 versus TP at 0.13, meaning that an average 60 percent of TP concentration is in the dissolved form. This ratio implies that nonpoint sources other than soil erosion may contribute to TP. A close review of Table 4-3 shows that the DP percentage is relatively higher in January and February than March through July, when the flow is higher and runoff-induced sediments deliver more particulate phosphorus to the river. As the flow decreases in October through December, DP increases as the steady low flow sources such as septic systems account for a larger percentage of the load. DP concentration and percentage is highest in August. Groundwater seepage may be another source of dissolved phosphorus. Speculation on sources needs to be further verified as more site-specific information becomes available in the next stage of TMDL development.

TABLE 4-3 MONTHLY AVERAGE DISSOLVED AND TOTAL PHOSPHORUS CONCENTRATIONS,
NORTH FORK VERMILION RIVER (BPG09)

Month	DP	TP	Percentage of TDP in TP
Jan	0.08	0.13	60
Feb	0.07	0.12	63
Mar	0.04	0.11	40
Apr	0.03	0.06	44
May	0.06	0.10	57
Jun	0.06	0.15	40
Jul	0.07	0.13	56
Aug	0.23	0.29	78
Sep	0.09	0.12	74
Oct	0.08	0.10	77
Nov	0.10	0.15	66
Dec	0.06	0.10	61
Average	**0.08**	**0.13**	**60**

4.3.2.2 Nitrate Nitrogen

The ingestion of excessive amounts of nitrate can cause adverse health effects in very young infants and susceptible adults. Consequently, the State of Illinois has set a maximum acceptable level of 10 mg/L as the food processing and public water supply standard. The most common sources of nitrate are agriculture overuse of fertilizer, municipal and industrial wastewaters, refuse dumps, animal feed lots, and septic systems. Other sources include runoff or leachate from manured or fertilized agricultural lands and urban drainage. The fertilizers and wastes are sources of nitrogen-containing compounds that are converted to nitrates in the soil. These sources also result in elevated levels of nitrate in groundwater. Nitrates are extremely soluble in water and can move easily through soil into the drinking water supply. In addition, nitrogen compounds are emitted into the air by power plants and automobiles and are carried from the atmosphere to the earth with rainfall. Once nitrate is formed, its movement in soil and its potential to contaminate groundwater depend on several factors including soil characteristics, location and characteristics of the underground water formations (aquifers), and climatic conditions. Nitrate nitrogen is evaluated in North Fork Vermilion River BPG05 because it is listed as a cause for the partial impairment in Lake Vermilion for food processing and public water supply. The North Fork Vermilion River Segment BPG05 upstream of the lake is a potential loading source of nitrate nitrogen for the lake.

ISWS (Keefer, 2003) collected nitrate nitrogen data at Bismarck, Illinois, from April 2000 to March 2002. Figure 4-6 presents the variation of the nitrate nitrogen over 2 years. The elevated nitrate nitrogen concentrations are observed from February to June, with the peak in June. From July to December, nitrogen nitrate concentrations are lower. The trend of nitrate nitrogen follows the flow pattern fairly well, meaning the nitrate nitrogen exceedance in Lake Vermilion may be caused by nonpoint sources although other sources are also significant.

4.3.2.3 Fecal Coliform

North Fork Vermilion River (BPG09) is listed for pathogen impairment. Fecal coliform is used as the indicator for pathogens in TMDL development. Various point and nonpoint sources may potentially contribute to fecal coliform loads to the North Fork Vermilion River. Point sources include wastewater treatment plants and households that are served by wastewater disposal systems. Because of the very small amount of discharge and the fact they are treated, these point sources do not pose a primary concern in the North Fork Vermilion River watershed, but they do contribute to the fecal coliform load. In addition, septic systems that discharge to tile drains are potential fecal coliform sources in the North Fork Vermilion River watershed. The further data and information on wastewater treatment plant and private wastewater disposal systems are crucial to quantify loading from these point sources. Nonpoint sources that contribute fecal coliform load include septic systems, urban runoff, wildlife, animal feedlots, and manure applications.

Fecal coliform data collected at Bismarck from 1978 to 1998 was used for listing the North Fork Vermilion River on the 2004 303(d) List. The data were collected on a monthly basis. This sampling approach cannot facilitate the calculation of the geometric mean based on the standard, which requires a minimum of 5 samples within 30 days. However, the monthly data from 1978 to 1998 shows that fecal coliform concentrations constantly exceeded the 200 cfu/100 mL standard and the 10 percent frequency standard of 200 cfu/100 mL. The maximum fecal coliform concentration is as high as 20,000 cfu/100 mL. As a result, North Fork Vermilion River was listed as partially supporting its designated use because of elevated fecal coliform concentrations. Figure 4-7 shows the fecal coliform concentration trend from 1978 to 1998. There is no obvious decreasing or increasing pattern.

Figure 4-8 presents the relationship between fecal coliform and flow. The graph reveals that the fecal coliform concentration exceeds the geometric mean standard of 200 cfu/100 mL in both low flow and high flow conditions. Fecal coliform was present at 1,700 cfu/100 mL at a low flow rate of about 11 cfs, when no overland runoff would occur. In addition, there appears to be a positive correlation between fecal coliform concentrations and flow when the flow is higher than 100 cfs.

Figure 4-9 shows the variation of monthly average fecal coliform concentration within a year based on the data from all years. The average fecal coliform concentration reached the highest values in the low flow months of July, August, and September. This implies that low flow steady sources contribute to the elevated fecal coliform concentration.

FIGURE 4-6 MONTHLY NITRATE NITROGEN CONCENTRATIONS NORTH FORK VERMILION RIVER AT BISMARCK

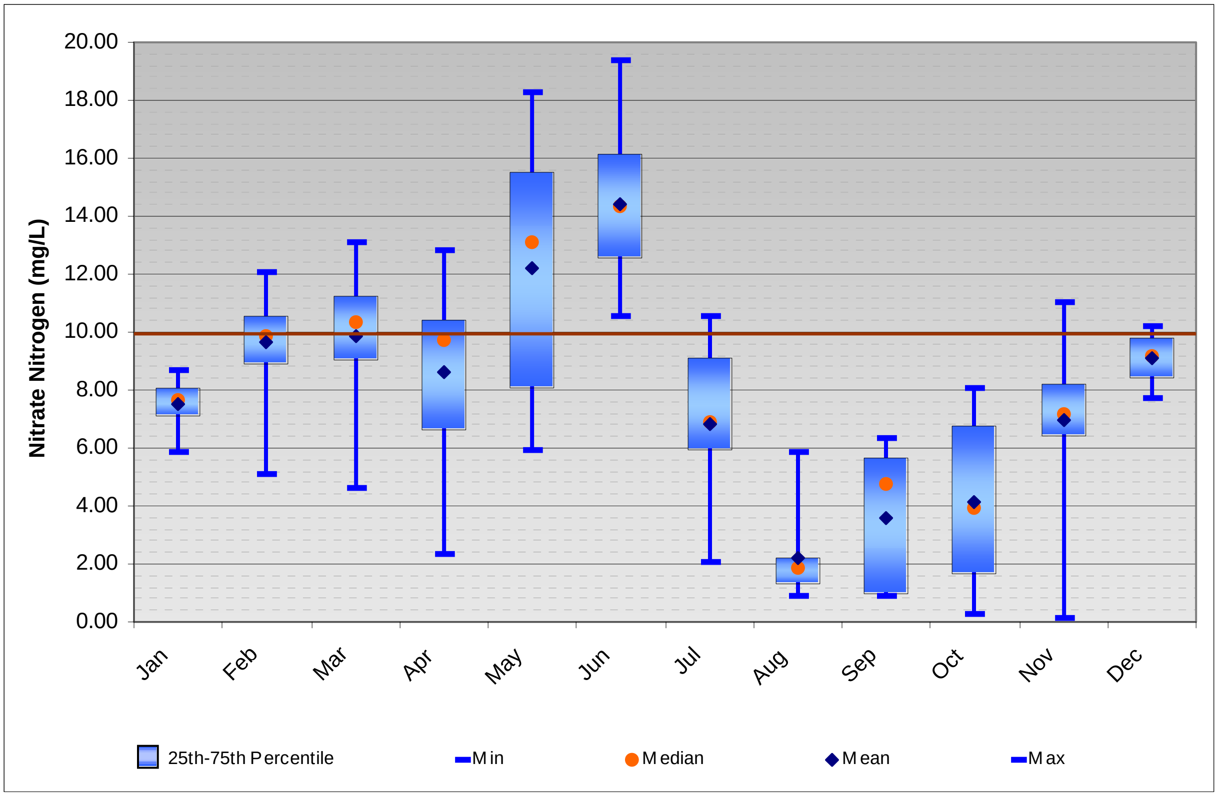


FIGURE 4-7 FECAL COLIFORM CONCENTRATIONS NORTH FORK VERMILION RIVER AT BISMARCK (1978 TO 1998)

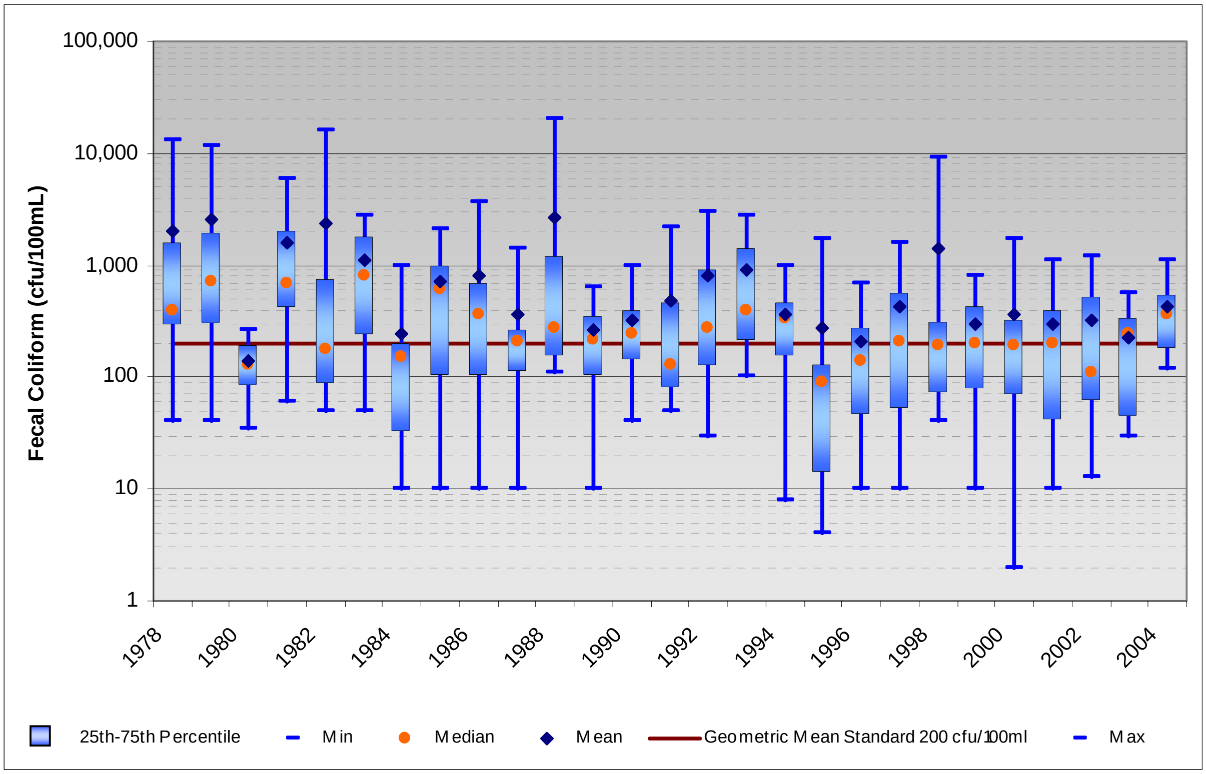


FIGURE 4-8 RELATIONSHIP BETWEEN FECAL COLIFORM CONCENTRATIONS AND FLOW RATE

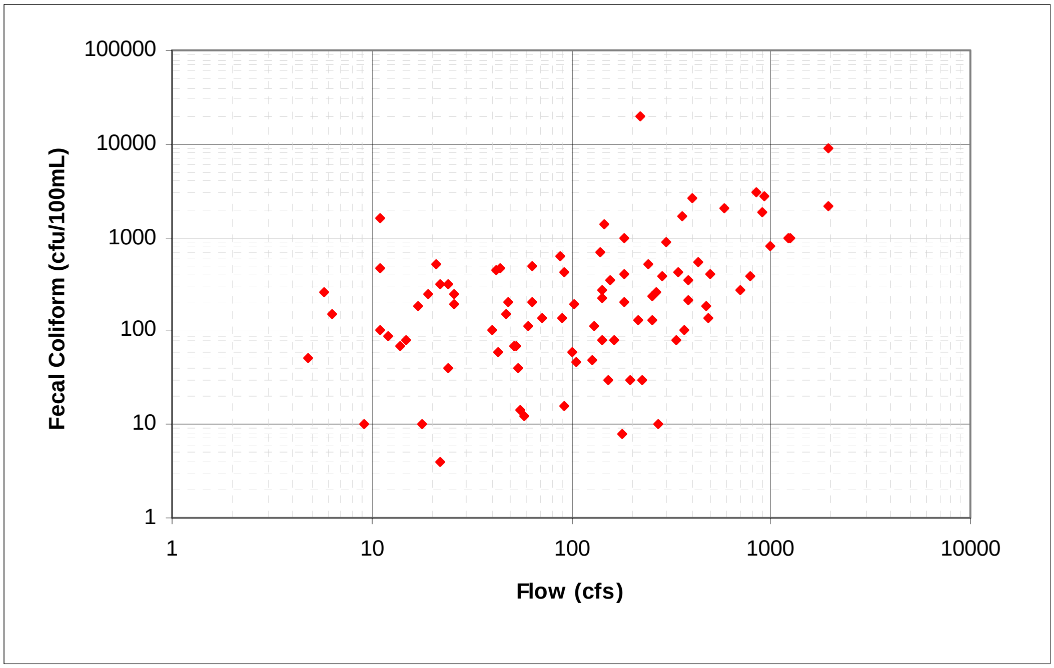
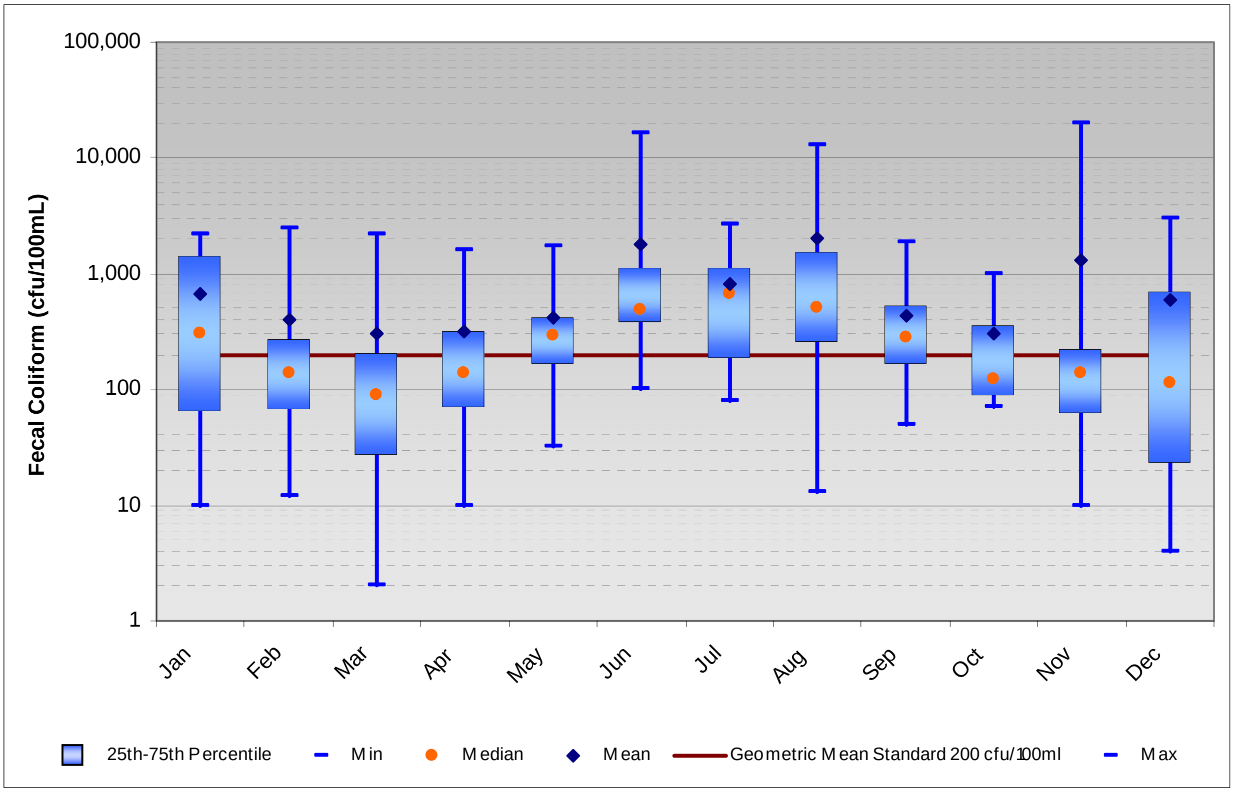


FIGURE 4-9 MONTHLY FECAL COLIFORM CONCENTRATIONS NORTH FORK VERMILION RIVER (BPG09)



4.3.3 Lake Vermilion (RBD)

This section presents the water quality assessment in Lake Vermilion using the available data from the RBD-1, RBD-2, RBD-3, RBD-4, and RBD-5 sites.

4.3.3.1 Phosphorus

Phosphorus was not explicitly listed as the cause of impairment in the 2004 IEPA 303(d) list. TP, however, is used as an indicator for organic enrichment, low DO, and excessive algae growth in Lake Vermilion (see Section 4.1.2). Figure 4-10 presents TP data collected at various sites in the lake from 1977 to 2001. RBD-T2 is located upstream of the lake in North Fork Vermilion River. The figure indicates that at all locations, TP concentrations exceed the water quality standard of 0.05 mg/L.

TP concentrations at RBD-3 and -4 are higher than other locations. One possible explanation is that TP concentrations at these two locations are affected by direct inflow from two nearby tributaries, which may provide sufficient phosphorus load to elevate the concentration locally.

FIGURE 4-10 TOTAL PHOSPHORUS CONCENTRATIONS IN LAKE VERMILION (1977-2003)

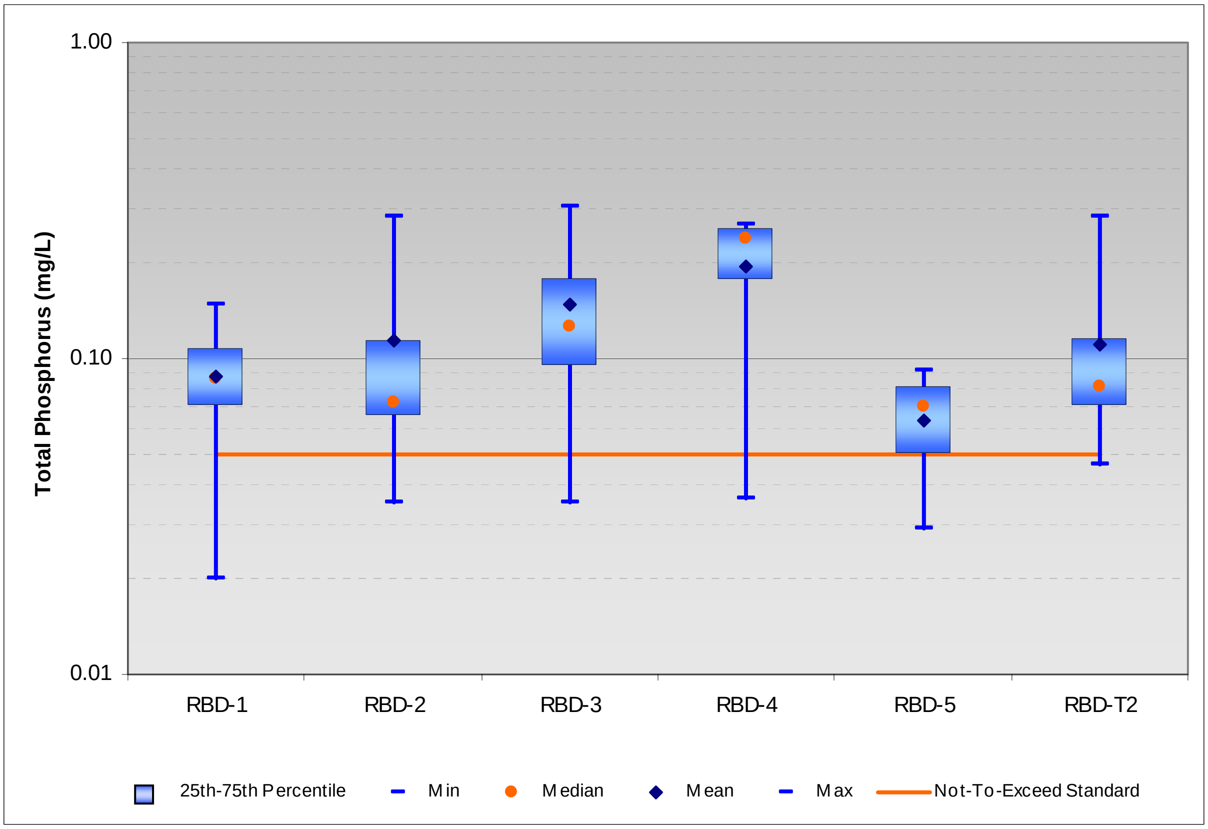


Figure 4-11 presents the variation of monthly average TP concentration in Lake Vermilion, based on data from all locations. The monthly average TP concentrations exceed the Illinois water quality standard from March to October. The monthly average TP is highest in June when flow is relatively high (Figure 3-3). The data indicate that the phosphorus load from non-erosion related sources may be an important load component for Lake Vermilion.

Table 4-4 summarizes the monthly average DP and TP concentrations in the lake. The trend is slightly different from the North Fork Vermilion River, most likely because of algae uptake, settlement, and the long retention time of the lake.

FIGURE 4-11 MONTHLY AVERAGE TOTAL PHOSPHORUS CONCENTRATION IN LAKE VERMILION

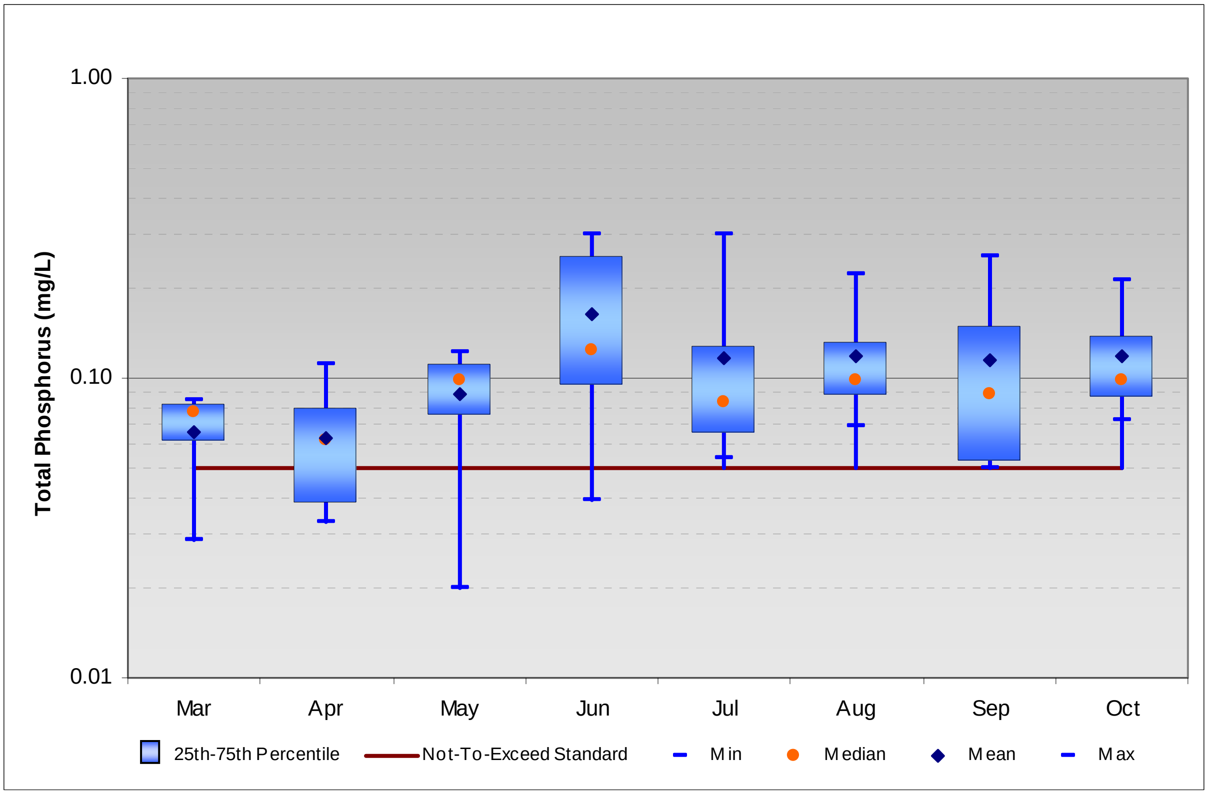


TABLE 4-4 MONTHLY AVERAGE DISSOLVED PHOSPHORUS AND TOTAL PHOSPHORUS CONCENTRATIONS IN LAKE VERMILION

Month	DP	TP	Percent DP
Apr	0.01	0.04	22
May	0.06	0.11	56
Jun	0.06	0.18	33
Jul	0.01	0.07	20
Aug	0.03	0.10	28
Sep	0.03	0.08	31
Oct	0.02	0.09	25
Average	**0.03**	**0.09**	**30**

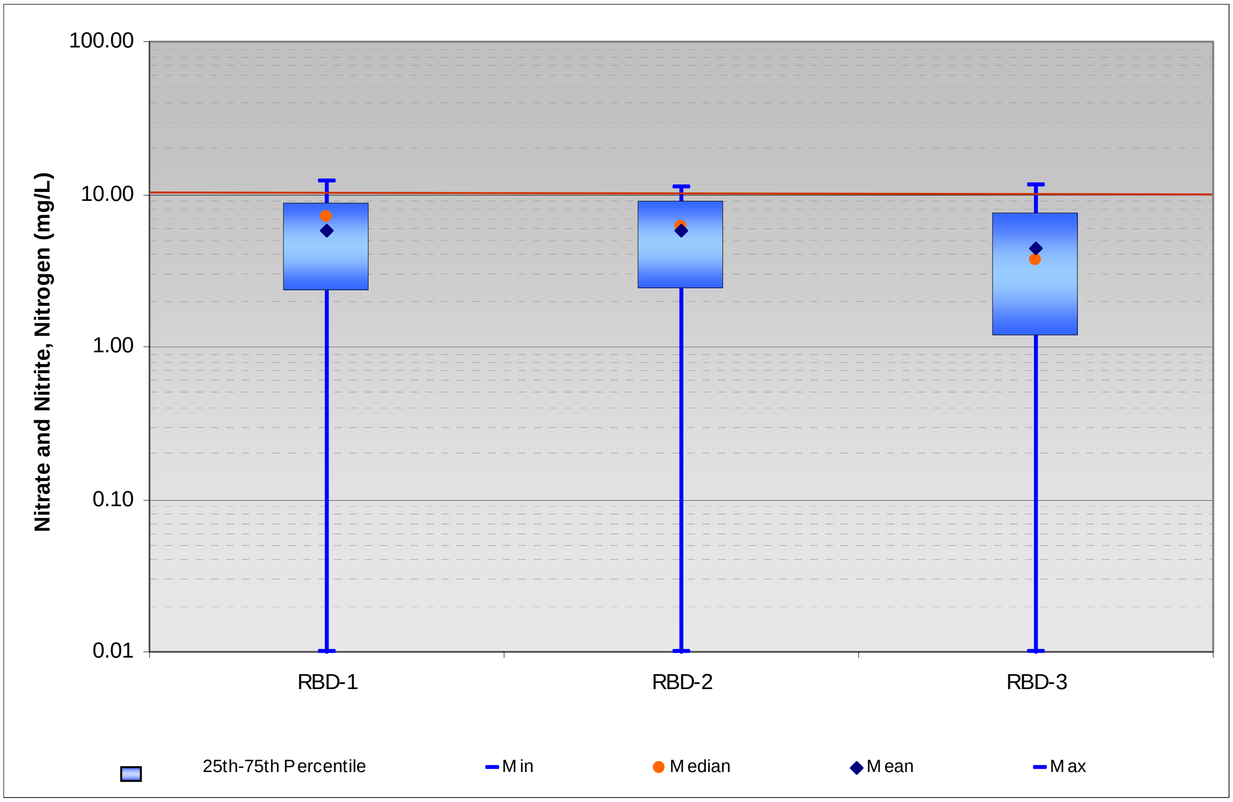
Source: IEPA 2001

Lake mixing dynamics can greatly affect water quality in terms of chemical (nutrient) availability and the concentrations, location, and forms in which chemicals are present. Phosphorus settles out of the water column to the lake bottom as particulate-phosphorus and is bound to the lake bottom sediment. This phosphorus generally is not available for aquatic plant growth and is not a water quality problem. However, anoxic conditions at the lake bottom can result in the release of bound phosphorus in the dissolved form. If no subsequent mixing occurs in the water column, the dissolved phosphorus will remain at the lake bottom. If mixing occurs (from wind action, tributary inflow, fish activity, or seasonal lake turnover following thermal stratification), the dissolved phosphorus is brought up to the surface, where it is available for algal uptake and growth.

4.3.3.2 Nitrate Nitrogen

Nitrate nitrogen is a listed cause of impairment in Lake Vermilion. The water quality standard for drinking water supply sources is 10 mg/L. Because nitrite nitrogen seldom appears in concentration greater than 1 mg/L and tends to transform to nitrate, the nitrate and nitrite concentration data is used to verify the exceedance. Figure 4-12 presents all the nitrite and nitrate data from RBD-1, RBD-2, and RBD-3. Equivalent data points are not available for RBD-4 and RBD-5. The maximum observed nitrite and nitrate concentration exceeds the standards at all three locations, although the average concentrations do not exceed the standard. As discussed in Section 4.3.2.2, the nitrate nitrogen concentration exceeds the standard of 10 mg/L in North Fork Vermilion River at Bismarck. The nitrate loads from the North Fork Vermilion River may be the main reason for the exceedance in Lake Vermilion.

FIGURE 4-12 NITRITE AND NITRATE CONCENTRATIONS IN LAKE VERMILION



4.3.3.3 Limiting Nutrients

A limiting nutrient is a nutrient or trace element that is essential for plants to grow but that is not available in quantities required by plants and algae to increase in abundance. Therefore, if more of a limiting nutrient is added to an aquatic ecosystem, larger algal populations will develop until nutrient limitation or another environmental factor (such as light or water temperature) curtails production at a higher threshold than previously possible. Reducing the limiting nutrient can lower the eutrophication level in the lake and improve the water quality. The stoichiometry ratio of nitrogen to phosphorus (TN:TP) in phytoplankton biomass is about 7.2:1. If the N:P ratio in a water body is less than 7.2, nitrogen is the limiting nutrient. Otherwise, phosphorus is the limiting nutrient. Table 4-5 summarizes the average TN:TP ratio in Lake Vermilion, based on the IEPA 2001 sampling data. The average TN:TP ratio is about 156.54. Therefore, phosphorus is considered to be the limiting nutrient for plant growth in Lake Vermilion. TP contributes to lake eutrophication (fertility) and algal blooms. Nitrogen is also an essential nutrient for plant growth; however, it is often so abundant that it does not limit algal growth, especially in water systems with low retention times (fast-flowing systems). Some species of algae can also "fix" their own atmospheric nitrogen and do not need another nitrogen source. With nitrogen abundant and available, an increase in limiting nutrient, TP, results in rapid algal growth.

TABLE 4-5 AVERAGE TOTAL PHOSPHORUS AND TOTAL NITROGEN CONCENTRATIONS IN LAKE VERMILION

Station	Date	TP	TN	TN:TP
RBD-1	03/28/01	0.08	10.46	129.14
RBD-1	03/28/01	0.08	10.89	129.64
RBD-1	04/19/01	0.09	13.68	157.24
RBD-1	04/19/01	0.11	11.25	100.45
RBD-1	04/26/01	0.06	10.02	161.61
RBD-1	04/26/01	0.07	9.74	141.16
RBD-2	03/28/01	0.07	10.91	151.53
RBD-2	04/19/01	0.10	11.25	114.80
RBD-2	04/26/01	0.07	9.98	151.21
RBD-5	03/28/01	0.03	10.74	370.34
RBD-5	04/19/01	0.07	11.80	166.20
RBD-5	04/26/01	0.09	9.57	105.16
Average		**0.08**	**10.86**	**156.54**

4.3.3.4 Trophic Index

Trophic status (or "fertility" status) is often used to describe the nutrient enrichment status of a lake ecosystem. Higher trophic status is associated with more nutrient availability and higher productivity. Generally, mesotrophic to eutrophic lakes are considered to be the best environments for supporting a variety of uses, including fishing, aquatic life support, swimming, boating, and other uses. Excessive nutrient loads can result in nuisance algal blooms and excessive turbidity. Very low nutrient status also can limit the support of aquatic life. Carlson Trophic State Index (TSI) values are used as indicators of trophic status, which can be calculated using TP concentrations, Chl-a concentrations, or Secchi disk depth respectively (Carlson, 1977). Generally, TP is considered the best indicator of *potential* trophic status, especially when the TP is the limiting nutrient. The diagram in Figure 4-13 depicts the relationship between the TSI, trophic status, and nutrient status.

Table 4-6 summarizes the TSI in Lake Vermilion, based on TP, Chl-a, and Secchi disk depth. Using the TP-based TSI, Lake Vermilion is classified as hypereutrophic. This conclusion is similar to that of Lin and Bogner (2004).

FIGURE 4-13 TSI RELATIONSHIP TO LAKE FERTILITY

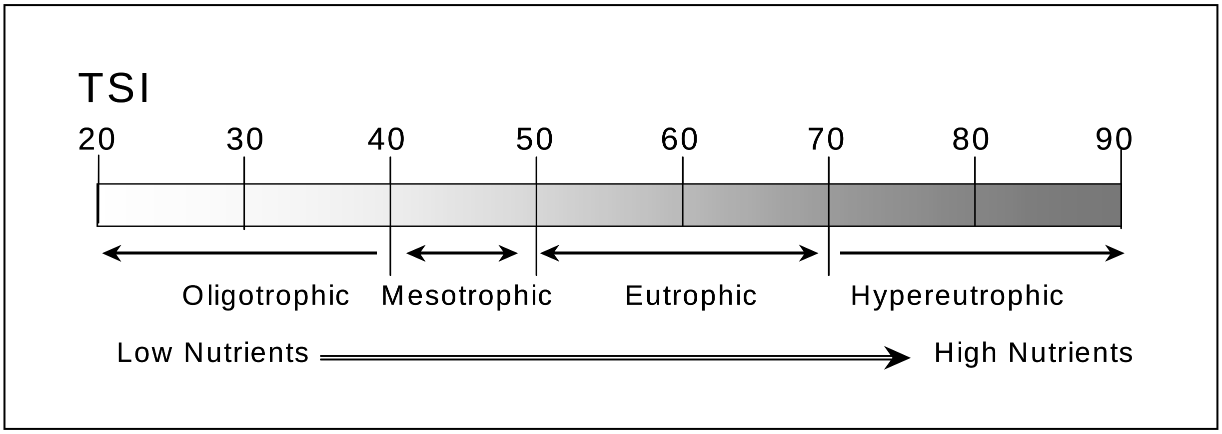


TABLE 4-6 TROPHIC STATE INDEX FOR LAKE VERMILION

Location	TSI (for Total Phosphorus)	TSI (for Chl-a)	TSI (for Secchi Depth)
TSI-1	68.7	62.0	71.9
TSI-2	72.5	65.9	75.2
TSI-3	76.2	65.9	78.1
TSI-4	80.1	no data	78.6
TSI-5	64.0	60.7	72.1
TSI-T2	72.1	no data	no data
Average	72.3	63.6	75.2

4.3.3.5 Excessive Algal Growth/Chlorophyll-a

Lake Vermilion is listed for impairment due to excessive algal growth. Chl-a, as an indicator for algal growth, is the dominant pigment in the algal cell and is commonly used as a surrogate measurement for algae. Algal blooms are also a direct cause of low DO related to nutrient enrichment. The narrative water quality standard for general use in the State of Illinois requires that waters of the state shall be free from algal growth other than natural origin. Figure 4-14 shows the Chl-a concentration at five sampling locations. Chl-a concentrations do not show large spatial variation, although stations 2 and 3 near the center of the lake have greater ranges of unmeasured Chl-a. The maximum Chl-a concentration of 170 ug/L occurred at RBD-3.

Figure 4-15 shows the observed monthly average Chl-a concentration values in Lake Vermilion. The figure indicates that the average Chl-a concentration is slightly higher in late summer and fall than the rest of the year. The highest observations, however, occurred in June.

FIGURE 4-14 CHLOROPHYLL-A CONCENTRATIONS IN LAKE VERMILION

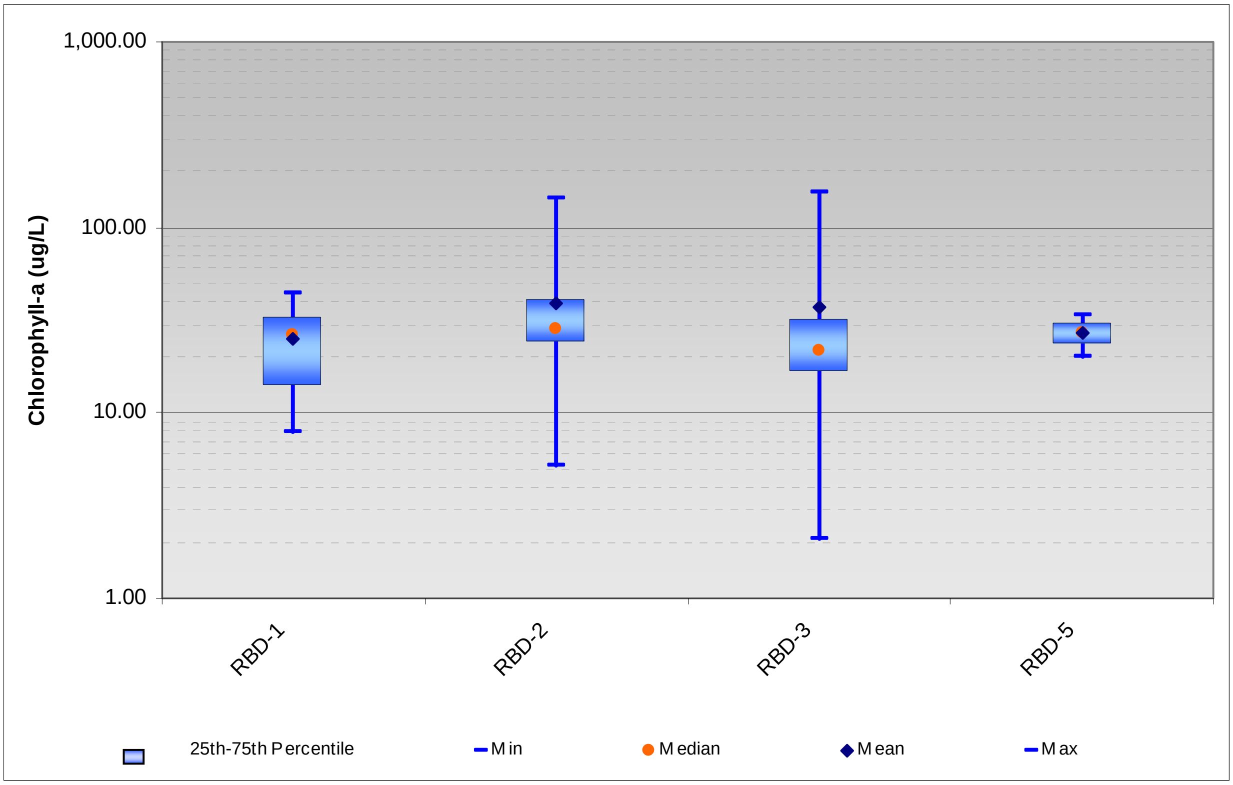
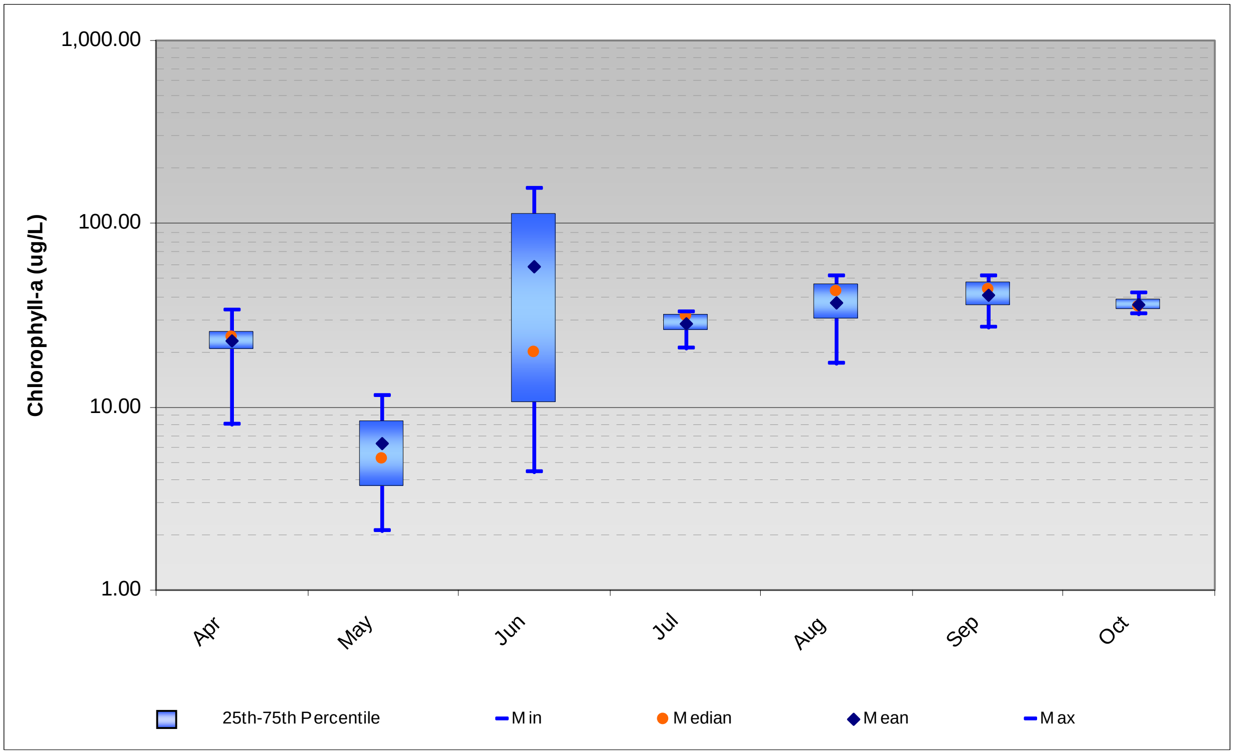


FIGURE 4-15 MONTHLY AVERAGE CHLOROPHYLL-A CONCENTRATIONS IN LAKE VERMILION



5.0 SOURCE ASSESSMENT

This section discusses point and nonpoint sources that potentially contribute to the impairment of the North Fork Vermilion River and Lake Vermilion.

5.1 NONPOINT SOURCES

The Illinois 2004 303(d) List identified agriculture (crop related, non-irrigated crop production) and hydrologic/habitat modification (flow regulation, stream bank modification, destabilization, recreation, salt storage, and unknown sources) as sources of nutrient loads to Lake Vermilion. Sources of pathogens to the North Fork Vermilion River have not been identified. Row crop agriculture is a common source of sediment and nutrient loads and is prevalent in the watershed. Overall, about 96 percent of the watershed is agricultural land. Crops primarily consist of corn and soybean rotations. Fertilizers commonly used in the watershed include anhydrous ammonia, ammonium phosphate, and potash. Fertilizers are applied in the fall and spring with a variety of application methods (Tetra Tech, 2004b).

Animal feedlots are another potential source of nutrient loads and pathogens. According to local Natural Resources Conservation Services (NRCS) staff, only 9,063 animal units were distributed among 217 farms in Vermilion County in 1997. Only five farms had more than 200 animal units, and only one farm had more than 500 animal units. No farm had more than 1,000 animal units.

Soils in the North Fork Vermilion River watershed have a relatively low permeability of 0.5 inch per hour. Rainfall does not easily infiltrate low permeability soils, and the resulting overland runoff rates may be high. Increased overland runoff typically results in larger nutrient and sediment loads to receiving water bodies. The absence of cropland buffer and filter strips in agricultural areas may not allow for adequate trapping of particles, uptake of dissolved nutrients, and infiltration of water and nutrients. Furthermore, grazing areas and pastureland may be crossed by small tributaries that are damaged and degraded by livestock. The 2004 Illinois Soil Conservation Transect Survey Summary indicates that about 15 percent of the points (locations) surveyed are still exceeding tolerable soil loss levels (Illinois Department of Agriculture, 2004). Vermilion County recorded 13 percent of the survey points exceeding tolerable soil loss levels, slightly lower than the state average. Vermilion County, however, has a high percentage (89 percent) of conventional tillage in corn fields, compared to the state average of 35.5 percent. The need for soil management is warranted to lower the soil loss level. It was also observed that the State average ephemeral and/or gully erosion increased in the past 8 years. Although this may be partially attributed to heavy rainfall intensity, the disturbance of soil surface may have contributed to the increased erosion.

Private septic systems are prevalent in Vermilion County and are another potential source of nutrient, sediment, and pathogen loads. Septic systems can potentially leach nutrients into the groundwater and can contaminate surface water if the system is not functioning properly. Except for residents of Danville, Rossville, and Hoopeston, all residents in the watershed use septic systems, for which the population is estimated to be 7,560, based on urban and nonurban population data shown in Tables 2-2 and 2-3 (Tetra Tech, 2004c). According to U.S. Census data, each household represents an average of 2.3 people; therefore, about 3,300 septic systems exist in the watershed. Only septic systems installed after 1970 are permitted. The number of permitted and nonpermitted septic systems in the watershed was determined as follows. There are 7,560 permitted septic systems in Vermilion County, and 1,013 permitted septic systems in Warren County (Tetra Tech, 2004c and d). Assuming permitted septic systems are distributed evenly throughout the county, and knowing that 21 percent of Vermillion County is in the watershed and 19 percent of Warren County, Indiana is in the watershed, about 1,767 permitted septic systems are located in the watershed. By subtracting 1,767 from 3,300, there are about 1,533 nonpermitted septic systems in the watershed. These nonpermitted septic systems may be a significant source of nutrient and fecal coliform loads to North Fork Vermilion River and Lake Vermilion.

Furthermore, it was reported that there are about 70 houses located around the shoreline of Lake Vermilion. About 40 percent of the houses discharge to the Danville wastewater treatment plant. The rest use septic tanks to treat their wastewater (Tetra Tech, 2004c). The potential influence of septic tank effluent on the lake will be investigated, based on site-specific information. About 95 percent of the soils in Warren County have severe limitations for conventional septic systems. Some older systems are connected to underground tile drains or discharge directly to drainage ditches. Both practices are illegal in Illinois and Indiana. Information from a detailed drain tile survey is needed to further quantify the density of the drain tile and its impact on the water quality.

5.2 POINT SOURCES

Most facilities in the North Fork Vermilion River watershed discharge a negligible flow and do not discharge loads of pollutants of concern. Six facilities either discharge a significant flow or potentially discharge sediment and nutrient loads. The six facilities are as follows, listed from upstream to downstream (see Table 5-1 and Figure 5-1):

1. **Hoopeston Foods Inc.** discharges non-contact cooling water and boiler blowdown through two outfalls. Each is monitored for temperature, biological oxygen demand (BOD), pH, and TSS (EPA 2003). It is likely that the receiving ditch of the discharge is a tributary to Hoopeston Branch (BPGD), which is listed as impaired by low DO. A new NPDES discharge permit is issued to the facility, which sets 30-day average BOD (5-day) discharge at 10 mg/L and daily maximum at 30 mg/L. Discharge monitoring reports (DMR) for Hoopeston Foods Incorporated will be evaluated as part of TMDL development.

2. **Hoopeston Sewage Treatment Plant** (STP) regularly discharges through one main outfall. The treatment processes include bar screens, grit chambers, two treatment tanks, two oxidation ditches, and four sand filters. The monitoring discharge record from April 2000 to May 2001 shows that the maximum discharge rate in the year is about 2.36 MGD. Monthly average CBOD, ammonia, and TSS are included in Table 5-1. The concentrations of these constituents did not exceed the NPDES permitted limits (Lin and Bogner 2004). Hoopeston STP has a year-round disinfection exemption that includes the entire length of Hoopeston Branch to the point where it enters North Fork Vermilion River.

3. **Rossville STP** discharges regularly through one outfall, which is monitored for pH, TSS, total residual chlorine, and BOD (EPA 2003). The treatment facility uses a two-lagoon system for primary and secondary treatment. Two intermittent sand filters polish the effluent before discharge (Lin and Bogner, 2004). The average discharge concentrations of BOD and TSS are included in Table 5-1. No discharge violation was reported. Rossville has a year-round disinfection exemption and discharges to Segment BPG-10.

4. **Alvin Water Treatment Plant** (WTP) discharges regularly through one outfall. The WTP regularly monitors pH, TSS, iron, and total residual chlorine (EPA, 2003). The DMR has not been retrieved. The Village of Alvin is an unsewered community.

5. **Bismarck Community Unit School** has an STP outfall that discharges regularly to Painter Creek, a tributary to North Fork Vermilion River. The school uses a septic tank system and two tertiary sand filers to treat the wastewater. The outfall is monitored monthly for pH, TSS, ammonia-nitrogen, total residual chlorine, and BOD (EPA, 2003). The DMR records from July 2002 to October 2003 show that the average discharge is about 0.005 MGD. The discharge record in January 2001exceeded the NPDES permitted ammonia concentration of 4.00 mg/L (Lin and Bogner, 2004).

6. **Bismarck Community Water District** is the water treatment plant for local water supply. The outfall is only monitored for suspended sediment discharge and pH since it probably does not contribute significant nutrient and fecal coliform to the North Fork Vermilion River.

TABLE 5-1 MAJOR POINT SOURCES DISCHARGING IN THE NORTH FORK VERMILION RIVER WATERSHED

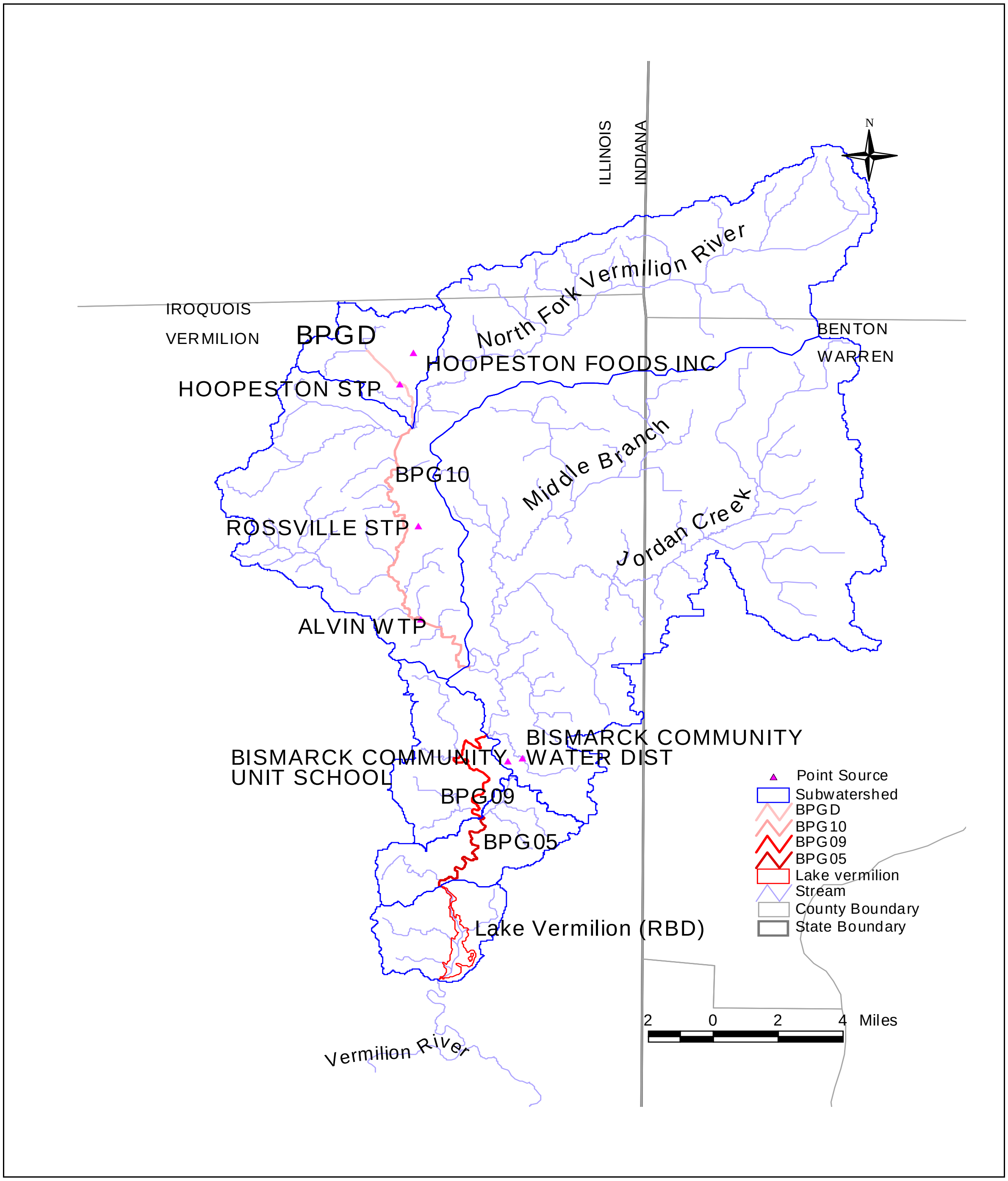
Facility Name	Location	NPDES No.	SIC No.	Receiving Waterbody	Average CBOD (mg/L)	Average TSS (mg/L)	Average Ammonia (mg/L)	Average Discharge (MGD)
Hoopeston Foods Inc.	Hoopeston, IL	IL0022250	2033	Stream Sewer to North Fork Vermilion River	Unknown	Unknown	Unknown	0.15
Hoopeston STP	Hoopeston, IL	IL0024830	4952	Unnamed Ditch to North Fork Vermilion River	3	3	0.21	1.652
Rossville STP	Rossville, IL	ILG580064	4952	North Fork Vermilion River	11.5	16	Unknown	0.18
Alvin WTP	Alvin, IL	ILG640002	4941	North Fork Vermilion River	Unknown	Unknown	Unknown	0.0006
Bismarck Community Unit School	Bismarck, IL	IL0067156	4941	Painter Creek	4.3	3.8	1.7	0.004
Bismarck Community Water District	Bismarck, IL	ILG640101	8211	Unnamed Tributary of Painter Creek	Unknown	Unknown	Unknown	0.007

Notes:

IL	Illinois
MGD	Million gallons per day
STP	Sewage treatment plant
WTP	Water treatment plant (water supply)

Source: USEPA 2003 and USEPA 1998

FIGURE 5-1 POINT SOURCE LOCATION MAP



6.0 TECHNICAL ANALYSIS

This chapter describes the technical analysis that was used for the development of TMDLs in North Fork Vermilion River (BPG05 and BPG09), and Lake Vermilion (RBD). A simpler approach is employed based on the recommendation of IL EPA Scientific Advisory Committee (SAC) and the consultation with IL EPA. The goal of a simple approach is to develop an approvable TMDLs that meet basic requirements of the Clean Water Act (CWA) without creating a sophisticated model that takes more time and resources. The technical approach involves a watershed flow estimate (Section 6.1), load duration curve and load estimate (Section 6.2), and a mass-balanced BATHTUB model (Section 6.3).

6.1 WATERSHED FLOW ESTIMATE AND DURATION CURVE

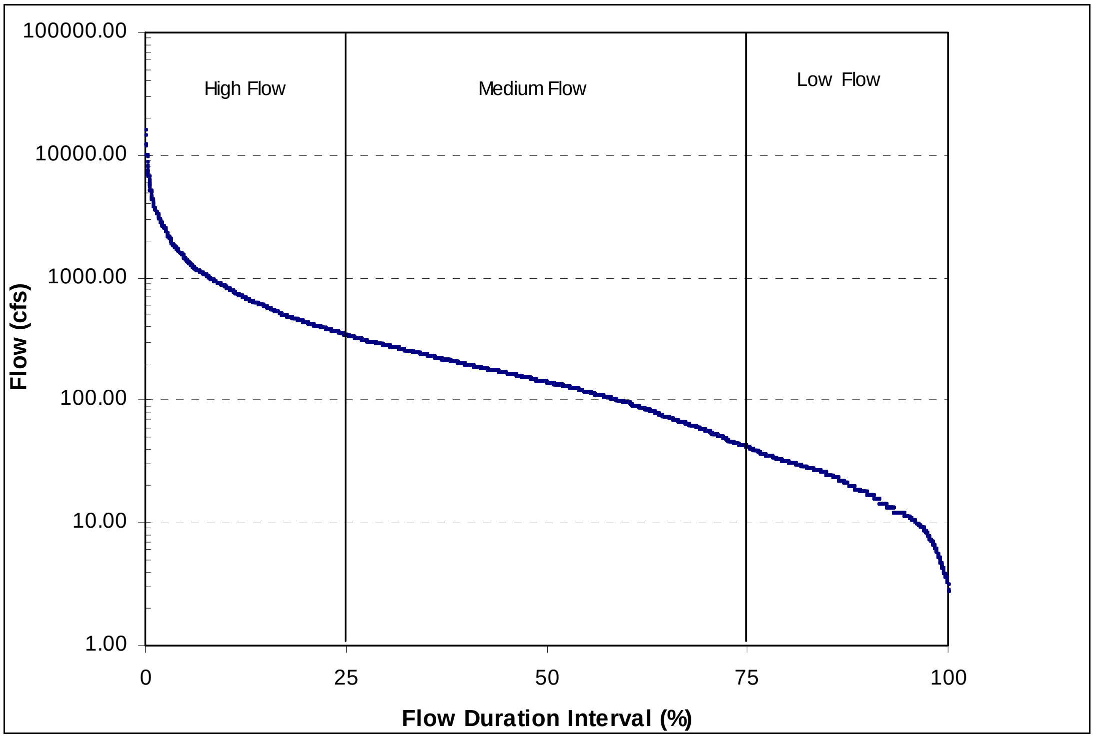
In order to calculate the total load for a water body, flows need to be estimated. Rather than developing a watershed hydrologic model, the flows in each segment were estimated indirectly using the observed flow data at the USGS gage (03338780) at Bismarck, Illinois, based on drainage area proportion. The ratio of the USGS station flow to its watershed drainage area was multiplied by the watershed area of BPG09 and BPG05 to calculate the respective flow at each location. For instance, the flow at BPG09 was calculated by using the formula:

$$Flow_{BPG09} = \frac{Flow_{USGS} \times DrainageArea_{BPG09}}{Drainage\ Area_{USGS}}$$

Flow duration curves were developed for BPG05 and BPG09 using the extrapolated flows to characterize the cumulative frequency of historic flow data over a specified period of time. The flow data from 1988 to 2006 were plotted against the duration intervals in a logarithmic scale. The entire daily flow data series is first ranked from highest to lowest and then the percent of days a flow value is exceeded is calculated. Flow duration intervals are expressed in percentage, with zero corresponding to the highest discharge (i.e. flood conditions) and 100 corresponding to the lowest (i.e. drought conditions).

Flow duration curve percentiles are grouped into three broad categories or zones to represent three major flow regimes: high flow (0 to 25th percentile), medium flow (25th to 75th percentiles), and low flow (75th to 100th percentile). The load capacity and existing loads are calculated for each flow zone in BPG05 and BPG09 segments. The use of duration curve zones allows for analysis of general patterns by conveying information about distribution of the data within each zone. It also provides additional insight about conditions and patterns associated with the impairment. Figure 6-1 presents flow duration curve and flow zones for BPG05. The flow duration curve for BPG-09 is similar since the drainage area is very close to that of BPG05.

FIGURE 6-1 FLOW DURATION CURVE FOR NORTH FORK VERMILION RIVER BPG05



The duration curves are based on the entire range of flow conditions estimated for the North Fork Vermilion River watershed, and may be used to enhance development of source assessments. Pollutant delivery mechanisms with the greatest potential influence on receiving waters (e.g. point source discharges, surface runoff) can be matched with the appropriate flow regime, as shown in Table 6-1.

TABLE 6-1 POTENTIAL RELATIONSHIP OF HYDROLOGIC CONDITION AND LOAD CONTRIBUTION BY SOURCE

Contributing Source	Hydrologic Condition		
	High Flow	Medium Flow	Low Flow
Point Sources	L	M	H
Septic System	L	M	H
Riparian Areas	H	M	L
Stormwater: Impervious	H	M	L
Combined Sewer Overflow	H	M	L
Stormwater: Upland	H	M	L
Bank Erosion	H	L	L
Tile Drainage	M	H	L
Livestock in streams	L	L	H

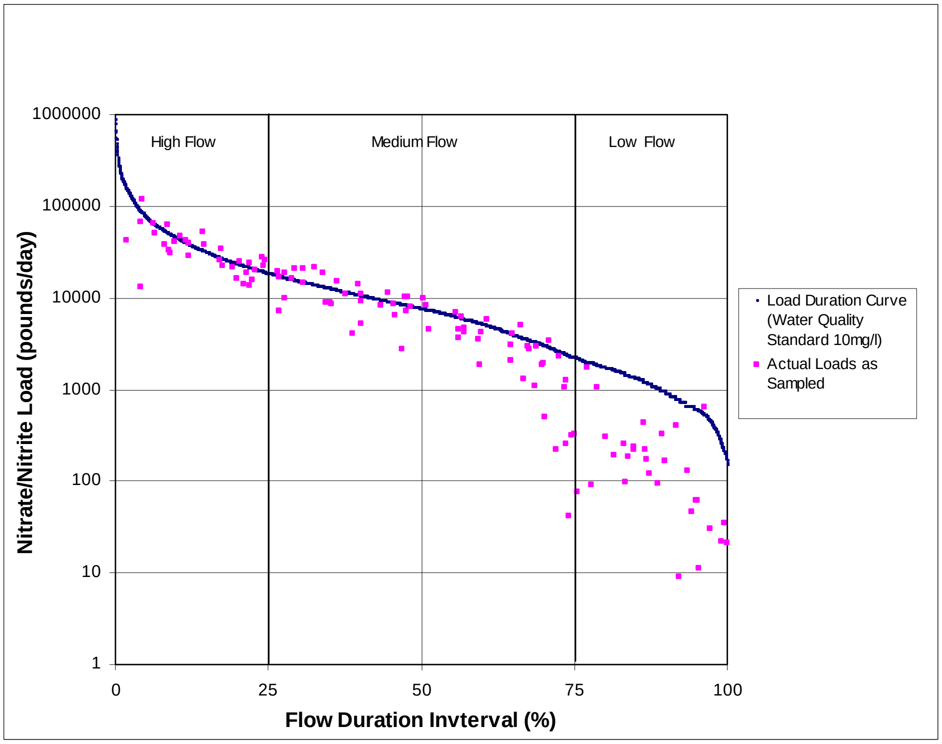
Note: 1) Potential relative importance of sources area to contribute loads under given hydrologic condition: H – High, M – Medium, and L – low.
2) The information is derived from Basic Hydrology and Water Quality Management, Guide to use of duration curve by Cleland (2002)

6.2 LOAD CURVE AND LOAD ESTIMATE

The flow duration curves for BPG05 and BPG09 were converted to load duration (TMDL) curves (Cleland 2002) for each water quality parameter of concern by multiplying the flow, water quality standard, and a conversion factor. Nitrate and fecal coliform were identified as the causes of impairment at BPG05 and BPG09, respectively, in the North Fork Vermilion River. The load duration curve was used to determine the allowable loads and the load reduction needed in the stream for each parameter. The load duration curve approach involves calculating the desired load over the range of flow conditions expected to occur in the stream. The resulting data points are plotted against the duration interval to produce a TMDL load curve, which represents allowable loads for various flows.

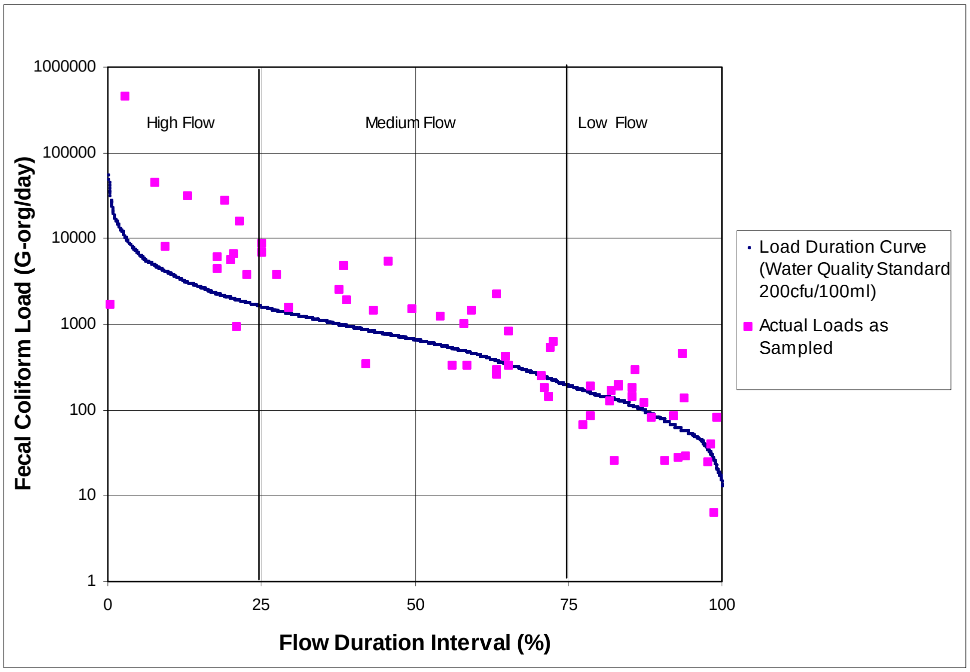
The water quality data for nitrate and fecal coliform were obtained from the USGS and IL EPA. Nitrate data were available from 1988 through 2002, and fecal coliform data were available from 1994 through 2005. For fecal coliform, only the data from May through October was considered for developing the duration curves because the Illinois water quality standard (fecal coliform 200 cfu/100ml) only applies for these months. The water quality data is converted to a load by multiplying the water quality concentration by the daily average flow on the day of sampling and by a conversion factor. The actual load is then plotted on the TMDL duration curve. Resulting points above the TMDL curve represent exceedances of the water quality standard (Figure 6-2 and Figure 6-3). Points existing below the curves represent compliance with the water quality standard.

FIGURE 6-2 NITRATE DURATION CURVE FOR BPG05



In Figure 6-2, 29 nitrate data points are above the loading curve and represent non-compliance with the water quality standard at BPG05. As shown in Figure 6-2, there is only one data point that exceeds the TMDL curve in the low flow condition. More than 96 percent of the exceedance occurs during medium to high flow conditions. This indicates that the point sources are not likely a major load contributor in low flows.

FIGURE 6-3 FECAL COLIFORM DURATION CURVE FOR BPG09



At BPG09, 42 fecal coliform data points were observed above the loading curve and exceed the water quality standard (Figure 6-3). The fecal coliform excursions occur consistently in all flow conditions, indicating several sources contributing to the problem.

The area below the loading curve is interpreted as the loading capacity of the segments. The difference between the loading curve and the existing load represents the load reduction needed to meet the water quality standards. Table 6-2 presents the existing and allowable loads under high, medium, and low flow conditions for nitrate in BPG05. Table 6-3 presents the existing and allowable average loads under high, medium, and low flow conditions for fecal coliform in BPG09.

TABLE 6-2. ALLOWABLE AND EXISTING LOADS OF NITRATE AT BPG05

Flow Zone	Average Flow (cfs)	Allowable Load (lbs/day)	Existing Average Load (lbs/day)	Reduction
Low (75%-100%)	19.8	1,067	645	0%
Medium (25%-75%)	138	7,470	13,007	43%
High (0-25%)	667	35,514	43,283	18%

TABLE 6-3. ALLOWABLE AND EXISTING LOADS OF FECAL COLIFORM AT BPG09 UNDER DIFFERENT FLOW CATEGORIES.

Flow Zone	Average Flow (cfs)	Allowable Load (10^9 cfu/day)	Existing Average Load (10^9 cfu/day)	Reduction
Low (75%-100%)	18.9	93	99	6%
Medium (25%-75%)	132	645	1,197	46%
High (0-25%)	637	3,150	10,384	70%

6.3 BATHTUB MODEL DEVELOPMENT

For Lake Vermilion, a mass-balancing BATHTUB model is used as a simple approach to link the nutrient loads with water quality. BATHTUB applies a series of empirical eutrophication equations and performs steady-state water and nutrient calculations for a lake. Eutrophication-related water quality conditions (total phosphorus and total nitrogen) are predicted using empirical relationships derived from assessments of lake data. Applications of BATHTUB are limited to steady-state evaluations of relations between nutrient loading, hydrology, and eutrophication responses.

This section explains the technical approach used in developing TMDLs for nutrients causing impairment in Lake Vermilion. TMDLs were developed for total phosphorus and nitrate. The State of Illinois lake water quality numeric standards specified for these nutrients are as follows:

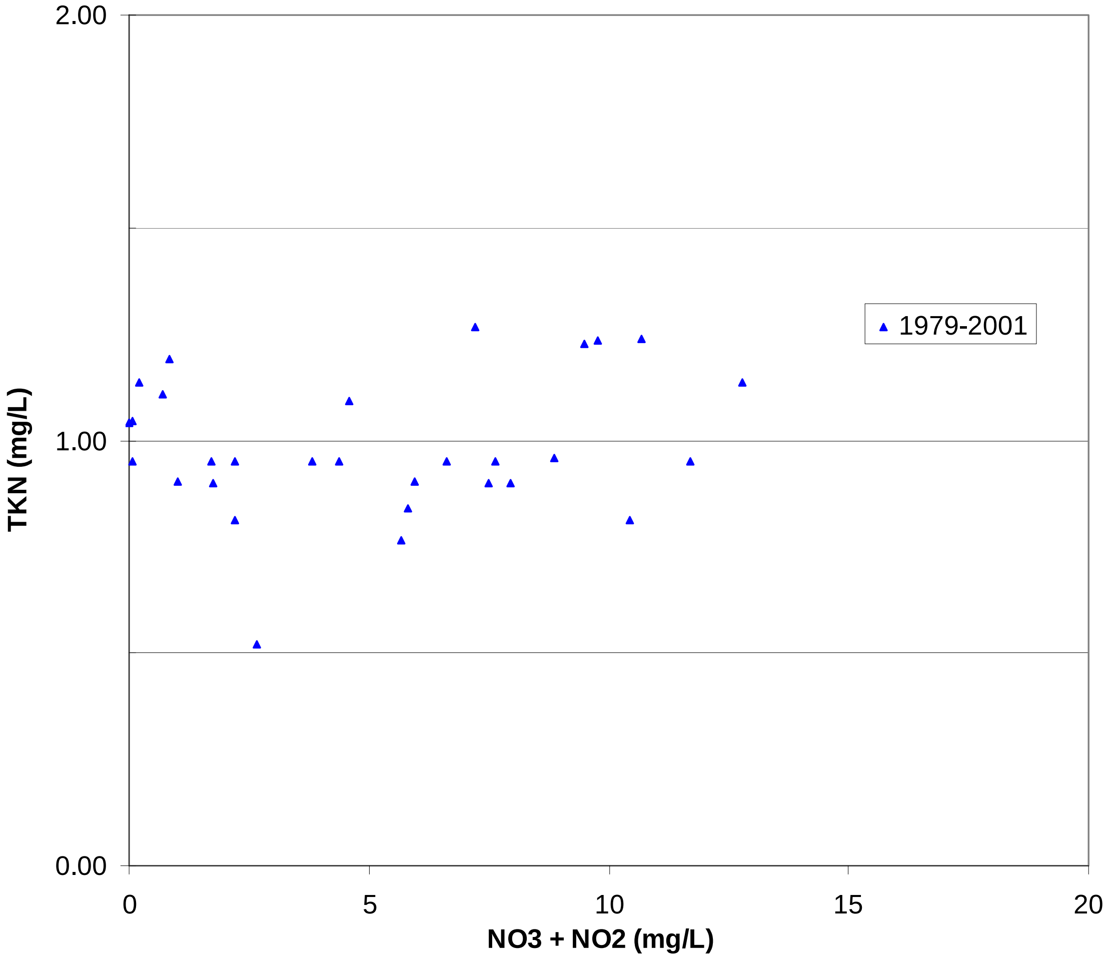
- Total Phosphorus (TP) shall not exceed 0.05 mg/L
- Nitrates (NO_3) shall not exceed 10 mg/L

BATHTUB v6.1, a steady-state water and nutrient mass balance model, was used for Lake Vermilion. BATHTUB performs a nutrient balance analysis in a spatially segmented hydraulic network, linking nutrient load inputs to the lake with the resulting concentration in Lake Vermilion. Empirical relationships previously developed and tested for lake applications are used in BATHTUB to predict water quality conditions related to eutrophication. This model was selected because it requires fairly simple inputs to predict the parameters of concern; it accounts for pollutant transport, sedimentation, and nutrient cycling; and it has been used for lake TMDLs in Illinois and other states.

The BATHTUB model uses total phosphorus and total nitrogen to represent nutrient concentrations. Total nitrogen (TN) is composed of total kjeldahl nitrogen (TKN), nitrite nitrogen (NO_2), and nitrate nitrogen (NO_3). Based on the water quality data observed in the lake, NO_2 seldom appears in concentrations greater than 1 mg/L and tends to transform to $N0_3$ through nitrification. Therefore, NO_2 is not considered and measured values of NO_3 + NO_2 are used for Nitrates. TN was not measured directly in laboratory test for all water quality samples and can be estimated using TKN and NO_3+NO_2. TKN was measured at North Fork Vermilion River from 1988 to 1998 and at few samples in recent years showing values fairly constant. To estimate TN input concentrations for the model, a statistical analysis was performed on the available samples for TKN and NO_3+NO_2. It was found that the TKN concentration is fairly steady, with a median concentration of 0.5 mg/L for all ranges of NO_3+NO_2. Therefore, the median of TKN values (0.5 mg/L) was used as a constant TKN concentration to predict TN for years with no TKN data. TN was estimated as the sum of NO_3 + NO_2 and TKN.

In Lake Vermilion, a similar relationship within the concentrations of TKN and NO_3+NO_2 is evident, with fairly constant values for TKN, although the concentrations of TKN in the lake are higher than in the river on average (Figure 6-4). There is a fairly flat linear relationship between TKN and NO_3+NO_2 with a mean TKN concentration of 1.0 mg/L for all ranges of NO_3+NO_2. As a percentage base, NO_3+NO_2 concentrations range from 16% to 94% of the TN concentrations, with an average percentage of 77%.

FIGURE 6-4 TKN VS. NO_3 + NO_2 MEASURED CONCENTRATIONS IN LAKE VERMILION



Total nitrogen (TN) is used for modeling purpose as a surrogate for Nitrates (NO_3+NO_2) because most of the TN content is from nitrates.

6.3.1 Model Setup

BATHTUB requires segment and tributary information such as lake bathymetry, hydrologic parameters, in-lake water quality concentrations, tributary flows and concentrations.

Lake Vermilion was divided into 4 segments, or reservoir zones linked in a network according to the lake's morphometry features. Figure 6-5 depicts the segmented areas used for Lake Vermilion modeling and the location of the water quality monitoring stations. At least 1 water quality monitoring station is located in each segment. Table 6-4 shows the segment names with the respective water quality station and morphometry parameters used in the model.

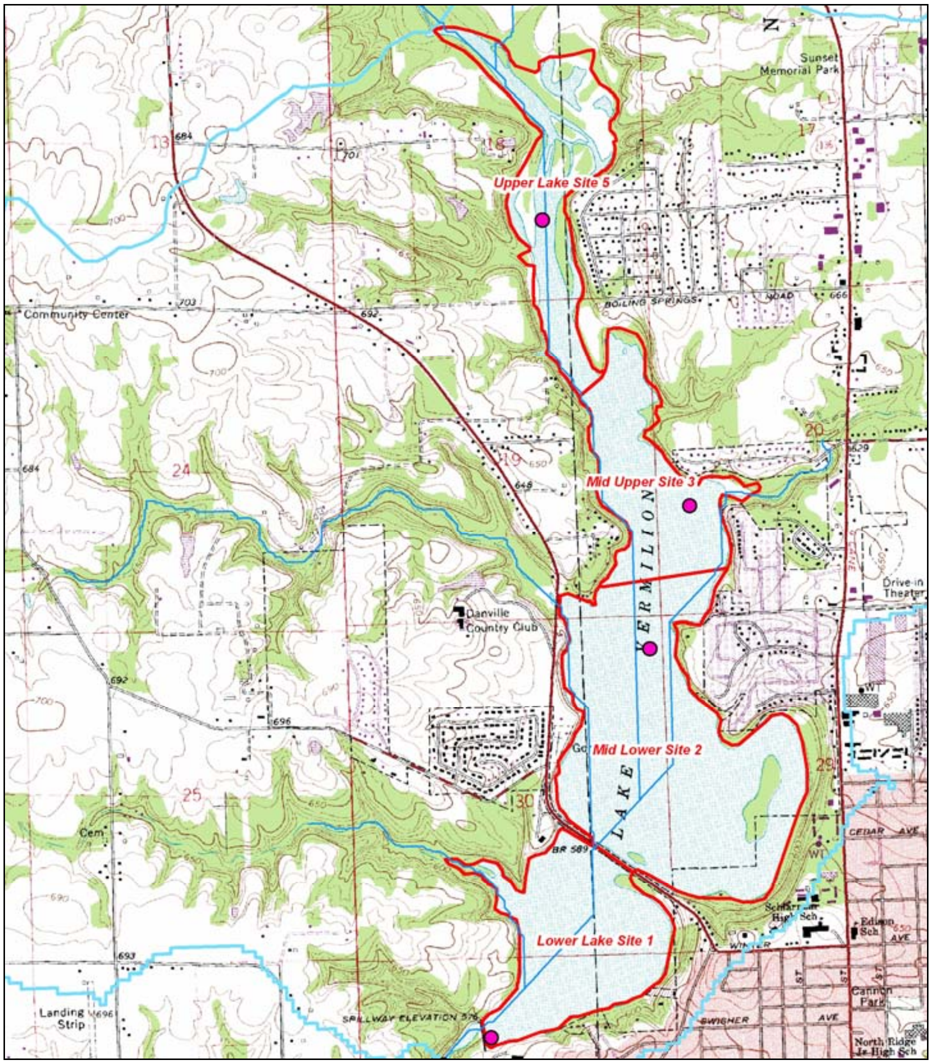
Lake bathymetry data was available from the "Phase I: Diagnostic Study of Lake Vermilion, Vermilion County, IL" prepared by the Consumers Illinois Water Company and Illinois Environmental Protection Agency.

TABLE 6-4. LAKE VERMILION MORPHOMETRY FOR BATHTUB

Seg	Name	WQ Station	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	Upper Lake	RBD5	0.6	1.2	1.2	2.2	0.7	0.3	8.2
2	Mid Upper	RBD3	0.5	1.8	1.8	1.1	0.9	0.5	2.3
3	Mid Lower	RBD2	1.3	3.0	3.0	1.4	4.0	0.9	1.5
4	Lower Lake	RBD1	0.6	5.5	5.5	1.1	3.4	0.5	2.1
Totals			3.0	3.0			9.0		

Note: 1) RBD4 is not considered because no data is available from the site.
2) It is assumed that the lake is well-mixed.

FIGURE 6-5 LAKE VERMILION SEGMENTS FOR BATHTUB



Hydrologic data needed for the model include precipitation, evaporation, and increase in storage. Monthly total and annual precipitation data from Danville, Illinois, were available from 1977 to 2006. The average annual lake evaporation rate was calculated from pan A evaporation. According to the US Class A Pan Evaporation Maps (Kohler et al, 1959), the pan evaporation in this area is 42 inches with a pan coefficient of 0.77. Therefore, a lake evaporation of 32.34 inches per year or 0.82 meters per year was used in all models.

The North Fork Vermilion River is the main tributary discharging into Lake Vermilion. Flows and concentrations for the river were not available at the upstream end of Lake Vermilion. Flows from this tributary; however, are available at the USGS Station 3338780 near Danville at Bismark (upstream of Lake Vermilion). Daily flows from this station have been recorded since 1988. Tributary flows for the Lake Vermilion drainage area were estimated from the USGS station based on the ratio of drainage area. The drainage area for the USGS station is 259 mi^2 and the drainage area for Lake Vermilion is 296 mi^2. Thus, the USGS stream flows were multiplied by 1.14 to estimate daily flow from all tributaries and direct runoff areas into Lake Vermilion.

Water quality concentrations for TP and NO_3+NO_2 at North Fork Vermilion River were measured at the USGS station during 1997 and 1998. Nutrient concentrations are also available from IEPA and ISWS near this location for 2000, 2001, and 2002. TKN was measured prior to 1998 and during certain days on 2000 and 2001.

The duration selected for the mass balance calculations is one year. Concentrations and loadings are predicted on an annual basis from 1997 to 2003 with the exception of 1999 for which no sampling data is available at all. Water quality data in the tributary and the lake is available for years 1997, 2000, and 2001. Years 1998 and 2002 do not have measured in-lake water quality data.

FLUX was used in combination with BATHTUB to estimate tributary mass loadings from sample concentration data and continuous daily flow records. FLUX provided annual mean flows, weighted concentrations, and coefficient of variance (CV) for the years selected. Six regression models were applied to the data and the best fit was selected based on the lowest coefficient of variance and the highest slope significance for residuals vs. date or residuals vs. flow. If good fit was not possible for all records, the data was stratified in two series to improve the fit. Stratification was performed by separating flow and concentration data points in two groups, in most cases using the mean flow rate. The mean flow rates and mean concentrations for the modeling period are shown in Table 6-5.

TABLE 6-5 NORTH FORK VERMILION RIVER (TRIBUTARY) MEAN FLOWS, TP AND TN CONCENTRATIONS

Year	Concentrations		Flow Rate cfs
	TP mg/L	TN mg/L	
1997	0.200	8.869	302.7
1998	0.393	3.301	488.7
1999	-	-	-
2000	0.210	11.937	101.4
2001	0.406	10.103	368.0
2002	0.244	9.136	471.3

Tributary inflows, concentration, and coefficients of variance from FLUX were used as input in BATHTUB to predict in-lake concentration and mass loads. Observed water quality data for the years selected were used to calibrate the model.

BATHTUB has several models to predict in-lake concentrations. Total Phosphorus was predicted using the 2nd order, available P model. Total Nitrogen was predicted using the 2nd order, available N model. These two models provide generally accurate second-order sedimentation coefficients. Chlorophyll-a (Chl-a) was predicted using P, light, and flushing because phosphorus and light are the limiting factors for this lake. Transparence vs. Chl-a and Turbidity was computed. Longitudinal dispersion was calculated based on the Fischer equation. Mass balance tables and phosphorus and nitrogen calibrations were performed using predicted concentrations. Model input data for each year is included in Appendix B.

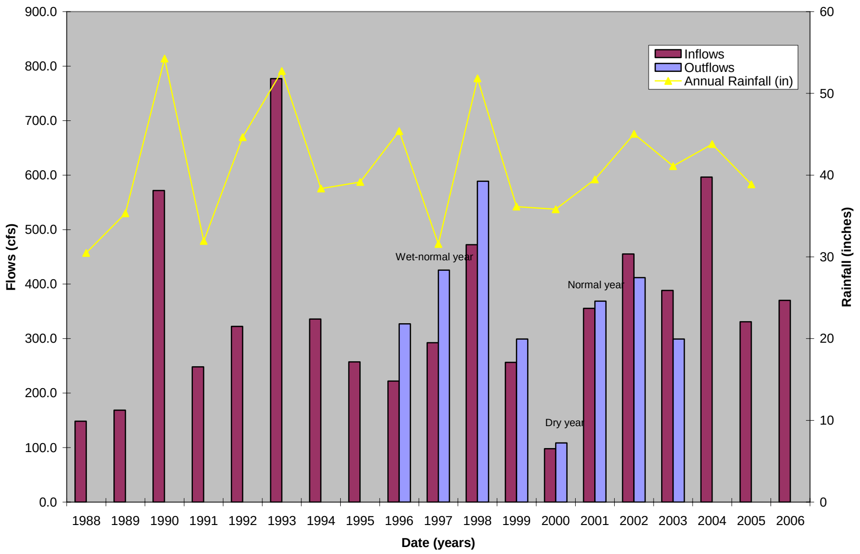
6.3.2 Model Calibration

Lakes are typically highly responsive to current and previous year weather and transport conditions. Therefore, it is difficult to validate the results of a model without looking at various weather oscillation periods. BATHTUB was calibrated for variable weather conditions that include significant climatic fluctuations. For Lake Vermilion, these conditions include wet (2001), dry (2000), and normal years (1997). For Lake Vermilion, 2000 was a dry year with the lowest discharge flows and below average rainfall for the monitoring period. 1997 was a normal year with near average inflows, high outflows and below average rainfall. 2001 was a wet-normal year, that had average rainfall during the year but slightly higher discharge flows. 1997 and 2000 were used for calibration because they have significant inflow data and water quality for both tributary and in-lake concentrations. 2001 has sufficient water quality data measured at the river but only few samples measured at the lake during March and April. This year was not used for calibration because the data was not representative of the entire year. Years 1998 and 2002 were not used for calibration due to the lack of in-lake measured nutrient concentrations. Figure 6-6 present a comparison of flows and rainfall data in Lake Vermilion.

Predicted concentrations in the lake were calibrated against observed concentration by adjusting the model coefficient factors in BATHTUB. Coefficient factors for TP, TN, Chlorophyll-a and Secchi depth were used for all the segments and in some instances a different factor was used in specific segments until the predicted weighted mean lake concentrations matched observed in-lake concentrations. Nutrient calibration factors were adjusted within the nominal ranges for Phosphorus (0.5 to 2.0) and Nitrogen (0.33 to 3). A calibration factor of 1 indicates that no adjustment was needed for the specific nutrient. The predicted current-condition concentrations are shown in Table 6-6.

BATHTUB also performs statistical comparison of observed and predicted concentrations in each model segment using the Student's t-Statistic testing (t-test) with alternative error terms (T1, T2, and T3). The t-test results are low confirming that the calibration is appropriate. T-test results are included in Appendix B.

FIGURE 6-6 ANNUAL INFLOWS, OUTFLOWS, AND RAINFALL FOR LAKE VERMILION



Predicted and observed average concentrations (based on measurements at all depths) for Lake Vermilion are shown in Table 6-6 for the years 1997 and 2000. Table 6-7 summarizes the predicted concentrations and watershed loading for all years modeled under the initial (current) conditions.

TABLE 6-6 PREDICTED AND OBSERVED NUTRIENT CONCENTRATIONS IN LAKE VERMILION FOR CURRENT CONDITIONS

Year	TP Concentrations		% Relative Error	TN Concentrations		% Relative Error
	Predicted mg/L	Observed mg/L		Predicted mg/L	Observed mg/L	
1997	0.086	0.099	-13%	6.283	6.348	-1%
1998	0.158	-		3.177	-	
1999	-	-		-	-	
2000	0.069	0.060	14%	5.650	5.472	3%
2001	0.150	-		7.253	-	-
2002	0.110	-		7.148	-	

TABLE 6-7 PREDICTED CONCENTRATIONS AND LOADS IN LAKE VERMILION FOR CURRENT CONDITIONS

Year	**Concentrations**		**Loads**	
	TP mg/L	**TN mg/L**	**TP kg/yr**	**TN kg/yr**
1997	0.086	6.283	54,237	2,402,337
1998	0.158	3.177	171,833	1,444,955
1999	-	-	-	-
2000	0.069	5.650	19,115	1,084,422
2001	0.150	7.253	133,526	3,325,699
2002	0.110	7.148	103,021	3,851,270

As shown in Table 6-7, the predicted in-lake average annual concentrations for total phosphorous exceeded the target concentration of 0.05 mg/L every year during the simulation period. In contrast, the predicted average annual concentrations for Total Nitrogen, used herein as surrogate for nitrates, do not exceed the target concentration of 10 mg/L in any single year.

7.0 TMDL CALCULATION

This Chapter describes the TMDL calculation for each segment based on the load duration curve and BATHTUB model discussed in Chapter 6. The load capacity, load allocations, and margin of safety are discussed.

7.1 LOADING CAPACITY – LINKING THE SOURCES WITH WATER QUALITY

A loading capacity, or allowable load, is the maximum amount of a pollutant that a water body can receive without violating water quality standards. TMDLs are the sum of the allocations plus a margin of safety, as shown in the following equation:

$$TMDL = WLA + LA + MOS$$

Where WLA (Waste Load Allocation) is the loading assigned to point sources, LA (Load Allocation) is the loading assigned to non-point sources, and MOS (Margin of Safety) is to account for any lack of knowledge, uncertainty, and potential error in the TMDL calculation. The loading capacity sets the target for the pollutant reduction needed to bring segments into compliance with the water quality standards.

For BPG05 and BPG09, the TMDL load curve is used to define the loading capacity for each flow zone. The median of the load curve for each flow zone is selected to define the load capacity for that flow zone. The median points above the TMDL load curve within each flow zone were used to obtain the existing load to be compared with the load capacity. The difference between load capacity and existing load represent the load reduction needed to meet the water quality standard.

For Lake Vermilion, the calibrated BATHTUB model is used to calculate the load capacities for total phosphorus and nitrate. The load input from tributary and direct runoff area are reduced until the average in-lake concentration is equal or lower than the standards.

7.1.1 North Fork Vermilion River Segment BPG05

Nitrate load capacities in BPG05 are 35,500 lb/day for high flow, 7,470 lb/day for medium flow, and 1,067 lb/day for low flow. A 26 percent load reduction is required to meet the water quality standard during high flow conditions. During moderate flow conditions, a 48 percent load reduction is required to meet the target concentration of 10 mg/l nitrate/nitrite at BPG05. No load reduction is needed during low flow condition because the average existing load is lower than the allowable load. The load capacity and reduction percentage are included in Table 6-2 in Section 6.2.

7.1.2 North Fork Vermilion River Segment BPG09

Fecal coliform load capacities for BPG09 are $3,150\text{x}10^9$ cfu/day for high flow, $645\text{x}10^9$ cfu/day for medium flow, and $93\text{x}10^9$ cfu/day for low flow. A 70 percent of reduction is required to meet the not-to-exceed water quality standard of 200 cfu/100 ml for high flow conditions from May through October. A 47 percent load reduction is required to meet the water quality standard for medium flow condition. A 8 percent reduction is required for low flow. The load capacity and reduction percentage are included in Table 6-3 in Section 6.2.

7.1.3 Lake Vermilion River RBD

The BATHTUB model with calibrated nutrient concentrations was used to identify the reduction loading needed for TP. Predicted total phosphorous (TP) was in exceedance in all years (TP > 0.05 mg/L). Table 7-1 shows the TP existing concentration, percent reductions needed in the input loads to meet the target value, the load capacity, and the concentration after load reduction is implemented.

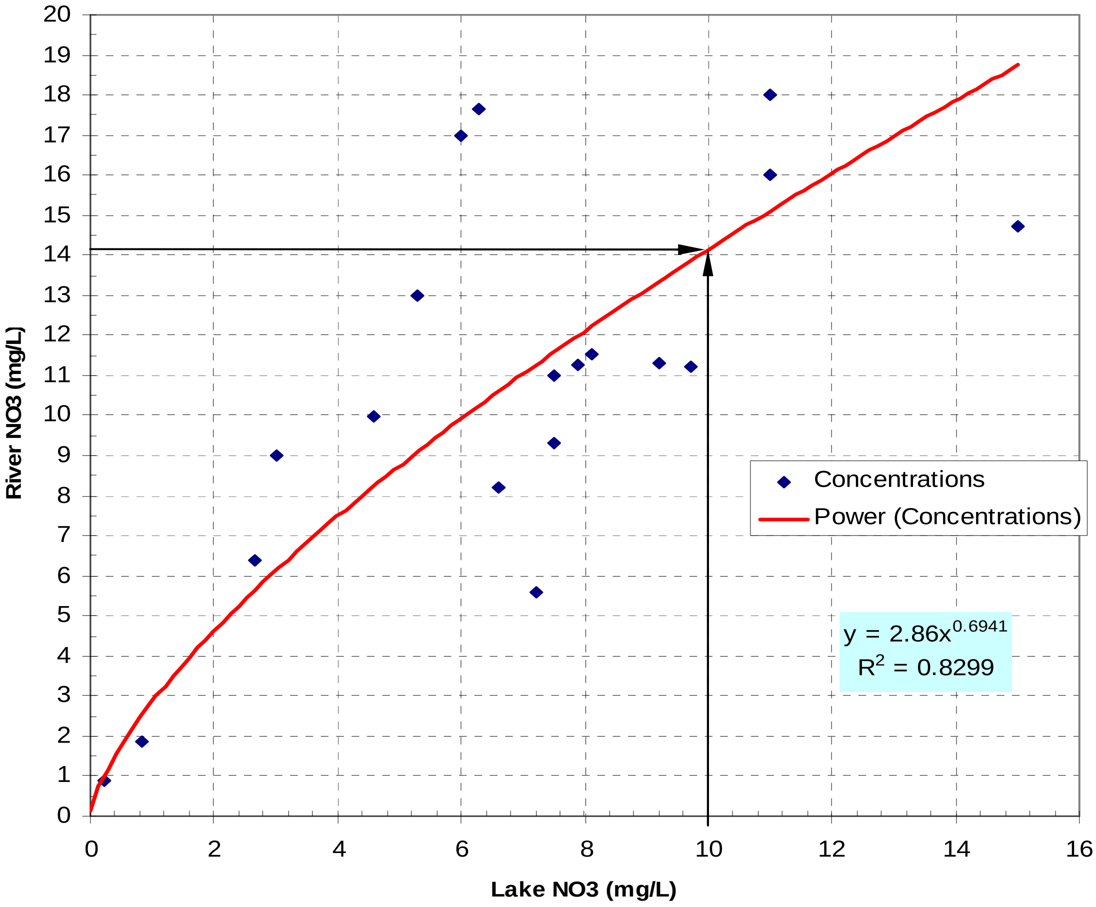
TABLE 7-1. PREDICTED NUTRIENT CONCENTRATIONS IN LAKE VERMILION AFTER TARGET LOAD REDUCTIONS

Year	Post-Reduction Tributary Concentrations	% Reduction	Post-Reduction Concentration	Load Capacity
	TP mg/L		TP mg/L	kg/yr
1997	0.100	50%	0.050	27,163
1998	0.090	77%	0.050	63,635
1999	-		-	-
2000	0.132	37%	0.050	12,076
2001	0.096	76%	0.050	31,662
2002	0.093	62%	0.050	39,204

Nitrates are not calculated directly by the BATHTUB model. Therefore, the concentration of TN was used in this analysis as a surrogate for NO3. The TN concentrations initially predicted in BATHTUB were based on mean annual input concentrations and resulted in in-lake concentrations lower than the target concentrations. There are, however, several measured concentrations at the tributary that are significantly higher than the target concentration. As a result, the Nitrates reduction loads needed to meet the target concentration in the lake of 10 mg/L were estimated in BATHTUB based on the input concentrations exceeding 10 mg/L at the North Fork Vermilion River.

A regression curve showing the relationship between the measured concentrations at the river compared to the measured concentrations at the lake is shown in Figure 7-1. In total, 19 samples were measured during 2000 and 2001 on the same day at both locations.

FIGURE 7-1 REGRESSION CURVE FOR NITRATE CONCENTRATIONS



As shown in Figure 7-1, the data points fit well the power regression curve with a relatively high coefficient of determination ($R^2 = 0.83$). According to the curve, for a value of 10 mg/L in the lake, the maximum concentration at the river should be 14.1 mg/L. This concentration, however, violates the water quality standard in BPG05, which has to meet 10 mg/L target. The correlation in Figure 7-1 indicates that the implementation measures in BPG05 will likely result in the compliance in Lake Vermilion RBD.

Concentrations in the river, greater than 10 mg/L were used to calculate the Nitrate reduction loads. Table 7-2 summarizes the input and output concentrations and load for the initial (current) conditions.

TABLE 7-2 TRIBUTARY AND LAKE MAXIMUM FLOWS AND MAXIMUM NITRATE CONCENTRATIONS FOR CURRENT CONDITIONS

Year	North Fork Vermilion River			Lake Vermilion
	Average Concentration mg/L	Flow Rate Cfs	Loads kg/yr	Concentrations mg/L
2000	16.780	1,112.8	16,693,057	13.838
2001	13.245	843.4	9,987,741	10.838

Total Nitrogen (or Nitrate) concentrations were only simulated for years 2000 and 2001 because the measured concentrations at the tributary and at the lake on the same date are available for the two years. Table 7-3 shows the Nitrate percentage reductions needed in the input loads to meet the target value, load capacity, and Nitrate concentration after the reduction measures are implemented.

TABLE 7-3 NITRATE PERCENTAGE REDUCTION IN INPUT CONCENTRATIONS FOR LAKE VERMILION

Year	Post-Reduction Tributary Concentrations	% Reduction	Post-Reduction In-lake Concentrations	Load Capacity
	mg/L		mg/L	kg/yr
2000	11.15	34%	10.00	11,093,234
2001	11.92	10%	9.99	8,989,267

7.2 LOAD ALLOCATIONS

The pollutant loads have been linked to violations of applicable standards through the duration curve and BATHTUB modeling. The magnitudes of the loads have been determined by a reliable quantitative procedure that is based either on duration curves for the river segments or in-lake measurements for climate conditions that cover the range of expected precipitation conditions. For simplicity, a watershed model was not developed for the TMDLs in this report. The load allocation (non-point sources) cannot therefore be calculated directly. Instead, the load allocation is calculated by subtracting the margin of safety (discussed in Section 7.3) and the waste load allocations (WLA) from the load capacity, as indicated in following formula:

$$LA = TMDL - WLA - MOS$$

The decay of fecal coliform and nutrients from point sources load is neglected to be conservative. The TMDLs were obtained from the duration curves presented in Figures 6-2 and 6-3. The WLA is the combination of discharge loads from the known facilities identified Chapter 5. After determining the margin of safety, the only information that remains to be calculated is the LA.

7.2.1 North Fork Vermilion River Segment BPG05

As shown in Figure 6-2, the nitrate concentration rarely exceeds the 10 mg/l standard during low flow conditions, which indicates the point sources contribution is negligible. Therefore, the nitrate contribution from all point sources is not considered in waste load allocations. The allocation of loads for BPG05 is summarized in Table 7-4. The total non-point source load allocation for BPG05 was about 6723 lb/day of nitrate during median flow conditions. Likely, the impairment is caused primarily due to the agricultural activities in the watershed because approximately 96 percent of the land use in the upstream watershed area is agricultural and loads from agricultural areas typically occur during runoff events. A margin of safety (MOS) of 10 percent was used.

TABLE 7-4. TMDL SUMMARY FOR THE NITRATE AT BPG05

Flow Range	**High**	**Medium**	**Low**
Flow Intervals	0-25%	25%-75%	75%-100%
Reduction (%)	18%	43%	0%
TMDL (lb/day)	35,514	7,470	1,067
Load Allocation (lb/day)	31,963	6,723	960
Waste Load Allocation (lb/day)	0	0	0
Margin of Safety (lb/day) (10%)	3,551	747	107

7.2.2 North Fork Vermilion River Segment BPG09

The Hoopeston, Rossville, and Bismark School sewage treatment plants (STP) are considered potential sources of fecal coliform load to segment BPG09. The three plants have been granted disinfection exemptions by IL EPA as a part of each facility's NPDES permit. Each facility should be meeting the 200 cfu/100ml at the end of their respective disinfection exemption stream reach as identified in the permits under all flow conditions. Daily fecal coliform loads from the three point sources were averaged and incorporated into the waste load allocation calculation (total $14\text{x}10^9$ cfu/day). The load allocation is calculated by multiplying the average discharges with 200 cfu/100ml and a unit conversion factor. It is assumed that Alvin water treatment plant, Hoopeston Foods Inc. and Bismarck community district water plant do not contribute fecal coliform to the segment and were not considered in the waste load allocation. Table 7-5 summarizes the point source discharge and load allocation for fecal coliform.

TABLE 7-5 SUMMARY OF WASTE LOAD ALLOCATION FROM POINT SOURCE DISCHARGES IN THE NORTH FORK VERMILION RIVER WATERSHED

Facility Name	**Discharge Flow (cfs)**	**F. Coliform Conc. (cfu/100ml)**	**F. Coliform Load (10^9 cfu/day)**
Hoopeston STP	2.56	200	12.52
Rossville STP	0.28	200	1.37
Bismarck Community Unit School	0.01	200	.05
Total	2.85	200	14

Note: the 200 cfu/100mL standard applies to the end of each facilities' exempted stream reach

During moderate flow conditions, a total load of $1{,}183\text{x}10^9$ cfu/day of fecal coliform is discharged into BPG09 from various non-point sources. The percent reductions on non-point source loads for medium and low flows are 47 and 8 percents respectively, while a 70 percent reduction is needed to meet the water quality standards under high flow condition. The reduction percentages were calculated only for the non-point sources at this time because current total fecal coliform data are not available from each discharger. Based on the historical fecal coliform data obtained from each facility used in granting the disinfection exemptions, it was determined that the exempted stream reaches for each facility would not adversely impact the North Fork Vermilion River. A margin of safety is not explicitly incorporated because it is included implicitly by using the more stringent standard. Table 7-6 summarizes the fecal coliform TMDL for BPG09.

Fecal coliform bacteria occur in ambient water as a result of the overflow of domestic sewage or non-point sources of human and animal waste. Nonpermitted septic systems (about 1,533 in the entire Lake Vermillion watershed) are potentially a significant source of nutrient and fecal coliform loads to both the river and the lake. Other non-point sources include uncontrolled discharges, wildlife, land application of manure, poultry litter, cattle contributions directly deposited in-stream, and grazing animals. Additionally, animal feedlots are also potential sources of nutrients and fecal coliform. Urban land use in the watershed area is only 1.8 percent for BPG05 and 1.1 percent for BPG09.

TABLE 7-6. TMDL SUMMARY FOR FECAL COLIFORM AT BPG09

Flow Range	**High**	**Medium**	**Low**
Flow Intervals	0-25%	25%-75%	75%-100%
Load Reduction (%)	70%	47%	8%
TMDL (10^9 cfu/day)	3,150	645	93
Load Allocation (10^9 cfu/day)	3,136	631	79
Waste Load Allocation (10^9 cfu/day)	14	14	14
Margin of Safety (10^9 cfu/day) (%)	0	0	0

7.2.3 Lake Vermilion (RBD)

This section presents the load allocations for Lake Vermilions.

7.2.3.1 Total Phosphorus

The load allocation for Lake Vermilion TP TMDL was calculated based on the maximum percentage reduction from the three years calibrated. As a result, a reduction of 77% was used for TMDL development. Table 7-7 shows the TMDL allocations for total phosphorus. The existing load is the mean load for the three years modeled and calibrated. The loading capacity represents the 77% reduction in the existing load. The waste load allocation (WLA) is the sum of the waste loads from the treatment plants discharging to Lake Vermilion. An average TP concentration of 3.5 mg/L and average flows from the point sources were used to calculate the WLA. A margin of safety (MOS) of 10% was used. The MOS is calculated as 10% of the load capacity.

TABLE 7-7 TMDL SUMMARY FOR LAKE VERMILION

Category	**TP (lb/day)**
Existing Load	581.9
Reduction	77%
Loading Capacity (TMDL)	133.8
Waste Load Allocation	53.6
MOS	13.4
Load Allocation	66.8

7.2.3.2 Nitrate

Table 7-8 shows the TMDL allocations for nitrates. The existing load is the mean load based on concentrations and flows from the samples measured on the same day at the river and the lake. The loading capacity represents the 34% reduction in the existing load, which is the maximum reduction predicted by the model required to meet the water quality standard. The waste load allocation (WLA) is assumed zero because it is very small compared to the non point source loading. A margin of safety (MOS) of 10% was used. The MOS is calculated as 10% of the load capacity.

TABLE 7-8 NITRATE TMDL SUMMARY FOR LAKE VERMILION

Category	**TN (lb/day)**
Existing Load	14,627.4
Reduction	34%
Loading Capacity (TMDL)	9,719.7
Waste Load Allocation	-
MOS	972.0
Load Allocation	8,747.7

7.3 MARGIN OF SAFETY

The margin of safety (MOS) is an additional factor included in the TMDL to account for scientific uncertainties, growth, etc., such that applicable water quality standards/guidelines are achieved and maintained. The MOS can be included implicitly in the calculations of the WLA and LA expressed explicitly as a separate value. The BATHTUB model calculated a measure of potential model error (coefficient of variation). This error term was used in combination with the coefficient of variation for percent load reductions in order to meet target water quality goals. The summation of these error terms was used to determine an explicit MOS. The coefficient of variation is a measure of variation in numbers relative to the mean value and can be expressed as either a fraction or percent of the mean. A 10 percent margin of safety has been incorporated into the North Fork Vermilion River TMDL for nitrate and Lake Vermilion for total phosphorus and nitrate. A margin of safety for fecal coliform is included implicitly by using the more stringent standard, 200 cfu/100 ml.

7.4 SEASONAL VARIATION

Section 303(d)(1)(C) of the Clean Water Act and USEPA's regulations at 40CFR 130.7 (c)(1) require that a TMDL be established that addresses seasonal variations normally found in the natural system. It is often essential to account for seasonal variations in the concentrations of contaminants addressed in the TMDL. However, while seasonal variation is important for reservoir and lake systems, climate conditions and climate history can have a great effect on transport and transformation processes. Runoff and transport will be affected by previous year climate as well as current climate conditions. Flushing or storage in the reservoir will be affected by the climate (amount of precipitation and runoff) and past inputs. Seasonal variation was addressed by using an averaging program, FLUX, to determine yearly flow-weighted average pollutant concentrations, which integrate the effects of seasonal variation and flow. Seasonal variation is modeled implicitly by including coefficients of variation for measured in-lake water quality parameters, which are descriptive of seasonal variations.

For the North Fork Vermilion River, the impact of seasonal and other short-term variability in nutrient loading will not be significant since the long-term average nutrient concentrations drive the biotic response. Previous investigations of seasonal trends of indicator bacteria densities in surface waters indicate that the summer months typically exhibit the highest densities of any season (DEP 2005). This is likely due to the enhanced ability of indicator bacteria to survive in surface waters and sediment when ambient temperatures more closely approximate those of warm-blooded animals, from which the bacteria originate (DEP, 2005). In addition, resident wildlife populations are likely to be more active during the warmer months and more migratory species are present during summer time (DEP, 2005). These factors combined, result in higher fecal coliform loads in the summer relative to the other seasons.

8.0 REFERENCES

Carlson, R.E. 1977. A trophic state index for lakes. *Limnology and Oceanography* 22:361-369.

City-Data.Com. 2004. On-Line Database with Climate Data for Danville, Illinois. On-Line Address: http://www.city-data.com/city/Danville-Illinois.html. Accessed on February 27.

Cleland, B.R. November 2002. TMDL Development From the “Bottom Up” – Part II: Using Duration Curves to Connect the Pieces. National TMDL Science and Policy 2002 -- WEF Specialty Conference. Phoenix, AZ.

Illinois Department of Agriculture. 2004 Illinois Soil Conservation Transect Survey Summary, September.

IEPA, 2003. ILLINOIS EPA - BOW - DWPC – Monitoring and Assessment Facility-Related Stream Survey Report for Hoopeston STP, June.

IEPA, 2004. Illinois Water Quality Report – Clean Water Act Section 305(b), Bureau of Water. May

Illinois State Water Survey (ISWS). 1998. Annual Summary of Illinois Agricultural Statistics. On-Line Address: http://www.nass.usda.gov/il/1998/9816.htm.

ISWS. 1999. “Sedimentation Survey of Lake Vermilion, Vermilion County, Illinois.” Prepared by William C. Bogner and K. Erin Hessler. May.

ISWS. 2003. “Sediment and Water Quality Monitoring for the Vermilion River and Little Vermilion River Watersheds.” Prepared by Laura Keefer. April.

Lin, S.D. and W. Bogner, 2004, Phase I: Diagnostic Study of Lake Vermilion, Vermilion County, Illinois. Prepared for the Consumers Illinois Water Company and IEPA (draft under review).

Miller-McClellan, J. 2003. A Comparative Study of the Total Maximum Daily Load (TMDL) Program and Process in Virginia and Kansas: Possible Outcomes and Effects upon Stakeholders, Master Thesis. Virginia Polytechnic Institute and State University, April.

Tetra Tech EM, Inc. (Tetra Tech). 2004a. Record of Telephone Conversation Regarding Characteristics of Lake Vermilion. Between Kelly Hirsch and David Cronk, Consumers Illinois Water Company. January 29.

Tetra Tech. 2004b. Record of Telephone Conservation Regarding Animal Feedlots and Agricultural Land in the North Fork Vermilion River Watershed. Between Kelly Hirsch and Glen O. Frank, Natural Resources Conservation Service, District Conservationist, Danville Field Office. February 4.

Tetra Tech. 2004c. Record of Telephone Conversation Regarding Septic System Use in Vermilion County. Between Kelly Hirsch and Doug Toole, Vermilion County Health Department. February 20.

Tetra Tech. 2004d. Record of Telephone Conversation Regarding Septic System Use in Warren County. Between Kelly Hirsch and Dr. Fred Martin, Warren County Health Department. February 23.

Tetra Tech. 2004e. Record of Telephone Conversation Regarding Tile Drainage Monitory Data in Vermilion County, Between Dr. Bin Zhang and Dr. Mike Hirschi, Department of Agricultural Engineering, University of Illinois-Urbana Champion.

U.S. Environmental Protection Agency (EPA). 2003. Search Engine for Permit Compliance System (PCS) database in Envirofacts. On-Line Address: http://www.epa.gov/enviro/html/pcs/pcs_query_java.html. November 24.

EPA. 2000. “Better Assessment Science Integration Point and Nonpoint Sources” (BASINS). Version 3.0. User’s Manual. Office of Water, Parts I and II. EPA-823-C-98-007. November

U.S. Census Bureau. 1990. 1990 Census of Population and Housing Public Law 94-171 Data (Official) Age by Race and Hispanic Origin. On-Line Address: http://censtats.census.gov/pl94/pl94.shtml.

U.S. Census Bureau. 2000. Census 2000 Redistricting Data (Public Law 94-171) Summary File, Matrices PL1, PL2, PL3, PL4. On-Line Address: http://www.census.gov/Press-Release/www/2003/SF4.html.

U.S. Department of Agriculture (USDA). 1995. State Soil Geographic (STATSGO) Database Data Use Information Miscellaneous Publication Number 1492. U.S. Department of Agriculture, Natural Resources Conservation Service. Fort Worth, TX.

Walker, W. W. 1998. BATHTUB Empirical Modeling of Reservoir Eutrophication v. 5.4. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Walker, W. W. 1998. PROFILE Reservoir Data Analysis v. 5). U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Walker, W. W. 1996. Simplified Procedures for Eutrophication Assessment and Prediction: User Manual. Instruction Report W-96-2 (Updated April 1999), U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.

Weischmeier, W.H. and D.D. Smith. 1978 “Predicting Rainfall Erosion Losses – A Guide to Conservation Planning” USDA Agriculture Handbook 537.

USEPA, 1999. Protocol for Developing Nutrient TMDLs. 1st Edition. EPA-841-B-99-007. US Environmental Protection Agency. Office of Water, Washington, D.C. Submitted to the Illinois Environmental Protection Agency on February 27.

USEPA. 2006. Permit Compliance System database. http://www.epa.gov/enviro/html/pcs/pcs_query.html

APPENDIX A
WATER QUALITY DATA

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPGD	BPGD-H-A1	9/23/2002	BOD		6	mg/L
BPGD	BPGD-H-A2	9/23/2002	BOD		2	mg/L
BPGD	BPGD-H-C1	9/23/2002	BOD		2	mg/L
BPGD	BPGD-H-C2	9/23/2002	BOD		1	mg/L
BPGD	BPGD-H-C3	9/23/2002	BOD		<1	mg/L
BPGD	BPGD-H-D2	9/23/2002	BOD		4	mg/L
BPGD	BPGD-H-D3	9/23/2002	BOD		<1	mg/L
BPGD	BPGD-H-E1	9/23/2002	BOD		<1	mg/L
BPGD	BPGD-H-A1	9/23/2002	BOD carb (Inh.)		4	mg/L
BPGD	BPGD-H-A2	9/23/2002	BOD carb (Inh.)		1	mg/L
BPGD	BPGD-H-C1	9/23/2002	BOD carb (Inh.)		1	mg/L
BPGD	BPGD-H-C2	9/23/2002	BOD carb (Inh.)		<1	mg/L
BPGD	BPGD-H-C3	9/23/2002	BOD carb (Inh.)		<1	mg/L
BPGD	BPGD-H-D2	9/23/2002	BOD carb (Inh.)		2	mg/L
BPGD	BPGD-H-D3	9/23/2002	BOD carb (Inh.)		<1	mg/L
BPGD	BPGD-H-E1	9/23/2002	BOD carb (Inh.)		<1	mg/L
RBD	RBD-1	6/28/1979	Chlorophyll a	4	27	mg/L
RBD	RBD-1	9/5/1979	Chlorophyll a	3	44	mg/L
RBD	RBD-1	5/18/1983	Chlorophyll a	1	11.46	mg/L
RBD	RBD-1	4/21/1997	Chlorophyll a	4	31.71	mg/L
RBD	RBD-1	6/9/1997	Chlorophyll a	2	12.57	mg/L
RBD	RBD-1	7/14/1997	Chlorophyll a	6	32.71	mg/L
RBD	RBD-1	8/12/1997	Chlorophyll a	3	17.32	mg/L
RBD	RBD-1	10/22/1997	Chlorophyll a	3	41.72	mg/L
RBD	RBD-1	5/1/2003	Chlorophyll a		33.9	mg/L
RBD	RBD-1	6/18/2003	Chlorophyll a		9	mg/L
RBD	RBD-1	04/19/01	Chlorophyll a		7.92	mg/L
RBD	RBD-1	04/26/01	Chlorophyll a		25.4	mg/L
RBD	RBD-2	6/28/1979	Chlorophyll a	1	144	mg/L
RBD	RBD-2	9/5/1979	Chlorophyll a	2	52	mg/L
RBD	RBD-2	5/18/1983	Chlorophyll a	1	5.24	mg/L
RBD	RBD-2	4/21/1997	Chlorophyll a	3	23.5	mg/L
RBD	RBD-2	6/9/1997	Chlorophyll a	1	9.54	mg/L
RBD	RBD-2	7/14/1997	Chlorophyll a	4	31.37	mg/L
RBD	RBD-2	8/12/1997	Chlorophyll a	3	42.86	mg/L
RBD	RBD-2	10/22/1997	Chlorophyll a	4	34.99	mg/L
RBD	RBD-2	04/19/01	Chlorophyll a		24.4	mg/L
RBD	RBD-2	04/26/01	Chlorophyll a		25.8	mg/L
RBD	RBD-2	5/1/2003	Chlorophyll a		39.2	mg/L
RBD	RBD-2	6/18/2003	Chlorophyll a		4.24	mg/L
RBD	RBD-3	6/28/1979	Chlorophyll a	1	154	mg/L
RBD	RBD-3	9/5/1979	Chlorophyll a	1	27	mg/L
RBD	RBD-3	5/18/1983	Chlorophyll a	1	2.11	mg/L
RBD	RBD-3	4/21/1997	Chlorophyll a	3	16.529	mg/L
RBD	RBD-3	6/9/1997	Chlorophyll a	1	4.45	mg/L
RBD	RBD-3	7/14/1997	Chlorophyll a	2	20.84	mg/L
RBD	RBD-3	8/12/1997	Chlorophyll a	2	51.49	mg/L
RBD	RBD-3	10/22/1997	Chlorophyll a	3	32.24	mg/L
RBD	RBD-4	4/21/1997	Chlorophyll a	3	21.76	mg/L
RBD	RBD-5	04/19/01	Chlorophyll a		20	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-5	04/26/01	Chlorophyll a		33.6	mg/L
RBD	RBD-5	5/1/2003	Chlorophyll a		28.4	mg/L
RBD	RBD-5	6/18/2003	Chlorophyll a		3.99	mg/L
RBD	RBD-01	7/2/1977	Dissolved Oxygen	0	6.5	mg/L
RBD	RBD-01	7/2/1977	Dissolved Oxygen	2	5.5	mg/L
RBD	RBD-01	7/2/1977	Dissolved Oxygen	4	4.5	mg/L
RBD	RBD-01	7/2/1977	Dissolved Oxygen	6	3.7	mg/L
RBD	RBD-01	7/2/1977	Dissolved Oxygen	8	3	mg/L
RBD	RBD-01	7/2/1977	Dissolved Oxygen	10	2.5	mg/L
RBD	RBD-01	7/2/1977	Dissolved Oxygen	12	1.8	mg/L
RBD	RBD-01	7/2/1977	Dissolved Oxygen	14	0.2	mg/L
RBD	RBD-01	7/2/1977	Dissolved Oxygen	16	0.1	mg/L
RBD	RBD-01	7/2/1977	Dissolved Oxygen	18	0.1	mg/L
RBD	RBD-01	7/2/1977	Dissolved Oxygen	19	0.1	mg/L
RBD	RBD-01	6/28/1979	Dissolved Oxygen	0	10.2	mg/L
RBD	RBD-01	6/28/1979	Dissolved Oxygen	1	10.5	mg/L
RBD	RBD-01	6/28/1979	Dissolved Oxygen	3	9.9	mg/L
RBD	RBD-01	6/28/1979	Dissolved Oxygen	5	9.5	mg/L
RBD	RBD-01	6/28/1979	Dissolved Oxygen	7	9.4	mg/L
RBD	RBD-01	6/28/1979	Dissolved Oxygen	9	9.2	mg/L
RBD	RBD-01	6/28/1979	Dissolved Oxygen	11	4.4	mg/L
RBD	RBD-01	6/28/1979	Dissolved Oxygen	13	3.2	mg/L
RBD	RBD-01	6/28/1979	Dissolved Oxygen	14	2.9	mg/L
RBD	RBD-01	9/5/1979	Dissolved Oxygen	0	15.7	mg/L
RBD	RBD-01	9/5/1979	Dissolved Oxygen	1	16	mg/L
RBD	RBD-01	9/5/1979	Dissolved Oxygen	3	15.8	mg/L
RBD	RBD-01	9/5/1979	Dissolved Oxygen	5	16.4	mg/L
RBD	RBD-01	9/5/1979	Dissolved Oxygen	7	16.9	mg/L
RBD	RBD-01	9/5/1979	Dissolved Oxygen	9	14.3	mg/L
RBD	RBD-01	9/5/1979	Dissolved Oxygen	11	4.3	mg/L
RBD	RBD-01	9/5/1979	Dissolved Oxygen	12	0.9	mg/L
RBD	RBD-01	5/18/1983	Dissolved Oxygen	0	9.4	mg/L
RBD	RBD-01	5/18/1983	Dissolved Oxygen	1	9.2	mg/L
RBD	RBD-01	5/18/1983	Dissolved Oxygen	3	9	mg/L
RBD	RBD-01	5/18/1983	Dissolved Oxygen	5	8.8	mg/L
RBD	RBD-01	5/18/1983	Dissolved Oxygen	7	8.7	mg/L
RBD	RBD-01	5/18/1983	Dissolved Oxygen	9	8.1	mg/L
RBD	RBD-01	5/18/1983	Dissolved Oxygen	10	8.2	mg/L
RBD	RBD-01	5/18/1983	Dissolved Oxygen	11	8	mg/L
RBD	RBD-01	5/18/1983	Dissolved Oxygen	12	7.9	mg/L
RBD	RBD-01	5/5/1993	Dissolved Oxygen	0	7.9	mg/L
RBD	RBD-01	5/5/1993	Dissolved Oxygen	1	7.8	mg/L
RBD	RBD-01	5/5/1993	Dissolved Oxygen	3	7.5	mg/L
RBD	RBD-01	5/5/1993	Dissolved Oxygen	5	7.1	mg/L
RBD	RBD-01	5/5/1993	Dissolved Oxygen	7	7.1	mg/L
RBD	RBD-01	5/5/1993	Dissolved Oxygen	9	8	mg/L
RBD	RBD-01	5/5/1993	Dissolved Oxygen	11	7.9	mg/L
RBD	RBD-01	5/5/1993	Dissolved Oxygen	13	7	mg/L
RBD	RBD-01	5/5/1993	Dissolved Oxygen	15	6.7	mg/L
RBD	RBD-01	5/12/1993	Dissolved Oxygen	0	15	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-01	5/12/1993	Dissolved Oxygen	1	15.5	mg/L
RBD	RBD-01	5/12/1993	Dissolved Oxygen	3	15.4	mg/L
RBD	RBD-01	5/12/1993	Dissolved Oxygen	5	14.5	mg/L
RBD	RBD-01	5/12/1993	Dissolved Oxygen	7	11.2	mg/L
RBD	RBD-01	5/12/1993	Dissolved Oxygen	9	9	mg/L
RBD	RBD-01	5/12/1993	Dissolved Oxygen	11	7	mg/L
RBD	RBD-01	5/12/1993	Dissolved Oxygen	13	5.4	mg/L
RBD	RBD-01	5/12/1993	Dissolved Oxygen	15	5	mg/L
RBD	RBD-01	5/27/1993	Dissolved Oxygen	0	13	mg/L
RBD	RBD-01	5/27/1993	Dissolved Oxygen	1	13	mg/L
RBD	RBD-01	5/27/1993	Dissolved Oxygen	3	13.1	mg/L
RBD	RBD-01	5/27/1993	Dissolved Oxygen	5	13	mg/L
RBD	RBD-01	5/27/1993	Dissolved Oxygen	7	10.4	mg/L
RBD	RBD-01	5/27/1993	Dissolved Oxygen	9	10	mg/L
RBD	RBD-01	5/27/1993	Dissolved Oxygen	11	10	mg/L
RBD	RBD-01	5/27/1993	Dissolved Oxygen	13	9.8	mg/L
RBD	RBD-01	5/27/1993	Dissolved Oxygen	15	9.5	mg/L
RBD	RBD-01	6/24/1993	Dissolved Oxygen	0	7	mg/L
RBD	RBD-01	6/24/1993	Dissolved Oxygen	1	6.9	mg/L
RBD	RBD-01	6/24/1993	Dissolved Oxygen	3	6.2	mg/L
RBD	RBD-01	6/24/1993	Dissolved Oxygen	5	4.5	mg/L
RBD	RBD-01	6/24/1993	Dissolved Oxygen	7	4.5	mg/L
RBD	RBD-01	6/24/1993	Dissolved Oxygen	9	4.2	mg/L
RBD	RBD-01	6/24/1993	Dissolved Oxygen	11	4	mg/L
RBD	RBD-01	6/24/1993	Dissolved Oxygen	13	4	mg/L
RBD	RBD-01	6/24/1993	Dissolved Oxygen	15	4	mg/L
RBD	RBD-01	7/1/1993	Dissolved Oxygen	0	6.5	mg/L
RBD	RBD-01	7/1/1993	Dissolved Oxygen	1	7	mg/L
RBD	RBD-01	7/1/1993	Dissolved Oxygen	3	7	mg/L
RBD	RBD-01	7/1/1993	Dissolved Oxygen	5	7.2	mg/L
RBD	RBD-01	7/1/1993	Dissolved Oxygen	7	7.4	mg/L
RBD	RBD-01	7/1/1993	Dissolved Oxygen	9	7.8	mg/L
RBD	RBD-01	7/1/1993	Dissolved Oxygen	11	8	mg/L
RBD	RBD-01	7/1/1993	Dissolved Oxygen	13	7.9	mg/L
RBD	RBD-01	7/1/1993	Dissolved Oxygen	15	8	mg/L
RBD	RBD-01	7/8/1993	Dissolved Oxygen	0	6.5	mg/L
RBD	RBD-01	7/8/1993	Dissolved Oxygen	1	7	mg/L
RBD	RBD-01	7/8/1993	Dissolved Oxygen	3	6.3	mg/L
RBD	RBD-01	7/8/1993	Dissolved Oxygen	5	6.5	mg/L
RBD	RBD-01	7/8/1993	Dissolved Oxygen	7	6.5	mg/L
RBD	RBD-01	7/8/1993	Dissolved Oxygen	9	6.5	mg/L
RBD	RBD-01	7/8/1993	Dissolved Oxygen	11	6	mg/L
RBD	RBD-01	7/8/1993	Dissolved Oxygen	13	5.5	mg/L
RBD	RBD-01	7/8/1993	Dissolved Oxygen	15	5	mg/L
RBD	RBD-01	7/22/1993	Dissolved Oxygen	0	8.5	mg/L
RBD	RBD-01	7/22/1993	Dissolved Oxygen	1	8.8	mg/L
RBD	RBD-01	7/22/1993	Dissolved Oxygen	3	8.7	mg/L
RBD	RBD-01	7/22/1993	Dissolved Oxygen	5	8.5	mg/L
RBD	RBD-01	7/22/1993	Dissolved Oxygen	7	8.5	mg/L
RBD	RBD-01	7/22/1993	Dissolved Oxygen	9	9	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-01	7/22/1993	Dissolved Oxygen	11	8.5	mg/L
RBD	RBD-01	7/22/1993	Dissolved Oxygen	13	7.5	mg/L
RBD	RBD-01	7/22/1993	Dissolved Oxygen	15	4	mg/L
RBD	RBD-01	8/5/1993	Dissolved Oxygen	0	7.1	mg/L
RBD	RBD-01	8/5/1993	Dissolved Oxygen	1	7	mg/L
RBD	RBD-01	8/5/1993	Dissolved Oxygen	3	6.9	mg/L
RBD	RBD-01	8/5/1993	Dissolved Oxygen	5	7.1	mg/L
RBD	RBD-01	8/5/1993	Dissolved Oxygen	7	6.9	mg/L
RBD	RBD-01	8/5/1993	Dissolved Oxygen	9	6.5	mg/L
RBD	RBD-01	8/5/1993	Dissolved Oxygen	11	5	mg/L
RBD	RBD-01	8/5/1993	Dissolved Oxygen	13	5	mg/L
RBD	RBD-01	8/5/1993	Dissolved Oxygen	15	5	mg/L
RBD	RBD-01	8/20/1993	Dissolved Oxygen	0	8.5	mg/L
RBD	RBD-01	8/20/1993	Dissolved Oxygen	1	9	mg/L
RBD	RBD-01	8/20/1993	Dissolved Oxygen	3	8.8	mg/L
RBD	RBD-01	8/20/1993	Dissolved Oxygen	5	8.4	mg/L
RBD	RBD-01	8/20/1993	Dissolved Oxygen	7	8	mg/L
RBD	RBD-01	8/20/1993	Dissolved Oxygen	9	8	mg/L
RBD	RBD-01	8/20/1993	Dissolved Oxygen	11	7	mg/L
RBD	RBD-01	8/20/1993	Dissolved Oxygen	13	7.4	mg/L
RBD	RBD-01	8/20/1993	Dissolved Oxygen	15	6	mg/L
RBD	RBD-01	9/1/1993	Dissolved Oxygen	0	8.6	mg/L
RBD	RBD-01	9/1/1993	Dissolved Oxygen	1	8.6	mg/L
RBD	RBD-01	9/1/1993	Dissolved Oxygen	3	8.3	mg/L
RBD	RBD-01	9/1/1993	Dissolved Oxygen	5	8.3	mg/L
RBD	RBD-01	9/1/1993	Dissolved Oxygen	9	8.5	mg/L
RBD	RBD-01	9/1/1993	Dissolved Oxygen	11	8.3	mg/L
RBD	RBD-01	9/1/1993	Dissolved Oxygen	13	8.3	mg/L
RBD	RBD-01	9/1/1993	Dissolved Oxygen	15	8.2	mg/L
RBD	RBD-01	9/24/1993	Dissolved Oxygen	0	6.4	mg/L
RBD	RBD-01	9/24/1993	Dissolved Oxygen	1	6.4	mg/L
RBD	RBD-01	9/24/1993	Dissolved Oxygen	3	6.9	mg/L
RBD	RBD-01	9/24/1993	Dissolved Oxygen	5	5.6	mg/L
RBD	RBD-01	9/24/1993	Dissolved Oxygen	7	5.6	mg/L
RBD	RBD-01	9/24/1993	Dissolved Oxygen	9	5.5	mg/L
RBD	RBD-01	9/24/1993	Dissolved Oxygen	11	5.5	mg/L
RBD	RBD-01	9/24/1993	Dissolved Oxygen	13	6	mg/L
RBD	RBD-01	9/24/1993	Dissolved Oxygen	15	6	mg/L
RBD	RBD-01	4/21/1997	Dissolved Oxygen	0	12.6	mg/L
RBD	RBD-01	4/21/1997	Dissolved Oxygen	1	12.5	mg/L
RBD	RBD-01	4/21/1997	Dissolved Oxygen	3	12.4	mg/L
RBD	RBD-01	4/21/1997	Dissolved Oxygen	5	12.4	mg/L
RBD	RBD-01	4/21/1997	Dissolved Oxygen	7	12.4	mg/L
RBD	RBD-01	4/21/1997	Dissolved Oxygen	9	12.3	mg/L
RBD	RBD-01	4/21/1997	Dissolved Oxygen	11	12.2	mg/L
RBD	RBD-01	4/21/1997	Dissolved Oxygen	13	11.9	mg/L
RBD	RBD-01	4/21/1997	Dissolved Oxygen	15	11.8	mg/L
RBD	RBD-01	4/21/1997	Dissolved Oxygen	17	10.4	mg/L
RBD	RBD-01	4/21/1997	Dissolved Oxygen	18	9.7	mg/L
RBD	RBD-01	4/21/1997	Dissolved Oxygen	19	8.7	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-01	4/21/1997	Dissolved Oxygen	20	8	mg/L
RBD	RBD-01	6/9/1997	Dissolved Oxygen	0	8.7	mg/L
RBD	RBD-01	6/9/1997	Dissolved Oxygen	1	8.6	mg/L
RBD	RBD-01	6/9/1997	Dissolved Oxygen	3	8.4	mg/L
RBD	RBD-01	6/9/1997	Dissolved Oxygen	5	8.3	mg/L
RBD	RBD-01	6/9/1997	Dissolved Oxygen	7	8.3	mg/L
RBD	RBD-01	6/9/1997	Dissolved Oxygen	9	8.1	mg/L
RBD	RBD-01	6/9/1997	Dissolved Oxygen	11	8.1	mg/L
RBD	RBD-01	6/9/1997	Dissolved Oxygen	13	8	mg/L
RBD	RBD-01	6/9/1997	Dissolved Oxygen	15	7.9	mg/L
RBD	RBD-01	6/9/1997	Dissolved Oxygen	17	7.8	mg/L
RBD	RBD-01	6/9/1997	Dissolved Oxygen	18	7.8	mg/L
RBD	RBD-01	6/9/1997	Dissolved Oxygen	19	7.8	mg/L
RBD	RBD-01	6/9/1997	Dissolved Oxygen	20	7.7	mg/L
RBD	RBD-01	7/14/1997	Dissolved Oxygen	0	10.8	mg/L
RBD	RBD-01	7/14/1997	Dissolved Oxygen	1	10.8	mg/L
RBD	RBD-01	7/14/1997	Dissolved Oxygen	3	10.7	mg/L
RBD	RBD-01	7/14/1997	Dissolved Oxygen	5	10.2	mg/L
RBD	RBD-01	7/14/1997	Dissolved Oxygen	7	9.1	mg/L
RBD	RBD-01	7/14/1997	Dissolved Oxygen	9	7.2	mg/L
RBD	RBD-01	7/14/1997	Dissolved Oxygen	11	6.4	mg/L
RBD	RBD-01	7/14/1997	Dissolved Oxygen	13	3.6	mg/L
RBD	RBD-01	7/14/1997	Dissolved Oxygen	15	2.3	mg/L
RBD	RBD-01	7/14/1997	Dissolved Oxygen	17	1.3	mg/L
RBD	RBD-01	7/14/1997	Dissolved Oxygen	18	0.6	mg/L
RBD	RBD-01	7/14/1997	Dissolved Oxygen	19	0.6	mg/L
RBD	RBD-01	7/14/1997	Dissolved Oxygen	20	0.5	mg/L
RBD	RBD-01	8/12/1997	Dissolved Oxygen	0	4.7	mg/L
RBD	RBD-01	8/12/1997	Dissolved Oxygen	1	4.6	mg/L
RBD	RBD-01	8/12/1997	Dissolved Oxygen	3	4.3	mg/L
RBD	RBD-01	8/12/1997	Dissolved Oxygen	5	4.3	mg/L
RBD	RBD-01	8/12/1997	Dissolved Oxygen	7	4.3	mg/L
RBD	RBD-01	8/12/1997	Dissolved Oxygen	9	4.1	mg/L
RBD	RBD-01	8/12/1997	Dissolved Oxygen	11	3.5	mg/L
RBD	RBD-01	8/12/1997	Dissolved Oxygen	13	2.7	mg/L
RBD	RBD-01	8/12/1997	Dissolved Oxygen	15	1.7	mg/L
RBD	RBD-01	8/12/1997	Dissolved Oxygen	17	1.3	mg/L
RBD	RBD-01	8/12/1997	Dissolved Oxygen	19	0.5	mg/L
RBD	RBD-01	10/22/1997	Dissolved Oxygen	0	11.7	mg/L
RBD	RBD-01	10/22/1997	Dissolved Oxygen	1	10.8	mg/L
RBD	RBD-01	10/22/1997	Dissolved Oxygen	3	10.1	mg/L
RBD	RBD-01	10/22/1997	Dissolved Oxygen	5	9.8	mg/L
RBD	RBD-01	10/22/1997	Dissolved Oxygen	7	9.6	mg/L
RBD	RBD-01	10/22/1997	Dissolved Oxygen	9	9.4	mg/L
RBD	RBD-01	10/22/1997	Dissolved Oxygen	11	9.4	mg/L
RBD	RBD-01	10/22/1997	Dissolved Oxygen	13	9.4	mg/L
RBD	RBD-01	10/22/1997	Dissolved Oxygen	15	9.4	mg/L
RBD	RBD-01	10/22/1997	Dissolved Oxygen	16	9.5	mg/L
RBD	RBD-01	10/22/1997	Dissolved Oxygen	17	9.5	mg/L
RBD	RBD-01	10/22/1997	Dissolved Oxygen	18	9.5	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-01	5/1/2003	Dissolved Oxygen	0	12.4	mg/L
RBD	RBD-01	5/1/2003	Dissolved Oxygen	1	12.3	mg/L
RBD	RBD-01	5/1/2003	Dissolved Oxygen	3	12.1	mg/L
RBD	RBD-01	5/1/2003	Dissolved Oxygen	5	11.5	mg/L
RBD	RBD-01	5/1/2003	Dissolved Oxygen	9	8.8	mg/L
RBD	RBD-01	5/1/2003	Dissolved Oxygen	11	7.7	mg/L
RBD	RBD-01	5/1/2003	Dissolved Oxygen	13	6.7	mg/L
RBD	RBD-01	5/1/2003	Dissolved Oxygen	15	5.8	mg/L
RBD	RBD-01	6/18/2003	Dissolved Oxygen	0	6.6	mg/L
RBD	RBD-01	6/18/2003	Dissolved Oxygen	1	5.9	mg/L
RBD	RBD-01	6/18/2003	Dissolved Oxygen	3	5.5	mg/L
RBD	RBD-01	6/18/2003	Dissolved Oxygen	5	5.1	mg/L
RBD	RBD-01	6/18/2003	Dissolved Oxygen	7	5	mg/L
RBD	RBD-01	6/18/2003	Dissolved Oxygen	9	4.8	mg/L
RBD	RBD-01	6/18/2003	Dissolved Oxygen	11	4.5	mg/L
RBD	RBD-01	6/18/2003	Dissolved Oxygen	13	4	mg/L
RBD	RBD-01	6/18/2003	Dissolved Oxygen	15	3.5	mg/L
RBD	RBD-01	7/16/2003	Dissolved Oxygen	0	9.4	mg/L
RBD	RBD-01	7/16/2003	Dissolved Oxygen	1	9.3	mg/L
RBD	RBD-01	7/16/2003	Dissolved Oxygen	3	8.9	mg/L
RBD	RBD-01	7/16/2003	Dissolved Oxygen	5	8	mg/L
RBD	RBD-01	7/16/2003	Dissolved Oxygen	7	7.6	mg/L
RBD	RBD-01	7/16/2003	Dissolved Oxygen	9	7.2	mg/L
RBD	RBD-01	7/16/2003	Dissolved Oxygen	11	7.2	mg/L
RBD	RBD-01	7/16/2003	Dissolved Oxygen	13	4.7	mg/L
RBD	RBD-01	7/16/2003	Dissolved Oxygen	15	2.7	mg/L
RBD	RBD-01	8/11/2003	Dissolved Oxygen	0	11	mg/L
RBD	RBD-01	8/11/2003	Dissolved Oxygen	1	11.4	mg/L
RBD	RBD-01	8/11/2003	Dissolved Oxygen	3	8.2	mg/L
RBD	RBD-01	8/11/2003	Dissolved Oxygen	5	8.2	mg/L
RBD	RBD-01	8/11/2003	Dissolved Oxygen	7	6.5	mg/L
RBD	RBD-01	8/11/2003	Dissolved Oxygen	9	6.9	mg/L
RBD	RBD-01	8/11/2003	Dissolved Oxygen	11	6.9	mg/L
RBD	RBD-01	8/11/2003	Dissolved Oxygen	13	5	mg/L
RBD	RBD-01	8/11/2003	Dissolved Oxygen	14	4.6	mg/L
RBD	RBD-02	7/2/1977	Dissolved Oxygen	0	7.9	mg/L
RBD	RBD-02	7/2/1977	Dissolved Oxygen	2	6.5	mg/L
RBD	RBD-02	7/2/1977	Dissolved Oxygen	4	5.1	mg/L
RBD	RBD-02	7/2/1977	Dissolved Oxygen	6	3.9	mg/L
RBD	RBD-02	7/2/1977	Dissolved Oxygen	7	3.7	mg/L
RBD	RBD-02	6/28/1979	Dissolved Oxygen	0	16.4	mg/L
RBD	RBD-02	6/28/1979	Dissolved Oxygen	1	12.2	mg/L
RBD	RBD-02	6/28/1979	Dissolved Oxygen	3	10.6	mg/L
RBD	RBD-02	6/28/1979	Dissolved Oxygen	5	11.1	mg/L
RBD	RBD-02	6/28/1979	Dissolved Oxygen	7	8.9	mg/L
RBD	RBD-02	9/5/1979	Dissolved Oxygen	0	14.2	mg/L
RBD	RBD-02	9/5/1979	Dissolved Oxygen	1	13.8	mg/L
RBD	RBD-02	9/5/1979	Dissolved Oxygen	3	13	mg/L
RBD	RBD-02	9/5/1979	Dissolved Oxygen	5	10.1	mg/L
RBD	RBD-02	5/18/1983	Dissolved Oxygen	0	9.9	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-02	5/18/1983	Dissolved Oxygen	1	9.6	mg/L
RBD	RBD-02	5/18/1983	Dissolved Oxygen	3	9.4	mg/L
RBD	RBD-02	5/18/1983	Dissolved Oxygen	5	9.2	mg/L
RBD	RBD-02	5/18/1983	Dissolved Oxygen	6	9.2	mg/L
RBD	RBD-02	5/5/1993	Dissolved Oxygen	0	7.5	mg/L
RBD	RBD-02	5/5/1993	Dissolved Oxygen	1	7.4	mg/L
RBD	RBD-02	5/5/1993	Dissolved Oxygen	3	7.9	mg/L
RBD	RBD-02	5/5/1993	Dissolved Oxygen	5	8	mg/L
RBD	RBD-02	5/5/1993	Dissolved Oxygen	7	8	mg/L
RBD	RBD-02	5/12/1993	Dissolved Oxygen	0	13.2	mg/L
RBD	RBD-02	5/12/1993	Dissolved Oxygen	1	12.5	mg/L
RBD	RBD-02	5/12/1993	Dissolved Oxygen	3	12.8	mg/L
RBD	RBD-02	5/12/1993	Dissolved Oxygen	5	12.4	mg/L
RBD	RBD-02	5/12/1993	Dissolved Oxygen	7	10.4	mg/L
RBD	RBD-02	5/27/1993	Dissolved Oxygen	0	13.1	mg/L
RBD	RBD-02	5/27/1993	Dissolved Oxygen	1	13	mg/L
RBD	RBD-02	5/27/1993	Dissolved Oxygen	3	12.9	mg/L
RBD	RBD-02	5/27/1993	Dissolved Oxygen	5	13.3	mg/L
RBD	RBD-02	5/27/1993	Dissolved Oxygen	7	13.3	mg/L
RBD	RBD-02	6/24/1993	Dissolved Oxygen	0	8.5	mg/L
RBD	RBD-02	6/24/1993	Dissolved Oxygen	1	8.5	mg/L
RBD	RBD-02	6/24/1993	Dissolved Oxygen	3	8.5	mg/L
RBD	RBD-02	6/24/1993	Dissolved Oxygen	5	8.2	mg/L
RBD	RBD-02	6/24/1993	Dissolved Oxygen	7	8.5	mg/L
RBD	RBD-02	6/24/1993	Dissolved Oxygen	9	8.5	mg/L
RBD	RBD-02	7/1/1993	Dissolved Oxygen	0	9	mg/L
RBD	RBD-02	7/1/1993	Dissolved Oxygen	1	8.8	mg/L
RBD	RBD-02	7/1/1993	Dissolved Oxygen	3	9	mg/L
RBD	RBD-02	7/1/1993	Dissolved Oxygen	5	9	mg/L
RBD	RBD-02	7/1/1993	Dissolved Oxygen	7	9	mg/L
RBD	RBD-02	7/1/1993	Dissolved Oxygen	9	9	mg/L
RBD	RBD-02	7/8/1993	Dissolved Oxygen	0	8	mg/L
RBD	RBD-02	7/8/1993	Dissolved Oxygen	1	9	mg/L
RBD	RBD-02	7/8/1993	Dissolved Oxygen	3	8.5	mg/L
RBD	RBD-02	7/8/1993	Dissolved Oxygen	5	8.3	mg/L
RBD	RBD-02	7/22/1993	Dissolved Oxygen	0	6.5	mg/L
RBD	RBD-02	7/22/1993	Dissolved Oxygen	1	6	mg/L
RBD	RBD-02	7/22/1993	Dissolved Oxygen	3	6.5	mg/L
RBD	RBD-02	7/22/1993	Dissolved Oxygen	5	6.5	mg/L
RBD	RBD-02	7/22/1993	Dissolved Oxygen	7	6.5	mg/L
RBD	RBD-02	8/5/1993	Dissolved Oxygen	0	6.5	mg/L
RBD	RBD-02	8/5/1993	Dissolved Oxygen	1	5	mg/L
RBD	RBD-02	8/5/1993	Dissolved Oxygen	3	5	mg/L
RBD	RBD-02	8/5/1993	Dissolved Oxygen	5	5	mg/L
RBD	RBD-02	8/20/1993	Dissolved Oxygen	0	7	mg/L
RBD	RBD-02	8/20/1993	Dissolved Oxygen	1	7	mg/L
RBD	RBD-02	8/20/1993	Dissolved Oxygen	3	7	mg/L
RBD	RBD-02	8/20/1993	Dissolved Oxygen	5	7	mg/L
RBD	RBD-02	8/20/1993	Dissolved Oxygen	7	6.3	mg/L
RBD	RBD-02	9/24/1993	Dissolved Oxygen	0	6.7	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-02	9/24/1993	Dissolved Oxygen	1	6.7	mg/L
RBD	RBD-02	9/24/1993	Dissolved Oxygen	3	6	mg/L
RBD	RBD-02	9/24/1993	Dissolved Oxygen	5	6	mg/L
RBD	RBD-02	9/24/1993	Dissolved Oxygen	7	6	mg/L
RBD	RBD-02	4/21/1997	Dissolved Oxygen	0	11.1	mg/L
RBD	RBD-02	4/21/1997	Dissolved Oxygen	1	11.1	mg/L
RBD	RBD-02	4/21/1997	Dissolved Oxygen	3	11	mg/L
RBD	RBD-02	4/21/1997	Dissolved Oxygen	5	11	mg/L
RBD	RBD-02	4/21/1997	Dissolved Oxygen	7	9.2	mg/L
RBD	RBD-02	4/21/1997	Dissolved Oxygen	9	8.7	mg/L
RBD	RBD-02	4/21/1997	Dissolved Oxygen	10	8	mg/L
RBD	RBD-02	6/9/1997	Dissolved Oxygen	0	8.8	mg/L
RBD	RBD-02	6/9/1997	Dissolved Oxygen	1	8.5	mg/L
RBD	RBD-02	6/9/1997	Dissolved Oxygen	3	8.4	mg/L
RBD	RBD-02	6/9/1997	Dissolved Oxygen	5	8.2	mg/L
RBD	RBD-02	6/9/1997	Dissolved Oxygen	7	8.1	mg/L
RBD	RBD-02	6/9/1997	Dissolved Oxygen	9	8	mg/L
RBD	RBD-02	6/9/1997	Dissolved Oxygen	10	7.9	mg/L
RBD	RBD-02	7/14/1997	Dissolved Oxygen	0	9.9	mg/L
RBD	RBD-02	7/14/1997	Dissolved Oxygen	1	9.9	mg/L
RBD	RBD-02	7/14/1997	Dissolved Oxygen	3	9.9	mg/L
RBD	RBD-02	7/14/1997	Dissolved Oxygen	5	9.8	mg/L
RBD	RBD-02	7/14/1997	Dissolved Oxygen	7	9.8	mg/L
RBD	RBD-02	7/14/1997	Dissolved Oxygen	9	9.8	mg/L
RBD	RBD-02	7/14/1997	Dissolved Oxygen	11	6.8	mg/L
RBD	RBD-02	8/12/1997	Dissolved Oxygen	0	7.1	mg/L
RBD	RBD-02	8/12/1997	Dissolved Oxygen	1	7	mg/L
RBD	RBD-02	8/12/1997	Dissolved Oxygen	3	6.9	mg/L
RBD	RBD-02	8/12/1997	Dissolved Oxygen	5	6.8	mg/L
RBD	RBD-02	8/12/1997	Dissolved Oxygen	7	6.7	mg/L
RBD	RBD-02	8/12/1997	Dissolved Oxygen	9	6.5	mg/L
RBD	RBD-02	8/12/1997	Dissolved Oxygen	10	5.6	mg/L
RBD	RBD-02	10/22/1997	Dissolved Oxygen	0	12.6	mg/L
RBD	RBD-02	10/22/1997	Dissolved Oxygen	1	11.9	mg/L
RBD	RBD-02	10/22/1997	Dissolved Oxygen	3	11.5	mg/L
RBD	RBD-02	10/22/1997	Dissolved Oxygen	5	11.4	mg/L
RBD	RBD-02	10/22/1997	Dissolved Oxygen	7	11.1	mg/L
RBD	RBD-02	10/22/1997	Dissolved Oxygen	9	10.6	mg/L
RBD	RBD-02	6/18/2003	Dissolved Oxygen	0	6.5	mg/L
RBD	RBD-02	6/18/2003	Dissolved Oxygen	1	6.1	mg/L
RBD	RBD-02	6/18/2003	Dissolved Oxygen	3	6.1	mg/L
RBD	RBD-02	6/18/2003	Dissolved Oxygen	5	6.1	mg/L
RBD	RBD-02	6/18/2003	Dissolved Oxygen	7	5.9	mg/L
RBD	RBD-02	7/16/2003	Dissolved Oxygen	0	9.9	mg/L
RBD	RBD-02	7/16/2003	Dissolved Oxygen	1	10.2	mg/L
RBD	RBD-02	7/16/2003	Dissolved Oxygen	3	7.5	mg/L
RBD	RBD-02	7/16/2003	Dissolved Oxygen	5	7.1	mg/L
RBD	RBD-02	7/16/2003	Dissolved Oxygen	7	6.7	mg/L
RBD	RBD-02	7/16/2003	Dissolved Oxygen	8	6.1	mg/L
RBD	RBD-02	8/11/2003	Dissolved Oxygen	0	9.4	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-02	8/11/2003	Dissolved Oxygen	1	8.7	mg/L
RBD	RBD-02	8/11/2003	Dissolved Oxygen	3	6.7	mg/L
RBD	RBD-02	8/11/2003	Dissolved Oxygen	5	6.3	mg/L
RBD	RBD-02	8/11/2003	Dissolved Oxygen	6	6.2	mg/L
RBD	RBD-03	7/2/1977	Dissolved Oxygen	0	9.5	mg/L
RBD	RBD-03	7/2/1977	Dissolved Oxygen	2	6	mg/L
RBD	RBD-03	7/22/1977	Dissolved Oxygen	1	8.3	mg/L
RBD	RBD-03	6/28/1979	Dissolved Oxygen	0	16.6	mg/L
RBD	RBD-03	6/28/1979	Dissolved Oxygen	1	15	mg/L
RBD	RBD-03	6/28/1979	Dissolved Oxygen	3	7.2	mg/L
RBD	RBD-03	9/5/1979	Dissolved Oxygen	0	7.5	mg/L
RBD	RBD-03	9/5/1979	Dissolved Oxygen	1	7.4	mg/L
RBD	RBD-03	9/5/1979	Dissolved Oxygen	2	7.1	mg/L
RBD	RBD-03	5/18/1983	Dissolved Oxygen	0	9.9	mg/L
RBD	RBD-03	5/18/1983	Dissolved Oxygen	1	9.6	mg/L
RBD	RBD-03	5/18/1983	Dissolved Oxygen	2	9.4	mg/L
RBD	RBD-03	5/5/1993	Dissolved Oxygen	0	8.2	mg/L
RBD	RBD-03	5/5/1993	Dissolved Oxygen	1	7.7	mg/L
RBD	RBD-03	5/5/1993	Dissolved Oxygen	3	7.7	mg/L
RBD	RBD-03	5/5/1993	Dissolved Oxygen	5	7.6	mg/L
RBD	RBD-03	5/5/1993	Dissolved Oxygen	6	7.6	mg/L
RBD	RBD-03	5/12/1993	Dissolved Oxygen	0	12	mg/L
RBD	RBD-03	5/12/1993	Dissolved Oxygen	1	11.9	mg/L
RBD	RBD-03	5/12/1993	Dissolved Oxygen	3	11.2	mg/L
RBD	RBD-03	5/12/1993	Dissolved Oxygen	5	8.2	mg/L
RBD	RBD-03	6/24/1993	Dissolved Oxygen	0	8.5	mg/L
RBD	RBD-03	6/24/1993	Dissolved Oxygen	1	8.5	mg/L
RBD	RBD-03	6/24/1993	Dissolved Oxygen	3	8.2	mg/L
RBD	RBD-03	6/24/1993	Dissolved Oxygen	5	8.1	mg/L
RBD	RBD-03	7/1/1993	Dissolved Oxygen	0	10	mg/L
RBD	RBD-03	7/1/1993	Dissolved Oxygen	1	10	mg/L
RBD	RBD-03	7/1/1993	Dissolved Oxygen	3	9.7	mg/L
RBD	RBD-03	7/1/1993	Dissolved Oxygen	5	9.6	mg/L
RBD	RBD-03	7/8/1993	Dissolved Oxygen	0	8	mg/L
RBD	RBD-03	7/8/1993	Dissolved Oxygen	1	7.5	mg/L
RBD	RBD-03	7/8/1993	Dissolved Oxygen	3	7	mg/L
RBD	RBD-03	7/22/1993	Dissolved Oxygen	0	6	mg/L
RBD	RBD-03	7/22/1993	Dissolved Oxygen	1	6	mg/L
RBD	RBD-03	7/22/1993	Dissolved Oxygen	3	5.5	mg/L
RBD	RBD-03	7/22/1993	Dissolved Oxygen	5	5.5	mg/L
RBD	RBD-03	8/5/1993	Dissolved Oxygen	0	8.5	mg/L
RBD	RBD-03	8/5/1993	Dissolved Oxygen	1	8	mg/L
RBD	RBD-03	8/5/1993	Dissolved Oxygen	3	8	mg/L
RBD	RBD-03	8/5/1993	Dissolved Oxygen	5	5	mg/L
RBD	RBD-03	8/20/1993	Dissolved Oxygen	0	10	mg/L
RBD	RBD-03	8/20/1993	Dissolved Oxygen	1	10.5	mg/L
RBD	RBD-03	8/20/1993	Dissolved Oxygen	3	8	mg/L
RBD	RBD-03	8/20/1993	Dissolved Oxygen	5	6.5	mg/L
RBD	RBD-03	9/24/1993	Dissolved Oxygen	0	7	mg/L
RBD	RBD-03	9/24/1993	Dissolved Oxygen	1	7	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-03	9/24/1993	Dissolved Oxygen	3	7	mg/L
RBD	RBD-03	9/24/1993	Dissolved Oxygen	5	7	mg/L
RBD	RBD-03	4/21/1997	Dissolved Oxygen	0	10.9	mg/L
RBD	RBD-03	4/21/1997	Dissolved Oxygen	1	10.8	mg/L
RBD	RBD-03	4/21/1997	Dissolved Oxygen	3	10.6	mg/L
RBD	RBD-03	4/21/1997	Dissolved Oxygen	5	10.5	mg/L
RBD	RBD-03	6/9/1997	Dissolved Oxygen	0	8.5	mg/L
RBD	RBD-03	6/9/1997	Dissolved Oxygen	1	8.4	mg/L
RBD	RBD-03	6/9/1997	Dissolved Oxygen	3	8	mg/L
RBD	RBD-03	6/9/1997	Dissolved Oxygen	5	8	mg/L
RBD	RBD-03	7/14/1997	Dissolved Oxygen	0	8.7	mg/L
RBD	RBD-03	7/14/1997	Dissolved Oxygen	1	8.7	mg/L
RBD	RBD-03	7/14/1997	Dissolved Oxygen	3	8.6	mg/L
RBD	RBD-03	7/14/1997	Dissolved Oxygen	5	5.9	mg/L
RBD	RBD-03	8/12/1997	Dissolved Oxygen	0	6.2	mg/L
RBD	RBD-03	8/12/1997	Dissolved Oxygen	1	6.1	mg/L
RBD	RBD-03	8/12/1997	Dissolved Oxygen	3	4.9	mg/L
RBD	RBD-03	8/12/1997	Dissolved Oxygen	5	1	mg/L
RBD	RBD-03	10/22/1997	Dissolved Oxygen	0	12.8	mg/L
RBD	RBD-03	10/22/1997	Dissolved Oxygen	1	11.6	mg/L
RBD	RBD-03	10/22/1997	Dissolved Oxygen	3	11.5	mg/L
RBD	RBD-04	5/5/1993	Dissolved Oxygen	0	7.7	mg/L
RBD	RBD-04	5/5/1993	Dissolved Oxygen	1	7.7	mg/L
RBD	RBD-04	5/5/1993	Dissolved Oxygen	3	7.5	mg/L
RBD	RBD-04	5/5/1993	Dissolved Oxygen	5	7.4	mg/L
RBD	RBD-04	5/12/1993	Dissolved Oxygen	0	11.7	mg/L
RBD	RBD-04	5/12/1993	Dissolved Oxygen	1	11.5	mg/L
RBD	RBD-04	5/12/1993	Dissolved Oxygen	3	11	mg/L
RBD	RBD-04	5/12/1993	Dissolved Oxygen	4	11.5	mg/L
RBD	RBD-04	5/27/1993	Dissolved Oxygen	0	11	mg/L
RBD	RBD-04	5/27/1993	Dissolved Oxygen	1	10.8	mg/L
RBD	RBD-04	5/27/1993	Dissolved Oxygen	3	10.5	mg/L
RBD	RBD-04	6/24/1993	Dissolved Oxygen	0	8.5	mg/L
RBD	RBD-04	6/24/1993	Dissolved Oxygen	1	8.5	mg/L
RBD	RBD-04	6/24/1993	Dissolved Oxygen	3	8.2	mg/L
RBD	RBD-04	6/24/1993	Dissolved Oxygen	5	8.1	mg/L
RBD	RBD-04	7/1/1993	Dissolved Oxygen	0	10.5	mg/L
RBD	RBD-04	7/1/1993	Dissolved Oxygen	1	10.3	mg/L
RBD	RBD-04	7/1/1993	Dissolved Oxygen	3	10.3	mg/L
RBD	RBD-04	7/1/1993	Dissolved Oxygen	5	10.3	mg/L
RBD	RBD-04	7/8/1993	Dissolved Oxygen	0	8.3	mg/L
RBD	RBD-04	7/8/1993	Dissolved Oxygen	1	8.5	mg/L
RBD	RBD-04	7/8/1993	Dissolved Oxygen	3	8	mg/L
RBD	RBD-04	7/8/1993	Dissolved Oxygen	5	6.5	mg/L
RBD	RBD-04	7/22/1993	Dissolved Oxygen	0	6.5	mg/L
RBD	RBD-04	7/22/1993	Dissolved Oxygen	1	6.5	mg/L
RBD	RBD-04	7/22/1993	Dissolved Oxygen	3	6.5	mg/L
RBD	RBD-04	7/22/1993	Dissolved Oxygen	5	7	mg/L
RBD	RBD-04	8/5/1993	Dissolved Oxygen	0	8.5	mg/L
RBD	RBD-04	8/5/1993	Dissolved Oxygen	1	8.5	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-04	8/5/1993	Dissolved Oxygen	3	8	mg/L
RBD	RBD-04	8/5/1993	Dissolved Oxygen	5	7.5	mg/L
RBD	RBD-04	8/20/1993	Dissolved Oxygen	0	7.5	mg/L
RBD	RBD-04	8/20/1993	Dissolved Oxygen	1	6	mg/L
RBD	RBD-04	8/20/1993	Dissolved Oxygen	3	5.5	mg/L
RBD	RBD-04	8/20/1993	Dissolved Oxygen	5	5.5	mg/L
RBD	RBD-04	9/24/1993	Dissolved Oxygen	0	8.2	mg/L
RBD	RBD-04	9/24/1993	Dissolved Oxygen	1	8.2	mg/L
RBD	RBD-04	9/24/1993	Dissolved Oxygen	3	8	mg/L
RBD	RBD-04	9/24/1993	Dissolved Oxygen	5	7.5	mg/L
RBD	RBD-04	4/21/1997	Dissolved Oxygen	0	10.7	mg/L
RBD	RBD-04	4/21/1997	Dissolved Oxygen	1	10.6	mg/L
RBD	RBD-04	4/21/1997	Dissolved Oxygen	3	10.4	mg/L
RBD	RBD-04	4/21/1997	Dissolved Oxygen	5	10.2	mg/L
RBD	RBD-04	4/21/1997	Dissolved Oxygen	7	8.2	mg/L
RBD	RBD-05	5/1/2003	Dissolved Oxygen	0	9.2	mg/L
RBD	RBD-05	5/1/2003	Dissolved Oxygen	1	9.1	mg/L
RBD	RBD-05	5/1/2003	Dissolved Oxygen	3	8.8	mg/L
RBD	RBD-05	5/1/2003	Dissolved Oxygen	4	8.4	mg/L
RBD	RBD-05	6/18/2003	Dissolved Oxygen	0	6.2	mg/L
RBD	RBD-05	6/18/2003	Dissolved Oxygen	1	6.2	mg/L
RBD	RBD-05	6/18/2003	Dissolved Oxygen	3	6.3	mg/L
RBD	RBD-05	6/18/2003	Dissolved Oxygen	5	6.3	mg/L
RBD	RBD-05	7/16/2003	Dissolved Oxygen	0	6.1	mg/L
RBD	RBD-05	7/16/2003	Dissolved Oxygen	1	6.1	mg/L
RBD	RBD-05	7/16/2003	Dissolved Oxygen	3	6.2	mg/L
RBD	RBD-05	7/16/2003	Dissolved Oxygen	5	6	mg/L
RBD	RBD-05	8/11/2003	Dissolved Oxygen	0	8.5	mg/L
RBD	RBD-05	8/11/2003	Dissolved Oxygen	1	7.9	mg/L
RBD	RBD-05	8/11/2003	Dissolved Oxygen	3	6.5	mg/L
BPGD	BPGD-H-A1	9/23/2002	Dissolved Oxygen (field)		4.7	mg/L
BPGD	BPGD-H-A2	9/23/2002	Dissolved Oxygen (field)		10.4	mg/L
BPGD	BPGD-H-C1	9/23/2002	Dissolved Oxygen (field)		9.1	mg/L
BPGD	BPGD-H-C2	9/23/2002	Dissolved Oxygen (field)		11.4	mg/L
BPGD	BPGD-H-C3	9/23/2002	Dissolved Oxygen (field)		9.4	mg/L
BPGD	BPGD-H-D2	9/23/2002	Dissolved Oxygen (field)		5.1	mg/L
BPGD	BPGD-H-D3	9/23/2002	Dissolved Oxygen (field)		9.9	mg/L
BPGD	BPGD-H-E1	9/23/2002	Dissolved Oxygen (field)		9.1	mg/L
BPG 09	BPG09	2/14/1980	Dissolved Phosphorus	1	0.2	mg/L
BPG 09	BPG09	3/31/1980	Dissolved Phosphorus	1	0.1	mg/L
BPG 09	BPG09	5/2/1980	Dissolved Phosphorus	1	0.09	mg/L
BPG 09	BPG09	5/2/1980	Dissolved Phosphorus	1	0.09	mg/L
BPG 09	BPG09	6/4/1980	Dissolved Phosphorus	1	0.11	mg/L
BPG 09	BPG09	7/7/1980	Dissolved Phosphorus	1	0.09	mg/L
BPG 09	BPG09	8/11/1980	Dissolved Phosphorus	1	0.17	mg/L
BPG 09	BPG09	5/2/1984	Dissolved Phosphorus	1	0.01	mg/L
BPG 09	BPG09	6/21/1984	Dissolved Phosphorus	1	0.05	mg/L
BPG 09	BPG09	7/18/1984	Dissolved Phosphorus	1	0.09	mg/L
BPG 09	BPG09	8/22/1984	Dissolved Phosphorus	1	0.1	mg/L
BPG 09	BPG09	9/19/1984	Dissolved Phosphorus	1	0.09	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	11/7/1984	Dissolved Phosphorus	1	0.09	mg/L
BPG 09	BPG09	12/13/1984	Dissolved Phosphorus	1	0.02	mg/L
BPG 09	BPG09	1/16/1985	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	3/6/1985	Dissolved Phosphorus	1	0.05	mg/L
BPG 09	BPG09	4/15/1985	Dissolved Phosphorus	1	0.02	mg/L
BPG 09	BPG09	5/23/1985	Dissolved Phosphorus	1	0.04	mg/L
BPG 09	BPG09	7/2/1985	Dissolved Phosphorus	1	0.1	mg/L
BPG 09	BPG09	8/19/1985	Dissolved Phosphorus	1	0.08	mg/L
BPG 09	BPG09	9/16/1985	Dissolved Phosphorus	1	0.13	mg/L
BPG 09	BPG09	10/16/1985	Dissolved Phosphorus	1	0.15	mg/L
BPG 09	BPG09	12/10/1985	Dissolved Phosphorus	1	0.05	mg/L
BPG 09	BPG09	1/29/1986	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	2/20/1986	Dissolved Phosphorus	1	0.08	mg/L
BPG 09	BPG09	3/25/1986	Dissolved Phosphorus	1	0.01	mg/L
BPG 09	BPG09	4/30/1986	Dissolved Phosphorus	1	0.05	mg/L
BPG 09	BPG09	6/17/1986	Dissolved Phosphorus	1	0.06	mg/L
BPG 09	BPG09	7/15/1986	Dissolved Phosphorus	1	0.07	mg/L
BPG 09	BPG09	9/10/1986	Dissolved Phosphorus	1	0.05	mg/L
BPG 09	BPG09	10/7/1986	Dissolved Phosphorus	1	0.1	mg/L
BPG 09	BPG09	12/2/1986	Dissolved Phosphorus	1	0.14	mg/L
BPG 09	BPG09	1/13/1987	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	2/17/1987	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	3/24/1987	Dissolved Phosphorus	1	0.01	mg/L
BPG 09	BPG09	4/28/1987	Dissolved Phosphorus	1	0.02	mg/L
BPG 09	BPG09	6/2/1987	Dissolved Phosphorus	1	0.08	mg/L
BPG 09	BPG09	7/20/1987	Dissolved Phosphorus	1	0.08	mg/L
BPG 09	BPG09	9/9/1987	Dissolved Phosphorus	1	0.09	mg/L
BPG 09	BPG09	11/3/1987	Dissolved Phosphorus	1	0.08	mg/L
BPG 09	BPG09	12/10/1987	Dissolved Phosphorus	1	0.07	mg/L
BPG 09	BPG09	1/21/1988	Dissolved Phosphorus	1	0.25	mg/L
BPG 09	BPG09	3/3/1988	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	4/5/1988	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	5/19/1988	Dissolved Phosphorus	1	0.05	mg/L
BPG 09	BPG09	6/23/1988	Dissolved Phosphorus	1	0.12	mg/L
BPG 09	BPG09	8/11/1988	Dissolved Phosphorus	1	1.9	mg/L
BPG 09	BPG09	9/15/1988	Dissolved Phosphorus	1	0.12	mg/L
BPG 09	BPG09	11/10/1988	Dissolved Phosphorus	1	0.19	mg/L
BPG 09	BPG09	12/14/1988	Dissolved Phosphorus	1	0.04	mg/L
BPG 09	BPG09	1/19/1989	Dissolved Phosphorus	1	0.029	mg/L
BPG 09	BPG09	2/23/1989	Dissolved Phosphorus	1	0.02	mg/L
BPG 09	BPG09	4/13/1989	Dissolved Phosphorus	1	0.01	mg/L
BPG 09	BPG09	5/10/1989	Dissolved Phosphorus	1	0.07	mg/L
BPG 09	BPG09	6/20/1989	Dissolved Phosphorus	1	0.06	mg/L
BPG 09	BPG09	8/2/1989	Dissolved Phosphorus	1	0.09	mg/L
BPG 09	BPG09	9/14/1989	Dissolved Phosphorus	1	0.12	mg/L
BPG 09	BPG09	11/8/1989	Dissolved Phosphorus	1	0.04	mg/L
BPG 09	BPG09	12/12/1989	Dissolved Phosphorus	1	0.02	mg/L
BPG 09	BPG09	1/24/1990	Dissolved Phosphorus	1	0.02	mg/L
BPG 09	BPG09	2/28/1990	Dissolved Phosphorus	1	0.08	mg/L
BPG 09	BPG09	3/28/1990	Dissolved Phosphorus	1	0.03	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	5/9/1990	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	7/3/1990	Dissolved Phosphorus	1	0.05	mg/L
BPG 09	BPG09	8/2/1990	Dissolved Phosphorus	1	0.07	mg/L
BPG 09	BPG09	9/26/1990	Dissolved Phosphorus	1	0.07	mg/L
BPG 09	BPG09	10/31/1990	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	12/10/1990	Dissolved Phosphorus	1	0.01	mg/L
BPG 09	BPG09	1/16/1991	Dissolved Phosphorus	1	0.2	mg/L
BPG 09	BPG09	3/5/1991	Dissolved Phosphorus	1	0.02	mg/L
BPG 09	BPG09	4/3/1991	Dissolved Phosphorus	1	0.02	mg/L
BPG 09	BPG09	5/22/1991	Dissolved Phosphorus	1	0.06	mg/L
BPG 09	BPG09	6/26/1991	Dissolved Phosphorus	1	0.04	mg/L
BPG 09	BPG09	8/21/1991	Dissolved Phosphorus	1	0.06	mg/L
BPG 09	BPG09	9/30/1991	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	11/14/1991	Dissolved Phosphorus	1	0.04	mg/L
BPG 09	BPG09	12/18/1991	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	2/4/1992	Dissolved Phosphorus	1	0.02	mg/L
BPG 09	BPG09	3/17/1992	Dissolved Phosphorus	1	0.01	mg/L
BPG 09	BPG09	6/3/1992	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	7/13/1992	Dissolved Phosphorus	1	0.08	mg/L
BPG 09	BPG09	8/12/1992	Dissolved Phosphorus	1	0.05	mg/L
BPG 09	BPG09	9/23/1992	Dissolved Phosphorus	1	0.07	mg/L
BPG 09	BPG09	11/18/1992	Dissolved Phosphorus	1	0.05	mg/L
BPG 09	BPG09	12/16/1992	Dissolved Phosphorus	1	0.12	mg/L
BPG 09	BPG09	2/1/1993	Dissolved Phosphorus	1	0.04	mg/L
BPG 09	BPG09	3/9/1993	Dissolved Phosphorus	1	0.083	mg/L
BPG 09	BPG09	4/7/1993	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	5/24/1993	Dissolved Phosphorus	1	0.12	mg/L
BPG 09	BPG09	6/28/1993	Dissolved Phosphorus	1	0.05	mg/L
BPG 09	BPG09	8/18/1993	Dissolved Phosphorus	1	0.05	mg/L
BPG 09	BPG09	9/28/1993	Dissolved Phosphorus	1	0.07	mg/L
BPG 09	BPG09	11/15/1993	Dissolved Phosphorus	1	0.14	mg/L
BPG 09	BPG09	12/20/1993	Dissolved Phosphorus	1	0.04	mg/L
BPG 09	BPG09	3/2/1994	Dissolved Phosphorus	1	0.08	mg/L
BPG 09	BPG09	3/29/1994	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	4/28/1994	Dissolved Phosphorus	1	0.08	mg/L
BPG 09	BPG09	6/30/1994	Dissolved Phosphorus	1	0.05	mg/L
BPG 09	BPG09	8/15/1994	Dissolved Phosphorus	1	0.06	mg/L
BPG 09	BPG09	9/6/1994	Dissolved Phosphorus	1	0.09	mg/L
BPG 09	BPG09	9/26/1994	Dissolved Phosphorus	1	0.12	mg/L
BPG 09	BPG09	11/2/1994	Dissolved Phosphorus	1	0.34	mg/L
BPG 09	BPG09	1/4/1995	Dissolved Phosphorus	1	0.06	mg/L
BPG 09	BPG09	2/1/1995	Dissolved Phosphorus	1	0.02	mg/L
BPG 09	BPG09	2/27/1995	Dissolved Phosphorus	1	0.021	mg/L
BPG 09	BPG09	5/11/1995	Dissolved Phosphorus	1	0.04	mg/L
BPG 09	BPG09	6/14/1995	Dissolved Phosphorus	1	0.035	mg/L
BPG 09	BPG09	9/7/1995	Dissolved Phosphorus	1	0.08	mg/L
BPG 09	BPG09	10/16/1995	Dissolved Phosphorus	1	0.055	mg/L
BPG 09	BPG09	12/12/1995	Dissolved Phosphorus	1	0.09	mg/L
BPG 09	BPG09	1/29/1996	Dissolved Phosphorus	1	0.055	mg/L
BPG 09	BPG09	2/29/1996	Dissolved Phosphorus	1	0.04	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	3/28/1996	Dissolved Phosphorus	1	0.02	mg/L
BPG 09	BPG09	4/19/1996	Dissolved Phosphorus	1	0.02	mg/L
BPG 09	BPG09	5/20/1996	Dissolved Phosphorus	1	0.05	mg/L
BPG 09	BPG09	7/18/1996	Dissolved Phosphorus	1	0.05	mg/L
BPG 09	BPG09	8/26/1996	Dissolved Phosphorus	1	0.06	mg/L
BPG 09	BPG09	10/28/1996	Dissolved Phosphorus	1	0.1	mg/L
BPG 09	BPG09	12/16/1996	Dissolved Phosphorus	1	0.051	mg/L
BPG 09	BPG09	2/4/1997	Dissolved Phosphorus	1	0.25	mg/L
BPG 09	BPG09	3/4/1997	Dissolved Phosphorus	1	0.1	mg/L
BPG 09	BPG09	4/2/1997	Dissolved Phosphorus	1	0.01	mg/L
BPG 09	BPG09	4/30/1997	Dissolved Phosphorus	1	0.01	mg/L
BPG 09	BPG09	7/9/1997	Dissolved Phosphorus	1	0.05	mg/L
BPG 09	BPG09	9/9/1997	Dissolved Phosphorus	1	0.07	mg/L
BPG 09	BPG09	9/26/1997	Dissolved Phosphorus	1	0.08	mg/L
BPG 09	BPG09	10/30/1997	Dissolved Phosphorus	1	0.04	mg/L
BPG 09	BPG09	11/19/1997	Dissolved Phosphorus	1	0.02	mg/L
BPG 09	BPG09	1/6/1998	Dissolved Phosphorus	1	0.05	mg/L
BPG 09	BPG09	3/13/1998	Dissolved Phosphorus	1	0.04	mg/L
BPG 09	BPG09	4/28/1998	Dissolved Phosphorus	1	0.02	mg/L
BPG 09	BPG09	7/1/1998	Dissolved Phosphorus	1	0.08	mg/L
BPG 09	BPG09	8/4/1998	Dissolved Phosphorus	1	0.21	mg/L
BPG 09	BPG09	8/31/1998	Dissolved Phosphorus	1	0.07	mg/L
BPG 09	BPG09	9/28/1998	Dissolved Phosphorus	1	0.14	mg/L
BPG 09	BPG09	11/23/1998	Dissolved Phosphorus	1	0.01	mg/L
BPG 09	BPG09	12/30/1998	Dissolved Phosphorus	1	0.08	mg/L
BPG 09	BPG09	01/24/00	Dissolved Phosphorus	1	2.8	mg/L
BPG 09	BPG09	03/03/00	Dissolved Phosphorus	1	0.06	mg/L
BPG 09	BPG09	05/23/00	Dissolved Phosphorus	1	0.09	mg/L
BPG 09	BPG09	06/14/00	Dissolved Phosphorus	1	0.07	mg/L
BPG 09	BPG09	07/26/00	Dissolved Phosphorus	1	0.06	mg/L
BPG 09	BPG09	09/28/00	Dissolved Phosphorus	1	0.22	mg/L
BPG 09	BPG09	11/28/00	Dissolved Phosphorus	1	0.09	mg/L
BPG 09	BPG09	12/28/00	Dissolved Phosphorus	1	0.13	mg/L
BPG 09	BPG09	01/30/01	Dissolved Phosphorus	1	1.5	mg/L
BPG 09	BPG09	03/19/01	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	04/18/01	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	05/14/01	Dissolved Phosphorus	1	0.08	mg/L
BPG 09	BPG09	06/19/01	Dissolved Phosphorus	1	0.06	mg/L
BPG 09	BPG09	6/28/01	Dissolved Phosphorus	1	0.16	mg/L
BPG 09	BPG09	08/02/01	Dissolved Phosphorus	1	0.09	mg/L
BPG 09	BPG09	08/21/01	Dissolved Phosphorus	1	0.21	mg/L
BPG 09	BPG09	8/21/01	Dissolved Phosphorus	1	0.47	mg/L
BPG 09	BPG09	10/10/01	Dissolved Phosphorus	1	0.16	mg/L
BPG 09	BPG09	10/29/01	Dissolved Phosphorus	1	0.08	mg/L
BPG 09	BPG09	11/08/01	Dissolved Phosphorus	1	0.04	mg/L
BPG 09	BPG09	12/20/01	Dissolved Phosphorus	1	0.07	mg/L
BPG 09	BPG09	01/30/02	Dissolved Phosphorus	1	0.07	mg/L
BPG 09	BPG09	03/04/02	Dissolved Phosphorus	1	0.07	mg/L
BPG 09	BPG09	04/11/02	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	04/18/02	Dissolved Phosphorus	1	0.02	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	04/24/02	Dissolved Phosphorus	1	0.02	mg/L
BPG 09	BPG09	05/14/02	Dissolved Phosphorus	1	0.15	mg/L
BPG 09	BPG09	06/05/02	Dissolved Phosphorus	1	0.03	mg/L
BPG 09	BPG09	06/05/02	Dissolved Phosphorus	1	0.63	mg/L
BPG 09	BPG09	07/01/02	Dissolved Phosphorus	1	0.04	mg/L
BPG 09	BPG09	07/11/02	Dissolved Phosphorus	1	0.09	mg/L
BPG 09	BPG09	07/24/02	Dissolved Phosphorus	1	0.14	mg/L
BPG 09	BPG09	08/19/02	Dissolved Phosphorus	1	0.23	mg/L
BPG 09	BPG09	08/31/02	Dissolved Phosphorus	1	0.12	mg/L
BPG 09	BPG09	09/20/02	Dissolved Phosphorus	1	0.07	mg/L
BPG 09	BPG09	09/27/02	Dissolved Phosphorus	1	0.07	mg/L
BPG 09	BPG09	11/12/02	Dissolved Phosphorus	1	0.06	mg/L
BPG 09	BPG09	11/14/02	Dissolved Phosphorus	1	0.08	mg/L
BPG 09	BPG09	12/12/02	Dissolved Phosphorus	1	0.02	mg/L
BPG 09	BPG09	12/19/02	Dissolved Phosphorus	1	0.07	mg/L
RBD	RBD-1	6/28/1979	Dissolved Phosphorus	1	0.02	mg/L
RBD	RBD-1	6/28/1979	Dissolved Phosphorus	14	0.04	mg/L
RBD	RBD-1	9/5/1979	Dissolved Phosphorus	1	0.01	mg/L
RBD	RBD-1	9/5/1979	Dissolved Phosphorus	12	0.01	mg/L
RBD	RBD-1	5/18/1983	Dissolved Phosphorus	1	0.101	mg/L
RBD	RBD-1	5/18/1983	Dissolved Phosphorus	10	0.065	mg/L
RBD	RBD-1	4/21/1997	Dissolved Phosphorus	1	0.01	mg/L
RBD	RBD-1	4/21/1997	Dissolved Phosphorus	18	0.007	mg/L
RBD	RBD-1	6/9/1997	Dissolved Phosphorus	1	0.053	mg/L
RBD	RBD-1	6/9/1997	Dissolved Phosphorus	18	0.053	mg/L
RBD	RBD-1	8/12/1997	Dissolved Phosphorus	1	0.026	mg/L
RBD	RBD-1	8/12/1997	Dissolved Phosphorus	17	0.035	mg/L
RBD	RBD-1	10/22/1997	Dissolved Phosphorus	1	0.026	mg/L
RBD	RBD-1	10/22/1997	Dissolved Phosphorus	16	0.025	mg/L
RBD	RBD-2	6/28/1979	Dissolved Phosphorus	1	0.02	mg/L
RBD	RBD-2	9/5/1979	Dissolved Phosphorus	1	0.01	mg/L
RBD	RBD-2	5/18/1983	Dissolved Phosphorus	1	0.054	mg/L
RBD	RBD-2	4/21/1997	Dissolved Phosphorus	1	0.008	mg/L
RBD	RBD-2	6/9/1997	Dissolved Phosphorus	1	0.11	mg/L
RBD	RBD-2	7/14/1997	Dissolved Phosphorus	1	0.009	mg/L
RBD	RBD-2	8/12/1997	Dissolved Phosphorus	1	0.018	mg/L
RBD	RBD-2	10/22/1997	Dissolved Phosphorus	1	0.018	mg/L
RBD	RBD-3	6/28/1979	Dissolved Phosphorus	1	0.02	mg/L
RBD	RBD-3	9/5/1979	Dissolved Phosphorus	1	0.07	mg/L
RBD	RBD-3	5/18/1983	Dissolved Phosphorus	1	0.028	mg/L
RBD	RBD-3	4/21/1997	Dissolved Phosphorus	1	0.007	mg/L
RBD	RBD-3	6/9/1997	Dissolved Phosphorus	1	0.155	mg/L
RBD	RBD-3	7/14/1997	Dissolved Phosphorus	1	0.018	mg/L
RBD	RBD-3	8/12/1997	Dissolved Phosphorus	1	0.032	mg/L
RBD	RBD-3	10/22/1997	Dissolved Phosphorus	1	0.018	mg/L
RBD	RBD-4	4/21/1997	Dissolved Phosphorus	1	0.008	mg/L
RBD	RBD-1	7/16/2003	Dissolved Phosphorus	15	0.131	mg/L
RBD	RBD-1	7/16/2003	Dissolved Phosphorus	9	0.123	mg/L
RBD	RBD-1	7/16/2003	Dissolved Phosphorus	1	0.122	mg/L
RBD	RBD-1	8/11/2003	Dissolved Phosphorus	7	0.005	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-1	10/16/2003	Dissolved Phosphorus	15	0.025	mg/L
RBD	RBD-1	10/16/2003	Dissolved Phosphorus	9	0.024	mg/L
RBD	RBD-1	10/16/2003	Dissolved Phosphorus	1	0.025	mg/L
RBD	RBD-2	7/16/2003	Dissolved Phosphorus	1	0.109	mg/L
RBD	RBD-2	8/11/2003	Dissolved Phosphorus	1	0.016	mg/L
RBD	RBD-2	10/16/2003	Dissolved Phosphorus	1	0.023	mg/L
RBD	RBD-5	7/16/2003	Dissolved Phosphorus	1	0.105	mg/L
RBD	RBD-5	8/11/2003	Dissolved Phosphorus	1	0.036	mg/L
RBD	RBD-5	10/16/2003	Dissolved Phosphorus	1	0.035	mg/L
BPG 09	BPG09	1/19/1978	FECAL COLIFORM	1	1700	#/100 mL
BPG 09	BPG09	2/28/1978	FECAL COLIFORM	1	70	#/100 mL
BPG 09	BPG09	4/13/1978	FECAL COLIFORM	1	1600	#/100 mL
BPG 09	BPG09	5/11/1978	FECAL COLIFORM	1	400	#/100 mL
BPG 09	BPG09	5/31/1978	FECAL COLIFORM	1	41	#/100 mL
BPG 09	BPG09	6/14/1978	FECAL COLIFORM	1	290	#/100 mL
BPG 09	BPG09	6/28/1978	FECAL COLIFORM	1	310	#/100 mL
BPG 09	BPG09	7/11/1978	FECAL COLIFORM	1	430	#/100 mL
BPG 09	BPG09	8/2/1978	FECAL COLIFORM	1	13000	#/100 mL
BPG 09	BPG09	2/6/1979	FECAL COLIFORM	1	40	#/100 mL
BPG 09	BPG09	3/7/1979	FECAL COLIFORM	1	2200	#/100 mL
BPG 09	BPG09	5/1/1979	FECAL COLIFORM	1	1100	#/100 mL
BPG 09	BPG09	5/31/1979	FECAL COLIFORM	1	330	#/100 mL
BPG 09	BPG09	5/31/1979	FECAL COLIFORM	1	290	#/100 mL
BPG 09	BPG09	8/1/1979	FECAL COLIFORM	1	11600	#/100 mL
BPG 09	BPG09	2/14/1980	FECAL COLIFORM	1	34	#/100 mL
BPG 09	BPG09	5/2/1980	FECAL COLIFORM	1	260	#/100 mL
BPG 09	BPG09	5/2/1980	FECAL COLIFORM	1	130	#/100 mL
BPG 09	BPG09	2/18/1981	FECAL COLIFORM	1	2500	#/100 mL
BPG 09	BPG09	3/19/1981	FECAL COLIFORM	1	60	#/100 mL
BPG 09	BPG09	4/16/1981	FECAL COLIFORM	1	660	#/100 mL
BPG 09	BPG09	5/21/1981	FECAL COLIFORM	1	500	#/100 mL
BPG 09	BPG09	6/23/1981	FECAL COLIFORM	1	6000	#/100 mL
BPG 09	BPG09	8/4/1981	FECAL COLIFORM	1	1900	#/100 mL
BPG 09	BPG09	8/19/1981	FECAL COLIFORM	1	710	#/100 mL
BPG 09	BPG09	11/10/1981	FECAL COLIFORM	1	150	#/100 mL
BPG 09	BPG09	1/6/1982	FECAL COLIFORM	1	1700	#/100 mL
BPG 09	BPG09	3/10/1982	FECAL COLIFORM	1	220	#/100 mL
BPG 09	BPG09	4/8/1982	FECAL COLIFORM	1	90	#/100 mL
BPG 09	BPG09	5/13/1982	FECAL COLIFORM	1	80	#/100 mL
BPG 09	BPG09	6/16/1982	FECAL COLIFORM	1	16000	#/100 mL
BPG 09	BPG09	8/12/1982	FECAL COLIFORM	1	420	#/100 mL
BPG 09	BPG09	9/30/1982	FECAL COLIFORM	1	130	#/100 mL
BPG 09	BPG09	11/10/1982	FECAL COLIFORM	1	50	#/100 mL
BPG 09	BPG09	1/4/1983	FECAL COLIFORM	1	200	#/100 mL
BPG 09	BPG09	2/4/1983	FECAL COLIFORM	1	1600	#/100 mL
BPG 09	BPG09	3/16/1983	FECAL COLIFORM	1	50	#/100 mL
BPG 09	BPG09	4/13/1983	FECAL COLIFORM	1	330	#/100 mL
BPG 09	BPG09	5/4/1983	FECAL COLIFORM	1	800	#/100 mL
BPG 09	BPG09	6/22/1983	FECAL COLIFORM	1	1800	#/100 mL
BPG 09	BPG09	8/18/1983	FECAL COLIFORM	1	2100	#/100 mL

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	11/2/1983	FECAL COLIFORM	1	230	#/100 mL
BPG 09	BPG09	12/8/1983	FECAL COLIFORM	1	2800	#/100 mL
BPG 09	BPG09	3/7/1984	FECAL COLIFORM	1	10	#/100 mL
BPG 09	BPG09	4/11/1984	FECAL COLIFORM	1	10	#/100 mL
BPG 09	BPG09	5/2/1984	FECAL COLIFORM	1	32	#/100 mL
BPG 09	BPG09	6/21/1984	FECAL COLIFORM	1	1000	#/100 mL
BPG 09	BPG09	7/18/1984	FECAL COLIFORM	1	180	#/100 mL
BPG 09	BPG09	8/22/1984	FECAL COLIFORM	1	500	#/100 mL
BPG 09	BPG09	9/19/1984	FECAL COLIFORM	1	150	#/100 mL
BPG 09	BPG09	11/7/1984	FECAL COLIFORM	1	80	#/100 mL
BPG 09	BPG09	12/13/1984	FECAL COLIFORM	1	200	#/100 mL
BPG 09	BPG09	1/16/1985	FECAL COLIFORM	1	80	#/100 mL
BPG 09	BPG09	3/6/1985	FECAL COLIFORM	1	2100	#/100 mL
BPG 09	BPG09	4/15/1985	FECAL COLIFORM	1	100	#/100 mL
BPG 09	BPG09	5/23/1985	FECAL COLIFORM	1	150	#/100 mL
BPG 09	BPG09	7/2/1985	FECAL COLIFORM	1	700	#/100 mL
BPG 09	BPG09	8/19/1985	FECAL COLIFORM	1	1700	#/100 mL
BPG 09	BPG09	9/16/1985	FECAL COLIFORM	1	620	#/100 mL
BPG 09	BPG09	10/16/1985	FECAL COLIFORM	1	1000	#/100 mL
BPG 09	BPG09	12/10/1985	FECAL COLIFORM	1	10	#/100 mL
BPG 09	BPG09	1/29/1986	FECAL COLIFORM	1	40	#/100 mL
BPG 09	BPG09	2/20/1986	FECAL COLIFORM	1	200	#/100 mL
BPG 09	BPG09	3/25/1986	FECAL COLIFORM	1	10	#/100 mL
BPG 09	BPG09	4/30/1986	FECAL COLIFORM	1	100	#/100 mL
BPG 09	BPG09	6/17/1986	FECAL COLIFORM	1	3700	#/100 mL
BPG 09	BPG09	7/15/1986	FECAL COLIFORM	1	680	#/100 mL
BPG 09	BPG09	9/10/1986	FECAL COLIFORM	1	370	#/100 mL
BPG 09	BPG09	10/7/1986	FECAL COLIFORM	1	430	#/100 mL
BPG 09	BPG09	12/2/1986	FECAL COLIFORM	1	1700	#/100 mL
BPG 09	BPG09	1/13/1987	FECAL COLIFORM	1	10	#/100 mL
BPG 09	BPG09	2/17/1987	FECAL COLIFORM	1	140	#/100 mL
BPG 09	BPG09	3/24/1987	FECAL COLIFORM	1	110	#/100 mL
BPG 09	BPG09	4/28/1987	FECAL COLIFORM	1	260	#/100 mL
BPG 09	BPG09	6/2/1987	FECAL COLIFORM	1	1400	#/100 mL
BPG 09	BPG09	7/20/1987	FECAL COLIFORM	1	90	#/100 mL
BPG 09	BPG09	9/9/1987	FECAL COLIFORM	1	210	#/100 mL
BPG 09	BPG09	11/3/1987	FECAL COLIFORM	1	210	#/100 mL
BPG 09	BPG09	12/10/1987	FECAL COLIFORM	1	800	#/100 mL
BPG 09	BPG09	1/21/1988	FECAL COLIFORM	1	1300	#/100 mL
BPG 09	BPG09	3/3/1988	FECAL COLIFORM	1	140	#/100 mL
BPG 09	BPG09	4/5/1988	FECAL COLIFORM	1	1200	#/100 mL
BPG 09	BPG09	5/19/1988	FECAL COLIFORM	1	280	#/100 mL
BPG 09	BPG09	6/23/1988	FECAL COLIFORM	1	240	#/100 mL
BPG 09	BPG09	8/11/1988	FECAL COLIFORM	1	710	#/100 mL
BPG 09	BPG09	9/15/1988	FECAL COLIFORM	1	150	#/100 mL
BPG 09	BPG09	11/10/1988	FECAL COLIFORM	1	20000	#/100 mL
BPG 09	BPG09	12/14/1988	FECAL COLIFORM	1	110	#/100 mL
BPG 09	BPG09	1/19/1989	FECAL COLIFORM	1	220	#/100 mL
BPG 09	BPG09	2/23/1989	FECAL COLIFORM	1	70	#/100 mL
BPG 09	BPG09	4/13/1989	FECAL COLIFORM	1	520	#/100 mL

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	5/10/1989	FECAL COLIFORM	1	350	#/100 mL
BPG 09	BPG09	6/20/1989	FECAL COLIFORM	1	640	#/100 mL
BPG 09	BPG09	8/2/1989	FECAL COLIFORM	1	250	#/100 mL
BPG 09	BPG09	9/14/1989	FECAL COLIFORM	1	200	#/100 mL
BPG 09	BPG09	11/8/1989	FECAL COLIFORM	1	100	#/100 mL
BPG 09	BPG09	12/12/1989	FECAL COLIFORM	1	10	#/100 mL
BPG 09	BPG09	1/24/1990	FECAL COLIFORM	1	40	#/100 mL
BPG 09	BPG09	2/28/1990	FECAL COLIFORM	1	140	#/100 mL
BPG 09	BPG09	3/28/1990	FECAL COLIFORM	1	200	#/100 mL
BPG 09	BPG09	5/9/1990	FECAL COLIFORM	1	240	#/100 mL
BPG 09	BPG09	7/3/1990	FECAL COLIFORM	1	1000	#/100 mL
BPG 09	BPG09	8/2/1990	FECAL COLIFORM	1	540	#/100 mL
BPG 09	BPG09	9/26/1990	FECAL COLIFORM	1	320	#/100 mL
BPG 09	BPG09	10/31/1990	FECAL COLIFORM	1	80	#/100 mL
BPG 09	BPG09	12/10/1990	FECAL COLIFORM	1	390	#/100 mL
BPG 09	BPG09	1/16/1991	FECAL COLIFORM	1	2200	#/100 mL
BPG 09	BPG09	3/5/1991	FECAL COLIFORM	1	80	#/100 mL
BPG 09	BPG09	4/3/1991	FECAL COLIFORM	1	130	#/100 mL
BPG 09	BPG09	5/22/1991	FECAL COLIFORM	1	880	#/100 mL
BPG 09	BPG09	6/26/1991	FECAL COLIFORM	1	460	#/100 mL
BPG 09	BPG09	8/21/1991	FECAL COLIFORM	1	260	#/100 mL
BPG 09	BPG09	9/30/1991	FECAL COLIFORM	1	50	#/100 mL
BPG 09	BPG09	11/14/1991	FECAL COLIFORM	1	80	#/100 mL
BPG 09	BPG09	12/18/1991	FECAL COLIFORM	1	110	#/100 mL
BPG 09	BPG09	2/4/1992	FECAL COLIFORM	1	80	#/100 mL
BPG 09	BPG09	3/17/1992	FECAL COLIFORM	1	30	#/100 mL
BPG 09	BPG09	6/3/1992	FECAL COLIFORM	1	150	#/100 mL
BPG 09	BPG09	7/13/1992	FECAL COLIFORM	1	2100	#/100 mL
BPG 09	BPG09	8/12/1992	FECAL COLIFORM	1	140	#/100 mL
BPG 09	BPG09	9/23/1992	FECAL COLIFORM	1	500	#/100 mL
BPG 09	BPG09	11/18/1992	FECAL COLIFORM	1	400	#/100 mL
BPG 09	BPG09	12/16/1992	FECAL COLIFORM	1	3000	#/100 mL
BPG 09	BPG09	2/1/1993	FECAL COLIFORM	1	210	#/100 mL
BPG 09	BPG09	3/9/1993	FECAL COLIFORM	1	1000	#/100 mL
BPG 09	BPG09	4/7/1993	FECAL COLIFORM	1	180	#/100 mL
BPG 09	BPG09	5/24/1993	FECAL COLIFORM	1	390	#/100 mL
BPG 09	BPG09	6/28/1993	FECAL COLIFORM	1	100	#/100 mL
BPG 09	BPG09	8/18/1993	FECAL COLIFORM	1	1400	#/100 mL
BPG 09	BPG09	9/28/1993	FECAL COLIFORM	1	1900	#/100 mL
BPG 09	BPG09	11/15/1993	FECAL COLIFORM	1	2800	#/100 mL
BPG 09	BPG09	12/20/1993	FECAL COLIFORM	1	350	#/100 mL
BPG 09	BPG09	3/2/1994	FECAL COLIFORM	1	16	#/100 mL
BPG 09	BPG09	3/29/1994	FECAL COLIFORM	1	8	#/100 mL
BPG 09	BPG09	4/28/1994	FECAL COLIFORM	1	1000	#/100 mL
BPG 09	BPG09	6/30/1994	FECAL COLIFORM	1	420	#/100 mL
BPG 09	BPG09	8/15/1994	FECAL COLIFORM	1	200	#/100 mL
BPG 09	BPG09	9/6/1994	FECAL COLIFORM	1	530	#/100 mL
BPG 09	BPG09	9/26/1994	FECAL COLIFORM	1	250	#/100 mL
BPG 09	BPG09	11/2/1994	FECAL COLIFORM	1	440	#/100 mL
BPG 09	BPG09	1/4/1995	FECAL COLIFORM	1	14	#/100 mL

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	2/1/1995	FECAL COLIFORM	1	48	#/100 mL
BPG 09	BPG09	2/27/1995	FECAL COLIFORM	1	12	#/100 mL
BPG 09	BPG09	3/29/1995	FECAL COLIFORM	1	130	#/100 mL
BPG 09	BPG09	5/11/1995	FECAL COLIFORM	1	1700	#/100 mL
BPG 09	BPG09	6/14/1995	FECAL COLIFORM	1	400	#/100 mL
BPG 09	BPG09	9/7/1995	FECAL COLIFORM	1	90	#/100 mL
BPG 09	BPG09	10/16/1995	FECAL COLIFORM	1	100	#/100 mL
BPG 09	BPG09	12/12/1995	FECAL COLIFORM	1	4	#/100 mL
BPG 09	BPG09	1/29/1996	FECAL COLIFORM	1	700	#/100 mL
BPG 09	BPG09	2/29/1996	FECAL COLIFORM	1	270	#/100 mL
BPG 09	BPG09	3/28/1996	FECAL COLIFORM	1	30	#/100 mL
BPG 09	BPG09	4/19/1996	FECAL COLIFORM	1	46	#/100 mL
BPG 09	BPG09	5/20/1996	FECAL COLIFORM	1	420	#/100 mL
BPG 09	BPG09	7/18/1996	FECAL COLIFORM	1	140	#/100 mL
BPG 09	BPG09	8/26/1996	FECAL COLIFORM	1	190	#/100 mL
BPG 09	BPG09	10/28/1996	FECAL COLIFORM	1	70	#/100 mL
BPG 09	BPG09	12/16/1996	FECAL COLIFORM	1	10	#/100 mL
BPG 09	BPG09	2/4/1997	FECAL COLIFORM	1	800	#/100 mL
BPG 09	BPG09	3/4/1997	FECAL COLIFORM	1	270	#/100 mL
BPG 09	BPG09	4/2/1997	FECAL COLIFORM	1	30	#/100 mL
BPG 09	BPG09	4/30/1997	FECAL COLIFORM	1	60	#/100 mL
BPG 09	BPG09	9/9/1997	FECAL COLIFORM	1	480	#/100 mL
BPG 09	BPG09	9/26/1997	FECAL COLIFORM	1	1600	#/100 mL
BPG 09	BPG09	10/30/1997	FECAL COLIFORM	1	150	#/100 mL
BPG 09	BPG09	11/19/1997	FECAL COLIFORM	1	10	#/100 mL
BPG 09	BPG09	1/6/1998	FECAL COLIFORM	1	70	#/100 mL
BPG 09	BPG09	3/13/1998	FECAL COLIFORM	1	260	#/100 mL
BPG 09	BPG09	4/28/1998	FECAL COLIFORM	1	190	#/100 mL
BPG 09	BPG09	7/1/1998	FECAL COLIFORM	1	2650	#/100 mL
BPG 09	BPG09	8/4/1998	FECAL COLIFORM	1	9000	#/100 mL
BPG 09	BPG09	8/31/1998	FECAL COLIFORM	1	310	#/100 mL
BPG 09	BPG09	9/28/1998	FECAL COLIFORM	1	185	#/100 mL
BPG 09	BPG09	11/23/1998	FECAL COLIFORM	1	60	#/100 mL
BPG 09	BPG09	12/30/1998	FECAL COLIFORM	1	40	#/100 mL
BPG 09	BPG09	04/29/99	FECAL COLIFORM	1	100	#/100 mL
BPG 09	BPG09	08/31/99	FECAL COLIFORM	1	800	#/100 mL
BPG 09	BPG09	09/29/99	FECAL COLIFORM	1	300	#/100 mL
BPG 09	BPG09	11/10/99	FECAL COLIFORM	1	10	#/100 mL
BPG 09	BPG09	01/24/00	FECAL COLIFORM	1	1700	#/100 mL
BPG 09	BPG09	03/03/00	FECAL COLIFORM	1	2	#/100 mL
BPG 09	BPG09	05/23/00	FECAL COLIFORM	1	250	#/100 mL
BPG 09	BPG09	06/14/00	FECAL COLIFORM	1	460	#/100 mL
BPG 09	BPG09	07/26/00	FECAL COLIFORM	1	80	#/100 mL
BPG 09	BPG09	09/28/00	FECAL COLIFORM	1	270	#/100 mL
BPG 09	BPG09	11/28/00	FECAL COLIFORM	1	140	#/100 mL
BPG 09	BPG09	12/28/00	FECAL COLIFORM	1	30	#/100 mL
BPG 09	BPG09	01/30/01	FECAL COLIFORM	1	400	#/100 mL
BPG 09	BPG09	03/19/01	FECAL COLIFORM	1	10	#/100 mL
BPG 09	BPG09	04/18/01	FECAL COLIFORM	1	40	#/100 mL
BPG 09	BPG09	05/14/01	FECAL COLIFORM	1	160	#/100 mL

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	06/19/01	FECAL COLIFORM	1	440	#/100 mL
BPG 09	BPG09	08/02/01	FECAL COLIFORM	1	40	#/100 mL
BPG 09	BPG09	08/21/01	FECAL COLIFORM	1	260	#/100 mL
BPG 09	BPG09	11/08/01	FECAL COLIFORM	1	200	#/100 mL
BPG 09	BPG09	12/20/01	FECAL COLIFORM	1	1100	#/100 mL
BPG 09	BPG09	01/30/02	FECAL COLIFORM	1	520	#/100 mL
BPG 09	BPG09	03/04/02	FECAL COLIFORM	1	100	#/100 mL
BPG 09	BPG09	04/18/02	FECAL COLIFORM	1	150	#/100 mL
BPG 09	BPG09	06/05/02	FECAL COLIFORM	1	690	#/100 mL
BPG 09	BPG09	07/11/02	FECAL COLIFORM	1	1200	#/100 mL
BPG 09	BPG09	08/19/02	FECAL COLIFORM	1	13	#/100 mL
BPG 09	BPG09	09/27/02	FECAL COLIFORM	1	110	#/100 mL
BPG 09	BPG09	11/12/02	FECAL COLIFORM	1	60	#/100 mL
BPG 09	BPG09	12/12/02	FECAL COLIFORM	1	20	#/100 mL
BPG 09	BPG09	02/06/03	FECAL COLIFORM	1	270	#/100 mL
BPG 09	BPG09	03/18/03	FECAL COLIFORM	1	39	#/100 mL
BPG 09	BPG09	04/24/03	FECAL COLIFORM	1	50	#/100 mL
BPG 09	BPG09	06/02/03	FECAL COLIFORM	1	570	#/100 mL
BPG 09	BPG09	07/22/03	FECAL COLIFORM	1	400	#/100 mL
BPG 09	BPG09	08/25/03	FECAL COLIFORM	1	240	#/100 mL
BPG 09	BPG09	11/04/03	FECAL COLIFORM	1	30	#/100 mL
BPG 09	BPG09	3/18/04	FECAL COLIFORM	1	120	#/100 mL
BPG 09	BPG09	04/20/04	FECAL COLIFORM	1	220	#/100 mL
BPG 09	BPG09	06/08/04	FECAL COLIFORM	1	510	#/100 mL
BPG 09	BPG09	07/15/04	FECAL COLIFORM	1	1100	#/100 mL
BPG 09	BPG09	09/01/04	FECAL COLIFORM	1	530	#/100 mL
BPG 09	BPG09	09/20/04	FECAL COLIFORM	1	570	#/100 mL
BPG 09	BPG09	11/08/04	FECAL COLIFORM	1	200	#/100 mL
BPG 09	BPG09	12/20/04	FECAL COLIFORM	1	120	#/100 mL
BPG 09	BPG09	3/9/2000	Nitrate (NO3)	1	4.61	mg/L
BPG 09	BPG09	3/29/2000	Nitrate (NO3)	1	8.27	mg/L
BPG 09	BPG09	4/4/2000	Nitrate (NO3)	1	5.68	mg/L
BPG 09	BPG09	4/10/2000	Nitrate (NO3)	1	4.96	mg/L
BPG 09	BPG09	4/17/2000	Nitrate (NO3)	1	2.32	mg/L
BPG 09	BPG09	4/24/2000	Nitrate (NO3)	1	10.19	mg/L
BPG 09	BPG09	5/1/2000	Nitrate (NO3)	1	5.91	mg/L
BPG 09	BPG09	5/8/2000	Nitrate (NO3)	1	6.39	mg/L
BPG 09	BPG09	5/17/2000	Nitrate (NO3)	1	9.19	mg/L
BPG 09	BPG09	5/22/2000	Nitrate (NO3)	1	13.7	mg/L
BPG 09	BPG09	5/28/2000	Nitrate (NO3)	1	13.13	mg/L
BPG 09	BPG09	5/28/2000	Nitrate (NO3)	1	15.54	mg/L
BPG 09	BPG09	5/29/2000	Nitrate (NO3)	1	16.7	mg/L
BPG 09	BPG09	5/29/2000	Nitrate (NO3)	1	17	mg/L
BPG 09	BPG09	5/30/2000	Nitrate (NO3)	1	18.26	mg/L
BPG 09	BPG09	6/1/2000	Nitrate (NO3)	1	16.59	mg/L
BPG 09	BPG09	6/7/2000	Nitrate (NO3)	1	13.95	mg/L
BPG 09	BPG09	6/12/2000	Nitrate (NO3)	1	11.45	mg/L
BPG 09	BPG09	6/19/2000	Nitrate (NO3)	1	12.81	mg/L
BPG 09	BPG09	6/26/2000	Nitrate (NO3)	1	14.72	mg/L
BPG 09	BPG09	7/5/2000	Nitrate (NO3)	1	9.83	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	7/11/2000	Nitrate (NO3)	1	10.55	mg/L
BPG 09	BPG09	7/17/2000	Nitrate (NO3)	1	10.09	mg/L
BPG 09	BPG09	7/24/2000	Nitrate (NO3)	1	6.55	mg/L
BPG 09	BPG09	7/31/2000	Nitrate (NO3)	1	5.73	mg/L
BPG 09	BPG09	8/8/2000	Nitrate (NO3)	1	5.84	mg/L
BPG 09	BPG09	8/14/2000	Nitrate (NO3)	1	3.57	mg/L
BPG 09	BPG09	8/22/2000	Nitrate (NO3)	1	1.45	mg/L
BPG 09	BPG09	8/29/2000	Nitrate (NO3)	1	0.9	mg/L
BPG 09	BPG09	9/5/2000	Nitrate (NO3)	1	0.95	mg/L
BPG 09	BPG09	9/12/2000	Nitrate (NO3)	1	0.94	mg/L
BPG 09	BPG09	9/18/2000	Nitrate (NO3)	1	1.41	mg/L
BPG 09	BPG09	9/25/2000	Nitrate (NO3)	1	0.93	mg/L
BPG 09	BPG09	10/2/2000	Nitrate (NO3)	1	1.19	mg/L
BPG 09	BPG09	10/10/2000	Nitrate (NO3)	1	1.47	mg/L
BPG 09	BPG09	10/17/2000	Nitrate (NO3)	1	2.13	mg/L
BPG 09	BPG09	10/24/2000	Nitrate (NO3)	1	0.88	mg/L
BPG 09	BPG09	10/30/2000	Nitrate (NO3)	1	0.26	mg/L
BPG 09	BPG09	11/6/2000	Nitrate (NO3)	1	0.14	mg/L
BPG 09	BPG09	11/13/2000	Nitrate (NO3)	1	11.02	mg/L
BPG 09	BPG09	11/20/2000	Nitrate (NO3)	1	9.9	mg/L
BPG 09	BPG09	11/27/2000	Nitrate (NO3)	1	7.27	mg/L
BPG 09	BPG09	12/4/2000	Nitrate (NO3)	1	7.96	mg/L
BPG 09	BPG09	12/14/2000	Nitrate (NO3)	1	9.8	mg/L
BPG 09	BPG09	12/18/2000	Nitrate (NO3)	1	9.74	mg/L
BPG 09	BPG09	1/2/2001	Nitrate (NO3)	1	7.58	mg/L
BPG 09	BPG09	2/5/2001	Nitrate (NO3)	1	9.98	mg/L
BPG 09	BPG09	2/9/2001	Nitrate (NO3)	1	9.42	mg/L
BPG 09	BPG09	2/10/2001	Nitrate (NO3)	1	9.1	mg/L
BPG 09	BPG09	2/12/2001	Nitrate (NO3)	1	12.09	mg/L
BPG 09	BPG09	2/13/2001	Nitrate (NO3)	1	11.96	mg/L
BPG 09	BPG09	2/20/2001	Nitrate (NO3)	1	12.04	mg/L
BPG 09	BPG09	2/25/2001	Nitrate (NO3)	1	5.12	mg/L
BPG 09	BPG09	2/26/2001	Nitrate (NO3)	1	8.21	mg/L
BPG 09	BPG09	2/27/2001	Nitrate (NO3)	1	10.53	mg/L
BPG 09	BPG09	2/28/2001	Nitrate (NO3)	1	11.27	mg/L
BPG 09	BPG09	3/1/2001	Nitrate (NO3)	1	11.52	mg/L
BPG 09	BPG09	3/5/2001	Nitrate (NO3)	1	11.32	mg/L
BPG 09	BPG09	3/12/2001	Nitrate (NO3)	1	10.44	mg/L
BPG 09	BPG09	3/19/2001	Nitrate (NO3)	1	13.09	mg/L
BPG 09	BPG09	3/26/2001	Nitrate (NO3)	1	11.2	mg/L
BPG 09	BPG09	4/2/2001	Nitrate (NO3)	1	10.04	mg/L
BPG 09	BPG09	4/9/2001	Nitrate (NO3)	1	9.39	mg/L
BPG 09	BPG09	4/16/2001	Nitrate (NO3)	1	12.84	mg/L
BPG 09	BPG09	4/23/2001	Nitrate (NO3)	1	10.5	mg/L
BPG 09	BPG09	4/30/2001	Nitrate (NO3)	1	9.35	mg/L
BPG 09	BPG09	5/7/2001	Nitrate (NO3)	1	8.05	mg/L
BPG 09	BPG09	5/14/2001	Nitrate (NO3)	1	7.38	mg/L
BPG 09	BPG09	5/21/2001	Nitrate (NO3)	1	15.42	mg/L
BPG 09	BPG09	5/30/2001	Nitrate (NO3)	1	12.35	mg/L
BPG 09	BPG09	6/6/2001	Nitrate (NO3)	1	17.67	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	6/8/2001	Nitrate (NO3)	1	19.41	mg/L
BPG 09	BPG09	6/13/2001	Nitrate (NO3)	1	14.76	mg/L
BPG 09	BPG09	6/18/2001	Nitrate (NO3)	1	12.49	mg/L
BPG 09	BPG09	6/25/2001	Nitrate (NO3)	1	10.57	mg/L
BPG 09	BPG09	7/2/2001	Nitrate (NO3)	1	6.79	mg/L
BPG 09	BPG09	7/9/2001	Nitrate (NO3)	1	6.97	mg/L
BPG 09	BPG09	7/16/2001	Nitrate (NO3)	1	6.98	mg/L
BPG 09	BPG09	7/23/2001	Nitrate (NO3)	1	2.37	mg/L
BPG 09	BPG09	7/30/2001	Nitrate (NO3)	1	2.1	mg/L
BPG 09	BPG09	8/6/2001	Nitrate (NO3)	1	1.97	mg/L
BPG 09	BPG09	8/14/2001	Nitrate (NO3)	1	0.95	mg/L
BPG 09	BPG09	8/20/2001	Nitrate (NO3)	1	1.83	mg/L
BPG 09	BPG09	8/27/2001	Nitrate (NO3)	1	1.31	mg/L
BPG 09	BPG09	8/31/2001	Nitrate (NO3)	1	2.19	mg/L
BPG 09	BPG09	9/1/2001	Nitrate (NO3)	1	5.05	mg/L
BPG 09	BPG09	9/4/2001	Nitrate (NO3)	1	4.73	mg/L
BPG 09	BPG09	9/10/2001	Nitrate (NO3)	1	6.35	mg/L
BPG 09	BPG09	9/17/2001	Nitrate (NO3)	1	5.64	mg/L
BPG 09	BPG09	9/24/2001	Nitrate (NO3)	1	6	mg/L
BPG 09	BPG09	10/1/2001	Nitrate (NO3)	1	4.18	mg/L
BPG 09	BPG09	10/9/2001	Nitrate (NO3)	1	8.08	mg/L
BPG 09	BPG09	10/15/2001	Nitrate (NO3)	1	3.07	mg/L
BPG 09	BPG09	10/15/2001	Nitrate (NO3)	1	3.75	mg/L
BPG 09	BPG09	10/16/2001	Nitrate (NO3)	1	5.01	mg/L
BPG 09	BPG09	10/17/2001	Nitrate (NO3)	1	6.14	mg/L
BPG 09	BPG09	10/18/2001	Nitrate (NO3)	1	6.99	mg/L
BPG 09	BPG09	10/22/2001	Nitrate (NO3)	1	7.49	mg/L
BPG 09	BPG09	10/31/2001	Nitrate (NO3)	1	7.62	mg/L
BPG 09	BPG09	11/5/2001	Nitrate (NO3)	1	7.68	mg/L
BPG 09	BPG09	11/14/2001	Nitrate (NO3)	1	7.07	mg/L
BPG 09	BPG09	11/19/2001	Nitrate (NO3)	1	6.39	mg/L
BPG 09	BPG09	11/26/2001	Nitrate (NO3)	1	6.38	mg/L
BPG 09	BPG09	12/3/2001	Nitrate (NO3)	1	8.93	mg/L
BPG 09	BPG09	12/10/2001	Nitrate (NO3)	1	7.71	mg/L
BPG 09	BPG09	12/19/2001	Nitrate (NO3)	1	10.2	mg/L
BPG 09	BPG09	12/27/2001	Nitrate (NO3)	1	9.2	mg/L
BPG 09	BPG09	1/2/2002	Nitrate (NO3)	1	8.68	mg/L
BPG 09	BPG09	1/7/2002	Nitrate (NO3)	1	7.77	mg/L
BPG 09	BPG09	1/14/2002	Nitrate (NO3)	1	7.22	mg/L
BPG 09	BPG09	1/23/2002	Nitrate (NO3)	1	6.63	mg/L
BPG 09	BPG09	1/28/2002	Nitrate (NO3)	1	5.85	mg/L
BPG 09	BPG09	1/31/2002	Nitrate (NO3)	1	8.72	mg/L
BPG 09	BPG09	1/31/2002	Nitrate (NO3)	1	7.91	mg/L
BPG 09	BPG09	2/1/2002	Nitrate (NO3)	1	7.49	mg/L
BPG 09	BPG09	2/2/2002	Nitrate (NO3)	1	9.43	mg/L
BPG 09	BPG09	2/4/2002	Nitrate (NO3)	1	10.32	mg/L
BPG 09	BPG09	2/5/2002	Nitrate (NO3)	1	9.79	mg/L
BPG 09	BPG09	2/13/2002	Nitrate (NO3)	1	9.19	mg/L
BPG 09	BPG09	2/19/2002	Nitrate (NO3)	1	8.06	mg/L
BPG 09	BPG09	2/20/2002	Nitrate (NO3)	1	8.17	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	2/21/2002	Nitrate (NO3)	1	9.87	mg/L
BPG 09	BPG09	2/22/2002	Nitrate (NO3)	1	10.6	mg/L
BPG 09	BPG09	2/25/2002	Nitrate (NO3)	1	10.27	mg/L
BPG 09	BPG09	3/6/2002	Nitrate (NO3)	1	10.36	mg/L
BPG 09	BPG09	3/11/2002	Nitrate (NO3)	1	10.01	mg/L
BPG 09	BPG09	3/18/2002	Nitrate (NO3)	1	9.85	mg/L
BPG 09	BPG09	3/27/2002	Nitrate (NO3)	1	8.18	mg/L
BPG 09	BPG09	4/4/2002	Nitrate (NO3)	1	10.7	mg/L
BPGD	BPGD-H-A1	9/23/2002	Nitrate + Nitrite		1.32	mg/L
BPGD	BPGD-H-A2	9/23/2002	Nitrate + Nitrite		2.01	mg/L
BPGD	BPGD-H-C1	9/23/2002	Nitrate + Nitrite		9.67	mg/L
BPGD	BPGD-H-C2	9/23/2002	Nitrate + Nitrite		8.91	mg/L
BPGD	BPGD-H-C3	9/23/2002	Nitrate + Nitrite		2.32	mg/L
BPGD	BPGD-H-D2	9/23/2002	Nitrate + Nitrite		1.86	mg/L
BPGD	BPGD-H-D3	9/23/2002	Nitrate + Nitrite		0.55	mg/L
BPGD	BPGD-H-E1	9/23/2002	Nitrate + Nitrite		13.10	mg/L
BPG 09	BPG09	1/19/1978	Nitrite + Nitrate	1	5.39999	mg/L
BPG 09	BPG09	2/28/1978	Nitrite + Nitrate	1	3.2	mg/L
BPG 09	BPG09	4/13/1978	Nitrite + Nitrate	1	7.29999	mg/L
BPG 09	BPG09	5/11/1978	Nitrite + Nitrate	1	7.89999	mg/L
BPG 09	BPG09	5/31/1978	Nitrite + Nitrate	1	6.99999	mg/L
BPG 09	BPG09	6/14/1978	Nitrite + Nitrate	1	4.5	mg/L
BPG 09	BPG09	6/28/1978	Nitrite + Nitrate	1	4	mg/L
BPG 09	BPG09	7/11/1978	Nitrite + Nitrate	1	4.6	mg/L
BPG 09	BPG09	8/2/1978	Nitrite + Nitrate	1	1.2	mg/L
BPG 09	BPG09	8/23/1978	Nitrite + Nitrate	1	0.7	mg/L
BPG 09	BPG09	9/13/1978	Nitrite + Nitrate	1	1	mg/L
BPG 09	BPG09	10/11/1978	Nitrite + Nitrate	1	1.8	mg/L
BPG 09	BPG09	11/15/1978	Nitrite + Nitrate	1	0.6	mg/L
BPG 09	BPG09	12/6/1978	Nitrite + Nitrate	1	1.7	mg/L
BPG 09	BPG09	1/10/1979	Nitrite + Nitrate	1	4.2	mg/L
BPG 09	BPG09	2/6/1979	Nitrite + Nitrate	1	1.8	mg/L
BPG 09	BPG09	3/7/1979	Nitrite + Nitrate	1	6.4	mg/L
BPG 09	BPG09	4/2/1979	Nitrite + Nitrate	1	12	mg/L
BPG 09	BPG09	5/1/1979	Nitrite + Nitrate	1	12	mg/L
BPG 09	BPG09	5/31/1979	Nitrite + Nitrate	1	7.6	mg/L
BPG 09	BPG09	5/31/1979	Nitrite + Nitrate	1	7.7	mg/L
BPG 09	BPG09	7/9/1979	Nitrite + Nitrate	1	7.6	mg/L
BPG 09	BPG09	7/9/1979	Nitrite + Nitrate	1	7.7	mg/L
BPG 09	BPG09	8/1/1979	Nitrite + Nitrate	1	5.1	mg/L
BPG 09	BPG09	9/13/1979	Nitrite + Nitrate	1	1.6	mg/L
BPG 09	BPG09	10/4/1979	Nitrite + Nitrate	1	1.2	mg/L
BPG 09	BPG09	10/4/1979	Nitrite + Nitrate	1	1.2	mg/L
BPG 09	BPG09	11/5/1979	Nitrite + Nitrate	1	0.6	mg/L
BPG 09	BPG09	12/5/1979	Nitrite + Nitrate	1	6.3	mg/L
BPG 09	BPG09	1/10/1980	Nitrite + Nitrate	1	7.3	mg/L
BPG 09	BPG09	2/14/1980	Nitrite + Nitrate	1	4.9	mg/L
BPG 09	BPG09	3/31/1980	Nitrite + Nitrate	1	8.9	mg/L
BPG 09	BPG09	5/2/1980	Nitrite + Nitrate	1	8.5	mg/L
BPG 09	BPG09	5/2/1980	Nitrite + Nitrate	1	8.6	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	6/4/1980	Nitrite + Nitrate	1	7.1	mg/L
BPG 09	BPG09	6/17/1980	Nitrite + Nitrate	1	12	mg/L
BPG 09	BPG09	7/7/1980	Nitrite + Nitrate	1	6	mg/L
BPG 09	BPG09	8/11/1980	Nitrite + Nitrate	1	1.4	mg/L
BPG 09	BPG09	9/10/1980	Nitrite + Nitrate	1	1.6	mg/L
BPG 09	BPG09	10/2/1980	Nitrite + Nitrate	1	1.5	mg/L
BPG 09	BPG09	10/27/1980	Nitrite + Nitrate	1	0.5	mg/L
BPG 09	BPG09	11/24/1980	Nitrite + Nitrate	1	1.1	mg/L
BPG 09	BPG09	12/22/1980	Nitrite + Nitrate	1	3.1	mg/L
BPG 09	BPG09	1/22/1981	Nitrite + Nitrate	1	1.6	mg/L
BPG 09	BPG09	2/18/1981	Nitrite + Nitrate	1	3.7	mg/L
BPG 09	BPG09	3/19/1981	Nitrite + Nitrate	1	3.5	mg/L
BPG 09	BPG09	4/16/1981	Nitrite + Nitrate	1	15	mg/L
BPG 09	BPG09	5/21/1981	Nitrite + Nitrate	1	15	mg/L
BPG 09	BPG09	6/23/1981	Nitrite + Nitrate	1	16	mg/L
BPG 09	BPG09	8/4/1981	Nitrite + Nitrate	1	9.4	mg/L
BPG 09	BPG09	8/19/1981	Nitrite + Nitrate	1	8.7	mg/L
BPG 09	BPG09	11/10/1981	Nitrite + Nitrate	1	8.4	mg/L
BPG 09	BPG09	1/6/1982	Nitrite + Nitrate	1	11	mg/L
BPG 09	BPG09	3/10/1982	Nitrite + Nitrate	1	7.2	mg/L
BPG 09	BPG09	4/8/1982	Nitrite + Nitrate	1	7.3	mg/L
BPG 09	BPG09	5/13/1982	Nitrite + Nitrate	1	13	mg/L
BPG 09	BPG09	6/16/1982	Nitrite + Nitrate	1	7.9	mg/L
BPG 09	BPG09	8/12/1982	Nitrite + Nitrate	1	4.1	mg/L
BPG 09	BPG09	9/30/1982	Nitrite + Nitrate	1	0.76	mg/L
BPG 09	BPG09	11/10/1982	Nitrite + Nitrate	1	2.9	mg/L
BPG 09	BPG09	1/4/1983	Nitrite + Nitrate	1	9.3	mg/L
BPG 09	BPG09	2/4/1983	Nitrite + Nitrate	1	9	mg/L
BPG 09	BPG09	3/16/1983	Nitrite + Nitrate	1	6.9	mg/L
BPG 09	BPG09	4/13/1983	Nitrite + Nitrate	1	10	mg/L
BPG 09	BPG09	5/4/1983	Nitrite + Nitrate	1	8.1	mg/L
BPG 09	BPG09	6/22/1983	Nitrite + Nitrate	1	8	mg/L
BPG 09	BPG09	8/18/1983	Nitrite + Nitrate	1	1.3	mg/L
BPG 09	BPG09	11/2/1983	Nitrite + Nitrate	1	3.2	mg/L
BPG 09	BPG09	12/8/1983	Nitrite + Nitrate	1	11	mg/L
BPG 09	BPG09	3/7/1984	Nitrite + Nitrate	1	7.4	mg/L
BPG 09	BPG09	4/11/1984	Nitrite + Nitrate	1	8.7	mg/L
BPG 09	BPG09	5/2/1984	Nitrite + Nitrate	1	8.8	mg/L
BPG 09	BPG09	6/21/1984	Nitrite + Nitrate	1	7.1	mg/L
BPG 09	BPG09	7/18/1984	Nitrite + Nitrate	1	2.2	mg/L
BPG 09	BPG09	8/22/1984	Nitrite + Nitrate	1	1.1	mg/L
BPG 09	BPG09	9/19/1984	Nitrite + Nitrate	1	1.3	mg/L
BPG 09	BPG09	11/7/1984	Nitrite + Nitrate	1	1.8	mg/L
BPG 09	BPG09	12/13/1984	Nitrite + Nitrate	1	3.6	mg/L
BPG 09	BPG09	1/16/1985	Nitrite + Nitrate	1	9.8	mg/L
BPG 09	BPG09	3/6/1985	Nitrite + Nitrate	1	12	mg/L
BPG 09	BPG09	4/15/1985	Nitrite + Nitrate	1	11	mg/L
BPG 09	BPG09	5/23/1985	Nitrite + Nitrate	1	9.3	mg/L
BPG 09	BPG09	7/2/1985	Nitrite + Nitrate	1	3.5	mg/L
BPG 09	BPG09	8/19/1985	Nitrite + Nitrate	1	4.5	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	9/16/1985	Nitrite + Nitrate	1	1.3	mg/L
BPG 09	BPG09	10/16/1985	Nitrite + Nitrate	1	1.5	mg/L
BPG 09	BPG09	12/10/1985	Nitrite + Nitrate	1	8.1	mg/L
BPG 09	BPG09	1/29/1986	Nitrite + Nitrate	1	7	mg/L
BPG 09	BPG09	2/20/1986	Nitrite + Nitrate	1	8.5	mg/L
BPG 09	BPG09	3/25/1986	Nitrite + Nitrate	1	9.5	mg/L
BPG 09	BPG09	4/30/1986	Nitrite + Nitrate	1	4.5	mg/L
BPG 09	BPG09	6/17/1986	Nitrite + Nitrate	1	9	mg/L
BPG 09	BPG09	7/15/1986	Nitrite + Nitrate	1	8	mg/L
BPG 09	BPG09	9/10/1986	Nitrite + Nitrate	1	1.4	mg/L
BPG 09	BPG09	10/7/1986	Nitrite + Nitrate	1	2.2	mg/L
BPG 09	BPG09	12/2/1986	Nitrite + Nitrate	1	3.8	mg/L
BPG 09	BPG09	1/13/1987	Nitrite + Nitrate	1	2.7	mg/L
BPG 09	BPG09	2/17/1987	Nitrite + Nitrate	1	12	mg/L
BPG 09	BPG09	3/24/1987	Nitrite + Nitrate	1	8	mg/L
BPG 09	BPG09	4/28/1987	Nitrite + Nitrate	1	12	mg/L
BPG 09	BPG09	6/2/1987	Nitrite + Nitrate	1	11	mg/L
BPG 09	BPG09	7/20/1987	Nitrite + Nitrate	1	2.4	mg/L
BPG 09	BPG09	9/9/1987	Nitrite + Nitrate	1	2	mg/L
BPG 09	BPG09	11/3/1987	Nitrite + Nitrate	1	0.1	mg/L
BPG 09	BPG09	12/10/1987	Nitrite + Nitrate	1	12	mg/L
BPG 09	BPG09	1/21/1988	Nitrite + Nitrate	1	5.7	mg/L
BPG 09	BPG09	3/3/1988	Nitrite + Nitrate	1	9.6	mg/L
BPG 09	BPG09	4/5/1988	Nitrite + Nitrate	1	12	mg/L
BPG 09	BPG09	5/19/1988	Nitrite + Nitrate	1	5.7	mg/L
BPG 09	BPG09	6/23/1988	Nitrite + Nitrate	1	1.5	mg/L
BPG 09	BPG09	8/11/1988	Nitrite + Nitrate	1	2.2	mg/L
BPG 09	BPG09	9/15/1988	Nitrite + Nitrate	1	1.4	mg/L
BPG 09	BPG09	11/10/1988	Nitrite + Nitrate	1	6.8	mg/L
BPG 09	BPG09	12/14/1988	Nitrite + Nitrate	1	8.2	mg/L
BPG 09	BPG09	1/19/1989	Nitrite + Nitrate	1	12	mg/L
BPG 09	BPG09	2/23/1989	Nitrite + Nitrate	1	11	mg/L
BPG 09	BPG09	4/13/1989	Nitrite + Nitrate	1	15	mg/L
BPG 09	BPG09	5/10/1989	Nitrite + Nitrate	1	12	mg/L
BPG 09	BPG09	6/20/1989	Nitrite + Nitrate	1	11	mg/L
BPG 09	BPG09	8/2/1989	Nitrite + Nitrate	1	0.83	mg/L
BPG 09	BPG09	9/14/1989	Nitrite + Nitrate	1	3.5	mg/L
BPG 09	BPG09	11/8/1989	Nitrite + Nitrate	1	1.4	mg/L
BPG 09	BPG09	12/12/1989	Nitrite + Nitrate	1	3.1	mg/L
BPG 09	BPG09	1/24/1990	Nitrite + Nitrate	1	6	mg/L
BPG 09	BPG09	2/28/1990	Nitrite + Nitrate	1	12	mg/L
BPG 09	BPG09	3/28/1990	Nitrite + Nitrate	1	10	mg/L
BPG 09	BPG09	5/9/1990	Nitrite + Nitrate	1	14	mg/L
BPG 09	BPG09	7/3/1990	Nitrite + Nitrate	1	13	mg/L
BPG 09	BPG09	8/2/1990	Nitrite + Nitrate	1	8.5	mg/L
BPG 09	BPG09	9/26/1990	Nitrite + Nitrate	1	1.7	mg/L
BPG 09	BPG09	10/31/1990	Nitrite + Nitrate	1	8.5	mg/L
BPG 09	BPG09	12/10/1990	Nitrite + Nitrate	1	11	mg/L
BPG 09	BPG09	1/16/1991	Nitrite + Nitrate	1	5.9	mg/L
BPG 09	BPG09	3/5/1991	Nitrite + Nitrate	1	11	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	4/3/1991	Nitrite + Nitrate	1	9.7	mg/L
BPG 09	BPG09	5/22/1991	Nitrite + Nitrate	1	11	mg/L
BPG 09	BPG09	6/26/1991	Nitrite + Nitrate	1	4	mg/L
BPG 09	BPG09	8/21/1991	Nitrite + Nitrate	1	1	mg/L
BPG 09	BPG09	9/30/1991	Nitrite + Nitrate	1	0.75	mg/L
BPG 09	BPG09	11/14/1991	Nitrite + Nitrate	1	4.5	mg/L
BPG 09	BPG09	12/18/1991	Nitrite + Nitrate	1	13	mg/L
BPG 09	BPG09	2/4/1992	Nitrite + Nitrate	1	12	mg/L
BPG 09	BPG09	3/17/1992	Nitrite + Nitrate	1	14	mg/L
BPG 09	BPG09	6/3/1992	Nitrite + Nitrate	1	8.4	mg/L
BPG 09	BPG09	7/13/1992	Nitrite + Nitrate	1	15	mg/L
BPG 09	BPG09	8/12/1992	Nitrite + Nitrate	1	7.9	mg/L
BPG 09	BPG09	9/23/1992	Nitrite + Nitrate	1	3.5	mg/L
BPG 09	BPG09	11/18/1992	Nitrite + Nitrate	1	8.9	mg/L
BPG 09	BPG09	12/16/1992	Nitrite + Nitrate	1	8.1	mg/L
BPG 09	BPG09	2/1/1993	Nitrite + Nitrate	1	8.3	mg/L
BPG 09	BPG09	3/9/1993	Nitrite + Nitrate	1	7	mg/L
BPG 09	BPG09	4/7/1993	Nitrite + Nitrate	1	7.9	mg/L
BPG 09	BPG09	5/24/1993	Nitrite + Nitrate	1	10	mg/L
BPG 09	BPG09	6/28/1993	Nitrite + Nitrate	1	7.2	mg/L
BPG 09	BPG09	8/18/1993	Nitrite + Nitrate	1	3.2	mg/L
BPG 09	BPG09	9/28/1993	Nitrite + Nitrate	1	5.7	mg/L
BPG 09	BPG09	11/15/1993	Nitrite + Nitrate	1	6	mg/L
BPG 09	BPG09	12/20/1993	Nitrite + Nitrate	1	6.1	mg/L
BPG 09	BPG09	3/2/1994	Nitrite + Nitrate	1	3.4	mg/L
BPG 09	BPG09	3/29/1994	Nitrite + Nitrate	1	4.8	mg/L
BPG 09	BPG09	4/28/1994	Nitrite + Nitrate	1	8.8	mg/L
BPG 09	BPG09	6/30/1994	Nitrite + Nitrate	1	6.5	mg/L
BPG 09	BPG09	8/15/1994	Nitrite + Nitrate	1	0.78	mg/L
BPG 09	BPG09	9/6/1994	Nitrite + Nitrate	1	0.98	mg/L
BPG 09	BPG09	9/26/1994	Nitrite + Nitrate	1	0.63	mg/L
BPG 09	BPG09	11/2/1994	Nitrite + Nitrate	1	0.17	mg/L
BPG 09	BPG09	1/4/1995	Nitrite + Nitrate	1	5.7	mg/L
BPG 09	BPG09	2/1/1995	Nitrite + Nitrate	1	6.1	mg/L
BPG 09	BPG09	2/27/1995	Nitrite + Nitrate	1	3.2	mg/L
BPG 09	BPG09	3/29/1995	Nitrite + Nitrate	1	6.7	mg/L
BPG 09	BPG09	5/11/1995	Nitrite + Nitrate	1	9.5	mg/L
BPG 09	BPG09	6/14/1995	Nitrite + Nitrate	1	8.6	mg/L
BPG 09	BPG09	9/7/1995	Nitrite + Nitrate	1	0.64	mg/L
BPG 09	BPG09	10/16/1995	Nitrite + Nitrate	1	0.17	mg/L
BPG 09	BPG09	12/12/1995	Nitrite + Nitrate	1	3.3	mg/L
BPG 09	BPG09	1/29/1996	Nitrite + Nitrate	1	9.7	mg/L
BPG 09	BPG09	2/29/1996	Nitrite + Nitrate	1	8.4	mg/L
BPG 09	BPG09	3/28/1996	Nitrite + Nitrate	1	9.6	mg/L
BPG 09	BPG09	4/19/1996	Nitrite + Nitrate	1	5.9	mg/L
BPG 09	BPG09	5/20/1996	Nitrite + Nitrate	1	13.7	mg/L
BPG 09	BPG09	7/18/1996	Nitrite + Nitrate	1	5	mg/L
BPG 09	BPG09	8/26/1996	Nitrite + Nitrate	1	1.64	mg/L
BPG 09	BPG09	10/28/1996	Nitrite + Nitrate	1	0.11	mg/L
BPG 09	BPG09	12/16/1996	Nitrite + Nitrate	1	9.9	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	2/4/1997	Nitrite + Nitrate	1	6.5	mg/L
BPG 09	BPG09	3/4/1997	Nitrite + Nitrate	1	9.39	mg/L
BPG 09	BPG09	4/2/1997	Nitrite + Nitrate	1	9.4	mg/L
BPG 09	BPG09	4/30/1997	Nitrite + Nitrate	1	7	mg/L
BPG 09	BPG09	7/9/1997	Nitrite + Nitrate	1	7.1	mg/L
BPG 09	BPG09	9/9/1997	Nitrite + Nitrate	1	0.93	mg/L
BPG 09	BPG09	9/26/1997	Nitrite + Nitrate	1	0.93	mg/L
BPG 09	BPG09	10/30/1997	Nitrite + Nitrate	1	0.57	mg/L
BPG 09	BPG09	11/19/1997	Nitrite + Nitrate	1	0.56	mg/L
BPG 09	BPG09	1/6/1998	Nitrite + Nitrate	1	1.61	mg/L
BPG 09	BPG09	3/13/1998	Nitrite + Nitrate	1	13	mg/L
BPG 09	BPG09	4/28/1998	Nitrite + Nitrate	1	10.07	mg/L
BPG 09	BPG09	7/1/1998	Nitrite + Nitrate	1	10.51	mg/L
BPG 09	BPG09	8/4/1998	Nitrite + Nitrate	1	1.15	mg/L
BPG 09	BPG09	8/31/1998	Nitrite + Nitrate	1	1.53	mg/L
BPG 09	BPG09	9/28/1998	Nitrite + Nitrate	1	1.68	mg/L
BPG 09	BPG09	11/23/1998	Nitrite + Nitrate	1	4.98	mg/L
BPG 09	BPG09	12/30/1998	Nitrite + Nitrate	1	1.64	mg/L
BPG 09	BPG09	01/24/00	Nitrite + Nitrate	1	11	mg/L
BPG 09	BPG09	03/03/00	Nitrite + Nitrate	1	8.7	mg/L
BPG 09	BPG09	05/23/00	Nitrite + Nitrate	1	13	mg/L
BPG 09	BPG09	06/14/00	Nitrite + Nitrate	1	11	mg/L
BPG 09	BPG09	07/26/00	Nitrite + Nitrate	1	5.6	mg/L
BPG 09	BPG09	09/28/00	Nitrite + Nitrate	1	1.85	mg/L
BPG 09	BPG09	11/28/00	Nitrite + Nitrate	1	7.7	mg/L
BPG 09	BPG09	12/28/00	Nitrite + Nitrate	1	8.3	mg/L
BPG 09	BPG09	01/30/01	Nitrite + Nitrate	1	4.1	mg/L
BPG 09	BPG09	03/19/01	Nitrite + Nitrate	1	13	mg/L
BPG 09	BPG09	04/18/01	Nitrite + Nitrate	1	12	mg/L
BPG 09	BPG09	05/14/01	Nitrite + Nitrate	1	7.3	mg/L
BPG 09	BPG09	06/19/01	Nitrite + Nitrate	1	11	mg/L
BPG 09	BPG09	6/28/01	Nitrite + Nitrate	1	9.7	mg/L
BPG 09	BPG09	08/02/01	Nitrite + Nitrate	1	1.26	mg/L
BPG 09	BPG09	08/21/01	Nitrite + Nitrate	1	1.37	mg/L
BPG 09	BPG09	8/21/01	Nitrite + Nitrate	1	3.1	mg/L
BPG 09	BPG09	10/10/01	Nitrite + Nitrate	1	7.1	mg/L
BPG 09	BPG09	10/29/01	Nitrite + Nitrate	1	7	mg/L
BPG 09	BPG09	11/08/01	Nitrite + Nitrate	1	6.8	mg/L
BPG 09	BPG09	12/20/01	Nitrite + Nitrate	1	9.8	mg/L
BPG 09	BPG09	01/30/02	Nitrite + Nitrate	1	5.8	mg/L
BPG 09	BPG09	03/04/02	Nitrite + Nitrate	1	11	mg/L
BPG 09	BPG09	04/11/02	Nitrite + Nitrate	1	11	mg/L
BPG 09	BPG09	04/18/02	Nitrite + Nitrate	1	9.6	mg/L
BPG 09	BPG09	04/24/02	Nitrite + Nitrate	1	11	mg/L
BPG 09	BPG09	05/14/02	Nitrite + Nitrate	1	11	mg/L
BPG 09	BPG09	06/05/02	Nitrite + Nitrate	1	2.4	mg/L
BPG 09	BPG09	06/05/02	Nitrite + Nitrate	1	9.8	mg/L
BPG 09	BPG09	07/01/02	Nitrite + Nitrate	1	7.91	mg/L
BPG 09	BPG09	07/11/02	Nitrite + Nitrate	1	4.93	mg/L
BPG 09	BPG09	07/24/02	Nitrite + Nitrate	1	6.62	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	08/19/02	Nitrite + Nitrate	1	1.39	mg/L
BPG 09	BPG09	08/31/02	Nitrite + Nitrate	1	3.55	mg/L
BPG 09	BPG09	09/20/02	Nitrite + Nitrate	1	1.35	mg/L
BPG 09	BPG09	09/27/02	Nitrite + Nitrate	1	1.74	mg/L
BPG 09	BPG09	11/12/02	Nitrite + Nitrate	1	0.34	mg/L
BPG 09	BPG09	11/14/02	Nitrite + Nitrate	1	0.46	mg/L
BPG 09	BPG09	12/12/02	Nitrite + Nitrate	1	1.16	mg/L
BPG 09	BPG09	12/19/02	Nitrite + Nitrate	1	0.99	mg/L
RBD	RBD-1	7/2/1977	Nitrite + Nitrate	0	3	mg/L
RBD	RBD-1	6/28/1979	Nitrite + Nitrate	12	4.5	mg/L
RBD	RBD-1	6/28/1979	Nitrite + Nitrate	1	5.1	mg/L
RBD	RBD-1	9/5/1979	Nitrite + Nitrate	1	4.1	mg/L
RBD	RBD-1	9/5/1979	Nitrite + Nitrate	1	3.8	mg/L
RBD	RBD-1	5/18/1983	Nitrite + Nitrate	1	8.4	mg/L
RBD	RBD-1	5/18/1983	Nitrite + Nitrate	1	8	mg/L
RBD	RBD-1	5/10/1991	Nitrite + Nitrate	1	7.1	mg/L
RBD	RBD-1	6/11/1991	Nitrite + Nitrate	1	7.7	mg/L
RBD	RBD-1	7/16/1991	Nitrite + Nitrate	1	2.5	mg/L
RBD	RBD-1	8/27/1991	Nitrite + Nitrate		0.01	mg/L
RBD	RBD-1	9/10/1991	Nitrite + Nitrate		0.01	mg/L
RBD	RBD-1	10/9/1991	Nitrite + Nitrate		0.06	mg/L
RBD	RBD-1	4/21/1997	Nitrite + Nitrate	1	7.7	mg/L
RBD	RBD-1	4/21/1997	Nitrite + Nitrate	1	7.8	mg/L
RBD	RBD-1	6/9/1997	Nitrite + Nitrate	1	12	mg/L
RBD	RBD-1	6/9/1997	Nitrite + Nitrate	1	12.3	mg/L
RBD	RBD-1	8/12/1997	Nitrite + Nitrate		1.92	mg/L
RBD	RBD-1	8/12/1997	Nitrite + Nitrate	0	2.1	mg/L
RBD	RBD-1	10/22/1997	Nitrite + Nitrate	1	0.12	mg/L
RBD	RBD-1	10/22/1997	Nitrite + Nitrate	1	0.12	mg/L
RBD	RBD-1	03/28/01	Nitrite + Nitrate	1	9.2	mg/L
RBD	RBD-1	03/28/01	Nitrite + Nitrate	1	9.3	mg/L
RBD	RBD-1	04/19/01	Nitrite + Nitrate	1	12	mg/L
RBD	RBD-1	04/19/01	Nitrite + Nitrate	1	9.8	mg/L
RBD	RBD-1	04/26/01	Nitrite + Nitrate		8.9	mg/L
RBD	RBD-1	04/26/01	Nitrite + Nitrate		8.8	mg/L
RBD	RBD-2	7/2/1977	Nitrite + Nitrate	14	2.4	mg/L
RBD	RBD-2	6/28/1979	Nitrite + Nitrate	10	4.2	mg/L
RBD	RBD-2	9/5/1979	Nitrite + Nitrate	1	3.8	mg/L
RBD	RBD-2	5/18/1983	Nitrite + Nitrate	18	8.8	mg/L
RBD	RBD-2	10/9/1991	Nitrite + Nitrate	0	0.06	mg/L
RBD	RBD-2	4/21/1997	Nitrite + Nitrate	1	7.7	mg/L
RBD	RBD-2	6/9/1997	Nitrite + Nitrate	1	11.2	mg/L
RBD	RBD-2	7/14/1997	Nitrite + Nitrate		6.2	mg/L
RBD	RBD-2	8/12/1997	Nitrite + Nitrate	1	1.78	mg/L
RBD	RBD-2	10/22/1997	Nitrite + Nitrate	1	0.01	mg/L
RBD	RBD-2	03/28/01	Nitrite + Nitrate	1	9.5	mg/L
RBD	RBD-2	04/19/01	Nitrite + Nitrate	1	9.9	mg/L
RBD	RBD-2	04/26/01	Nitrite + Nitrate		9.1	mg/L
RBD	RBD-3	7/2/1977	Nitrite + Nitrate	1	1.2	mg/L
RBD	RBD-3	6/28/1979	Nitrite + Nitrate	1	3.7	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-3	9/5/1979	Nitrite + Nitrate	1	3.6	mg/L
RBD	RBD-3	5/18/1983	Nitrite + Nitrate	1	1.3	mg/L
RBD	RBD-3	5/10/1991	Nitrite + Nitrate	17	7.9	mg/L
RBD	RBD-3	6/11/1991	Nitrite + Nitrate	16	8.2	mg/L
RBD	RBD-3	7/16/1991	Nitrite + Nitrate		0.99	mg/L
RBD	RBD-3	4/21/1997	Nitrite + Nitrate	1	7.4	mg/L
RBD	RBD-3	6/9/1997	Nitrite + Nitrate	1	11.3	mg/L
RBD	RBD-3	7/14/1997	Nitrite + Nitrate		5.7	mg/L
RBD	RBD-3	8/12/1997	Nitrite + Nitrate	1	1.11	mg/L
RBD	RBD-3	10/22/1997	Nitrite + Nitrate	1	0.01	mg/L
RBD	RBD-4	6/20/1988	Nitrite + Nitrate	18	0.1	mg/L
RBD	RBD-4	8/27/1991	Nitrite + Nitrate		0.01	mg/L
RBD	RBD-4	9/10/1991	Nitrite + Nitrate		0.01	mg/L
RBD	RBD-4	4/21/1997	Nitrite + Nitrate	1	7.4	mg/L
RBD	RBD-5	03/28/01	Nitrite + Nitrate	1	9.9	mg/L
RBD	RBD-5	04/19/01	Nitrite + Nitrate	1	11	mg/L
RBD	RBD-5	04/26/01	Nitrite + Nitrate		8.6	mg/L
RBD	RBD-T1	06/06/01	Nitrite + Nitrate		6.3	mg/L
RBD	RBD-T2	04/09/01	Nitrite + Nitrate	1	9.2	mg/L
RBD	RBD-T2	04/23/01	Nitrite + Nitrate		11	mg/L
RBD	RBD-T2	05/07/01	Nitrite + Nitrate		8.2	mg/L
RBD	RBD-T2	05/21/01	Nitrite + Nitrate		14	mg/L
RBD	RBD-T2	06/06/01	Nitrite + Nitrate		16	mg/L
RBD	RBD-T2	06/08/01	Nitrite + Nitrate		17	mg/L
RBD	RBD-T2	06/13/01	Nitrite + Nitrate		14	mg/L
RBD	RBD-1	5/1/2003	Nitrite+Nitrate	15	3.77	mg/L
RBD	RBD-1	5/1/2003	Nitrite+Nitrate	9	3.85	mg/L
RBD	RBD-1	5/1/2003	Nitrite+Nitrate	1	4.11	mg/L
RBD	RBD-1	6/18/2003	Nitrite+Nitrate	1	11	mg/L
RBD	RBD-1	6/18/2003	Nitrite+Nitrate	9	11.1	mg/L
RBD	RBD-1	6/18/2003	Nitrite+Nitrate	15	11.3	mg/L
RBD	RBD-1	7/16/2003	Nitrite+Nitrate	15	5.8	mg/L
RBD	RBD-1	7/16/2003	Nitrite+Nitrate	9	5.71	mg/L
RBD	RBD-1	7/16/2003	Nitrite+Nitrate	1	5.52	mg/L
RBD	RBD-1	8/11/2003	Nitrite+Nitrate	14	4.18	mg/L
RBD	RBD-1	8/11/2003	Nitrite+Nitrate	7	4.17	mg/L
RBD	RBD-1	8/11/2003	Nitrite+Nitrate	1	4.14	mg/L
RBD	RBD-1	10/16/2003	Nitrite+Nitrate	15	4.93	mg/L
RBD	RBD-1	10/16/2003	Nitrite+Nitrate	9	5.01	mg/L
RBD	RBD-1	10/16/2003	Nitrite+Nitrate	1	5	mg/L
RBD	RBD-2	5/1/2003	Nitrite+Nitrate	1	3.88	mg/L
RBD	RBD-2	6/18/2003	Nitrite+Nitrate	1	12.5	mg/L
RBD	RBD-2	7/16/2003	Nitrite+Nitrate	1	5.88	mg/L
RBD	RBD-2	8/11/2003	Nitrite+Nitrate	1	3.88	mg/L
RBD	RBD-2	10/16/2003	Nitrite+Nitrate	1	4.91	mg/L
RBD	RBD-5	5/1/2003	Nitrite+Nitrate	1	4.66	mg/L
RBD	RBD-5	6/18/2003	Nitrite+Nitrate	1	14	mg/L
RBD	RBD-5	7/16/2003	Nitrite+Nitrate	1	5.75	mg/L
RBD	RBD-5	8/11/2003	Nitrite+Nitrate	1	3.6	mg/L
RBD	RBD-5	10/16/2003	Nitrite+Nitrate	1	5.2	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	1/19/1978	Nitrogen, Ammonia	1	0.30	mg/L
BPG 09	BPG09	2/28/1978	Nitrogen, Ammonia	1	0.30	mg/L
BPG 09	BPG09	4/13/1978	Nitrogen, Ammonia	1	0.40	mg/L
BPG 09	BPG09	5/11/1978	Nitrogen, Ammonia	1	0.60	mg/L
BPG 09	BPG09	5/31/1978	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	6/14/1978	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	6/28/1978	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	7/11/1978	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	8/2/1978	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	8/23/1978	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	9/13/1978	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	10/11/1978	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	11/15/1978	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	12/6/1978	Nitrogen, Ammonia	1	0.50	mg/L
BPG 09	BPG09	1/10/1979	Nitrogen, Ammonia	1	0.60	mg/L
BPG 09	BPG09	2/6/1979	Nitrogen, Ammonia	1	1.20	mg/L
BPG 09	BPG09	3/7/1979	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	4/2/1979	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	5/1/1979	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	5/31/1979	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	5/31/1979	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	7/9/1979	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	7/9/1979	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	8/1/1979	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	9/13/1979	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	10/4/1979	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	10/4/1979	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	11/5/1979	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	12/5/1979	Nitrogen, Ammonia	1	0.20	mg/L
BPG 09	BPG09	1/10/1980	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	2/14/1980	Nitrogen, Ammonia	1	0.20	mg/L
BPG 09	BPG09	3/31/1980	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	5/2/1980	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	5/2/1980	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	6/4/1980	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	6/17/1980	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	7/7/1980	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	8/11/1980	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	9/10/1980	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	10/2/1980	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	10/27/1980	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	11/24/1980	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	12/22/1980	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	1/22/1981	Nitrogen, Ammonia	1	0.50	mg/L
BPG 09	BPG09	2/18/1981	Nitrogen, Ammonia	1	0.30	mg/L
BPG 09	BPG09	3/19/1981	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	4/16/1981	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	5/21/1981	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	6/23/1981	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	8/4/1981	Nitrogen, Ammonia	1	0.01	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	8/19/1981	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	11/10/1981	Nitrogen, Ammonia	1	0.12	mg/L
BPG 09	BPG09	1/6/1982	Nitrogen, Ammonia	1	0.17	mg/L
BPG 09	BPG09	3/10/1982	Nitrogen, Ammonia	1	0.11	mg/L
BPG 09	BPG09	4/8/1982	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	5/13/1982	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	6/16/1982	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	8/12/1982	Nitrogen, Ammonia	1	0.15	mg/L
BPG 09	BPG09	9/30/1982	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	11/10/1982	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	1/4/1983	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	2/4/1983	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	3/16/1983	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	4/13/1983	Nitrogen, Ammonia	1	0.18	mg/L
BPG 09	BPG09	5/4/1983	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	6/22/1983	Nitrogen, Ammonia	1	0.14	mg/L
BPG 09	BPG09	8/18/1983	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	11/2/1983	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	12/8/1983	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	3/7/1984	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	4/11/1984	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	5/2/1984	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	6/21/1984	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	7/18/1984	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	8/22/1984	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	9/19/1984	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	11/7/1984	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	12/13/1984	Nitrogen, Ammonia	1	0.12	mg/L
BPG 09	BPG09	1/16/1985	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	3/6/1985	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	4/15/1985	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	5/23/1985	Nitrogen, Ammonia	1	0.13	mg/L
BPG 09	BPG09	7/2/1985	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	8/19/1985	Nitrogen, Ammonia	1	0.17	mg/L
BPG 09	BPG09	9/16/1985	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	10/16/1985	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	12/10/1985	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	1/29/1986	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	2/20/1986	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	3/25/1986	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	4/30/1986	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	6/17/1986	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	7/15/1986	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	9/10/1986	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	10/7/1986	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	12/2/1986	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	1/13/1987	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	2/17/1987	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	3/24/1987	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	4/28/1987	Nitrogen, Ammonia	1	0.10	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	6/2/1987	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	7/20/1987	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	9/9/1987	Nitrogen, Ammonia	1	0.14	mg/L
BPG 09	BPG09	11/3/1987	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	12/10/1987	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	1/21/1988	Nitrogen, Ammonia	1	0.18	mg/L
BPG 09	BPG09	3/3/1988	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	4/5/1988	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	5/19/1988	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	6/23/1988	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	8/11/1988	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	9/15/1988	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	11/10/1988	Nitrogen, Ammonia	1	0.21	mg/L
BPG 09	BPG09	12/14/1988	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	1/19/1989	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	2/23/1989	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	4/13/1989	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	5/10/1989	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	6/20/1989	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	8/2/1989	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	9/14/1989	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	11/8/1989	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	12/12/1989	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	1/24/1990	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	2/28/1990	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	3/28/1990	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	5/9/1990	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	7/3/1990	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	8/2/1990	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	9/26/1990	Nitrogen, Ammonia	1	0.04	mg/L
BPG 09	BPG09	10/31/1990	Nitrogen, Ammonia	1	0.02	mg/L
BPG 09	BPG09	12/10/1990	Nitrogen, Ammonia	1	0.03	mg/L
BPG 09	BPG09	1/16/1991	Nitrogen, Ammonia	1	0.20	mg/L
BPG 09	BPG09	3/5/1991	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	4/3/1991	Nitrogen, Ammonia	1	0.02	mg/L
BPG 09	BPG09	5/22/1991	Nitrogen, Ammonia	1	0.05	mg/L
BPG 09	BPG09	6/26/1991	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	8/21/1991	Nitrogen, Ammonia	1	0.08	mg/L
BPG 09	BPG09	9/30/1991	Nitrogen, Ammonia	1	0.04	mg/L
BPG 09	BPG09	11/14/1991	Nitrogen, Ammonia	1	0.02	mg/L
BPG 09	BPG09	12/18/1991	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	2/4/1992	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	3/17/1992	Nitrogen, Ammonia	1	0.17	mg/L
BPG 09	BPG09	6/3/1992	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	7/13/1992	Nitrogen, Ammonia	1	0.05	mg/L
BPG 09	BPG09	8/12/1992	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	9/23/1992	Nitrogen, Ammonia	1	0.02	mg/L
BPG 09	BPG09	11/18/1992	Nitrogen, Ammonia	1	0.07	mg/L
BPG 09	BPG09	12/16/1992	Nitrogen, Ammonia	1	0.07	mg/L
BPG 09	BPG09	2/1/1993	Nitrogen, Ammonia	1	0.08	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	3/9/1993	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	4/7/1993	Nitrogen, Ammonia	1	0.02	mg/L
BPG 09	BPG09	5/24/1993	Nitrogen, Ammonia	1	0.18	mg/L
BPG 09	BPG09	6/28/1993	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	8/18/1993	Nitrogen, Ammonia	1	0.09	mg/L
BPG 09	BPG09	9/28/1993	Nitrogen, Ammonia	1	0.02	mg/L
BPG 09	BPG09	11/15/1993	Nitrogen, Ammonia	1	0.35	mg/L
BPG 09	BPG09	12/20/1993	Nitrogen, Ammonia	1	0.02	mg/L
BPG 09	BPG09	3/2/1994	Nitrogen, Ammonia	1	0.06	mg/L
BPG 09	BPG09	3/29/1994	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	4/28/1994	Nitrogen, Ammonia	1	0.11	mg/L
BPG 09	BPG09	6/30/1994	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	8/15/1994	Nitrogen, Ammonia	1	0.05	mg/L
BPG 09	BPG09	9/6/1994	Nitrogen, Ammonia	1	0.25	mg/L
BPG 09	BPG09	9/26/1994	Nitrogen, Ammonia	1	0.06	mg/L
BPG 09	BPG09	11/2/1994	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	1/4/1995	Nitrogen, Ammonia	1	0.05	mg/L
BPG 09	BPG09	2/1/1995	Nitrogen, Ammonia	1	0.06	mg/L
BPG 09	BPG09	2/27/1995	Nitrogen, Ammonia	1	0.04	mg/L
BPG 09	BPG09	3/29/1995	Nitrogen, Ammonia	1	0.02	mg/L
BPG 09	BPG09	5/11/1995	Nitrogen, Ammonia	1	0.45	mg/L
BPG 09	BPG09	6/14/1995	Nitrogen, Ammonia	1	0.02	mg/L
BPG 09	BPG09	9/7/1995	Nitrogen, Ammonia	1	0.12	mg/L
BPG 09	BPG09	10/16/1995	Nitrogen, Ammonia	1	0.03	mg/L
BPG 09	BPG09	12/12/1995	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	1/29/1996	Nitrogen, Ammonia	1	0.12	mg/L
BPG 09	BPG09	2/29/1996	Nitrogen, Ammonia	1	0.07	mg/L
BPG 09	BPG09	3/28/1996	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	4/19/1996	Nitrogen, Ammonia	1	0.28	mg/L
BPG 09	BPG09	5/20/1996	Nitrogen, Ammonia	1	0.13	mg/L
BPG 09	BPG09	7/18/1996	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	8/26/1996	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	10/28/1996	Nitrogen, Ammonia	1	0.07	mg/L
BPG 09	BPG09	12/16/1996	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	2/4/1997	Nitrogen, Ammonia	1	0.23	mg/L
BPG 09	BPG09	3/4/1997	Nitrogen, Ammonia	1	0.17	mg/L
BPG 09	BPG09	4/2/1997	Nitrogen, Ammonia	1	0.15	mg/L
BPG 09	BPG09	4/30/1997	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	7/9/1997	Nitrogen, Ammonia	1	0.44	mg/L
BPG 09	BPG09	9/9/1997	Nitrogen, Ammonia	1	0.30	mg/L
BPG 09	BPG09	9/26/1997	Nitrogen, Ammonia	1	0.10	mg/L
BPG 09	BPG09	10/30/1997	Nitrogen, Ammonia	1	0.23	mg/L
BPG 09	BPG09	11/19/1997	Nitrogen, Ammonia	1	0.19	mg/L
BPG 09	BPG09	1/6/1998	Nitrogen, Ammonia	1	0.20	mg/L
BPG 09	BPG09	3/13/1998	Nitrogen, Ammonia	1	0.14	mg/L
BPG 09	BPG09	4/28/1998	Nitrogen, Ammonia	1	0.39	mg/L
BPG 09	BPG09	7/1/1998	Nitrogen, Ammonia	1	0.21	mg/L
BPG 09	BPG09	8/4/1998	Nitrogen, Ammonia	1	0.24	mg/L
BPG 09	BPG09	8/31/1998	Nitrogen, Ammonia	1	0.18	mg/L
BPG 09	BPG09	9/28/1998	Nitrogen, Ammonia	1	0.38	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	11/23/1998	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	12/30/1998	Nitrogen, Ammonia	1	0.04	mg/L
BPG 09	BPG09	01/24/00	Nitrogen, Ammonia	1	0.02	mg/L
BPG 09	BPG09	03/03/00	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	05/23/00	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	06/14/00	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	07/26/00	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	09/28/00	Nitrogen, Ammonia	1	0.16	mg/L
BPG 09	BPG09	11/28/00	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	12/28/00	Nitrogen, Ammonia	1	0.05	mg/L
BPG 09	BPG09	01/30/01	Nitrogen, Ammonia	1	1.6	mg/L
BPG 09	BPG09	03/19/01	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	04/18/01	Nitrogen, Ammonia	1	0.03	mg/L
BPG 09	BPG09	05/14/01	Nitrogen, Ammonia	1	0.08	mg/L
BPG 09	BPG09	06/19/01	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	6/28/01	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	08/02/01	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	08/21/01	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	8/21/01	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	10/10/01	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	10/29/01	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	11/08/01	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	12/20/01	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	01/30/02	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	03/04/02	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	04/11/02	Nitrogen, Ammonia	1	0.02	mg/L
BPG 09	BPG09	04/18/02	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	04/24/02	Nitrogen, Ammonia	1	0.03	mg/L
BPG 09	BPG09	05/14/02	Nitrogen, Ammonia	1	0.12	mg/L
BPG 09	BPG09	06/05/02	Nitrogen, Ammonia	1	0.04	mg/L
BPG 09	BPG09	06/05/02	Nitrogen, Ammonia	1	0.33	mg/L
BPG 09	BPG09	07/01/02	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	07/11/02	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	07/24/02	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	08/19/02	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	08/31/02	Nitrogen, Ammonia	1	0.1	mg/L
BPG 09	BPG09	09/20/02	Nitrogen, Ammonia	1	0.08	mg/L
BPG 09	BPG09	09/27/02	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	11/12/02	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	11/14/02	Nitrogen, Ammonia	1	0.05	mg/L
BPG 09	BPG09	12/12/02	Nitrogen, Ammonia	1	0.01	mg/L
BPG 09	BPG09	12/19/02	Nitrogen, Ammonia	1	0.03	mg/L
BPGD	BPGD-H-A1	9/23/2002	Nitrogen, Ammonia		0.30	mg/L
BPGD	BPGD-H-A2	9/23/2002	Nitrogen, Ammonia		0.89	mg/L
BPGD	BPGD-H-C1	9/23/2002	Nitrogen, Ammonia		0.32	mg/L
BPGD	BPGD-H-C2	9/23/2002	Nitrogen, Ammonia		0.22	mg/L
BPGD	BPGD-H-C3	9/23/2002	Nitrogen, Ammonia		0.11	mg/L
BPGD	BPGD-H-D2	9/23/2002	Nitrogen, Ammonia		0.5	mg/L
BPGD	BPGD-H-D3	9/23/2002	Nitrogen, Ammonia		0.03	mg/L
BPGD	BPGD-H-E1	9/23/2002	Nitrogen, Ammonia		0.01	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-1	6/28/1979	Nitrogen, Ammonia	14	0.24	mg/L
RBD	RBD-1	6/28/1979	Nitrogen, Ammonia	1	0.06	mg/L
RBD	RBD-1	9/5/1979	Nitrogen, Ammonia	12	0.1	mg/L
RBD	RBD-1	9/5/1979	Nitrogen, Ammonia	1	0.01	mg/L
RBD	RBD-1	5/18/1983	Nitrogen, Ammonia	10	0.1	mg/L
RBD	RBD-1	5/18/1983	Nitrogen, Ammonia	1	0.1	mg/L
RBD	RBD-1	5/10/1991	Nitrogen, Ammonia	1	0.27	mg/L
RBD	RBD-1	6/11/1991	Nitrogen, Ammonia	1	0.07	mg/L
RBD	RBD-1	7/16/1991	Nitrogen, Ammonia	1	0.03	mg/L
RBD	RBD-1	9/10/1991	Nitrogen, Ammonia	1	0.04	mg/L
RBD	RBD-1	10/9/1991	Nitrogen, Ammonia	1	0.22	mg/L
RBD	RBD-1	4/21/1997	Nitrogen, Ammonia	18	0.07	mg/L
RBD	RBD-1	4/21/1997	Nitrogen, Ammonia	1	0.04	mg/L
RBD	RBD-1	6/9/1997	Nitrogen, Ammonia	18	0.21	mg/L
RBD	RBD-1	6/9/1997	Nitrogen, Ammonia	1	0.12	mg/L
RBD	RBD-1	8/12/1997	Nitrogen, Ammonia	17	0.54	mg/L
RBD	RBD-1	8/12/1997	Nitrogen, Ammonia	1	0.5	mg/L
RBD	RBD-1	10/22/1997	Nitrogen, Ammonia	16	0.23	mg/L
RBD	RBD-1	10/22/1997	Nitrogen, Ammonia	1	0.27	mg/L
RBD	RBD-1	03/28/01	Nitrogen, Ammonia		0.07	mg/L
RBD	RBD-1	03/28/01	Nitrogen, Ammonia		0.08	mg/L
RBD	RBD-1	04/19/01	Nitrogen, Ammonia		0.15	mg/L
RBD	RBD-1	04/19/01	Nitrogen, Ammonia		0.17	mg/L
RBD	RBD-1	04/26/01	Nitrogen, Ammonia		0.05	mg/L
RBD	RBD-1	04/26/01	Nitrogen, Ammonia		0.03	mg/L
RBD	RBD-2	07/02/77	Nitrogen, Ammonia	0	0.1	mg/L
RBD	RBD-2	06/28/79	Nitrogen, Ammonia	1	0.03	mg/L
RBD	RBD-2	09/05/79	Nitrogen, Ammonia	1	0.02	mg/L
RBD	RBD-2	05/18/83	Nitrogen, Ammonia	1	0.1	mg/L
RBD	RBD-2	10/09/91	Nitrogen, Ammonia	1	0.2	mg/L
RBD	RBD-2	04/21/97	Nitrogen, Ammonia	1	0.06	mg/L
RBD	RBD-2	06/09/97	Nitrogen, Ammonia	1	0.14	mg/L
RBD	RBD-2	07/14/97	Nitrogen, Ammonia	1	0.06	mg/L
RBD	RBD-2	08/12/97	Nitrogen, Ammonia	1	0.34	mg/L
RBD	RBD-2	10/22/97	Nitrogen, Ammonia	1	0.21	mg/L
RBD	RBD-2	03/28/01	Nitrogen, Ammonia		0.01	mg/L
RBD	RBD-2	04/19/01	Nitrogen, Ammonia		0.24	mg/L
RBD	RBD-2	04/26/01	Nitrogen, Ammonia		0.06	mg/L
RBD	RBD-3	06/28/79	Nitrogen, Ammonia	1	0.02	mg/L
RBD	RBD-3	09/05/79	Nitrogen, Ammonia	1	0.03	mg/L
RBD	RBD-3	05/18/83	Nitrogen, Ammonia	1	0.1	mg/L
RBD	RBD-3	05/10/91	Nitrogen, Ammonia	1	0.29	mg/L
RBD	RBD-3	06/11/91	Nitrogen, Ammonia	1	0.05	mg/L
RBD	RBD-3	07/16/91	Nitrogen, Ammonia	1	0.17	mg/L
RBD	RBD-3	04/21/97	Nitrogen, Ammonia	1	0.13	mg/L
RBD	RBD-3	06/09/97	Nitrogen, Ammonia	1	0.13	mg/L
RBD	RBD-3	07/14/97	Nitrogen, Ammonia	1	0.09	mg/L
RBD	RBD-3	08/12/97	Nitrogen, Ammonia	1	0.45	mg/L
RBD	RBD-3	10/22/97	Nitrogen, Ammonia	1	0.21	mg/L
RBD	RBD-4	06/20/88	Nitrogen, Ammonia	1	0.01	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-4	08/27/91	Nitrogen, Ammonia	1	0.03	mg/L
RBD	RBD-4	09/10/91	Nitrogen, Ammonia	1	0.08	mg/L
RBD	RBD-4	04/21/97	Nitrogen, Ammonia	1	0.07	mg/L
RBD	RBD-5	03/28/01	Nitrogen, Ammonia		0.06	mg/L
RBD	RBD-5	04/19/01	Nitrogen, Ammonia		0.14	mg/L
RBD	RBD-5	04/26/01	Nitrogen, Ammonia		0.08	mg/L
RBD	RBD-T1	06/06/01	Nitrogen, Ammonia		0.01	mg/L
RBD	RBD-T2	04/09/01	Nitrogen, Ammonia		0.05	mg/L
RBD	RBD-T2	04/23/01	Nitrogen, Ammonia		0.05	mg/L
RBD	RBD-T2	05/07/01	Nitrogen, Ammonia		0.14	mg/L
RBD	RBD-T2	05/21/01	Nitrogen, Ammonia		0.32	mg/L
RBD	RBD-T2	06/06/01	Nitrogen, Ammonia		0.06	mg/L
RBD	RBD-T2	06/08/01	Nitrogen, Ammonia		0.03	mg/L
RBD	RBD-T2	06/13/01	Nitrogen, Ammonia		0.01	mg/L
BPGD	BPGD-H-A1	9/23/2002	pH (field)		7.2	unit
BPGD	BPGD-H-A2	9/23/2002	pH (field)		7.6	unit
BPGD	BPGD-H-C1	9/23/2002	pH (field)		7.6	unit
BPGD	BPGD-H-C2	9/23/2002	pH (field)		7.9	unit
BPGD	BPGD-H-C3	9/23/2002	pH (field)		8.0	unit
BPGD	BPGD-H-D2	9/23/2002	pH (field)		8.0	unit
BPGD	BPGD-H-D3	9/23/2002	pH (field)		7.8	unit
BPGD	BPGD-H-E1	9/23/2002	pH (field)		7.7	unit
BPG 09	BPG09	1/19/1978	Total Phosphorus	1	0.07	mg/L
BPG 09	BPG09	2/28/1978	Total Phosphorus	1	0.12	mg/L
BPG 09	BPG09	4/13/1978	Total Phosphorus	1	0.09	mg/L
BPG 09	BPG09	5/11/1978	Total Phosphorus	1	0.07	mg/L
BPG 09	BPG09	5/31/1978	Total Phosphorus	1	0.07	mg/L
BPG 09	BPG09	6/14/1978	Total Phosphorus	1	0.10	mg/L
BPG 09	BPG09	7/11/1978	Total Phosphorus	1	0.18	mg/L
BPG 09	BPG09	8/23/1978	Total Phosphorus	1	0.3	mg/L
BPG 09	BPG09	9/13/1978	Total Phosphorus	1	0.41	mg/L
BPG 09	BPG09	10/11/1978	Total Phosphorus	1	0.32	mg/L
BPG 09	BPG09	11/15/1978	Total Phosphorus	1	0.34	mg/L
BPG 09	BPG09	12/6/1978	Total Phosphorus	1	0.31	mg/L
BPG 09	BPG09	1/10/1979	Total Phosphorus	1	0.18	mg/L
BPG 09	BPG09	2/6/1979	Total Phosphorus	1	0.32	mg/L
BPG 09	BPG09	3/7/1979	Total Phosphorus	1	0.78	mg/L
BPG 09	BPG09	4/2/1979	Total Phosphorus	1	0.09	mg/L
BPG 09	BPG09	5/1/1979	Total Phosphorus	1	0.08	mg/L
BPG 09	BPG09	5/31/1979	Total Phosphorus	1	0.08	mg/L
BPG 09	BPG09	5/31/1979	Total Phosphorus	1	0.07	mg/L
BPG 09	BPG09	7/9/1979	Total Phosphorus	1	0.18	mg/L
BPG 09	BPG09	7/9/1979	Total Phosphorus	1	0.18	mg/L
BPG 09	BPG09	8/1/1979	Total Phosphorus	1	0.22	mg/L
BPG 09	BPG09	9/13/1979	Total Phosphorus	1	0.19	mg/L
BPG 09	BPG09	10/4/1979	Total Phosphorus	1	0.18	mg/L
BPG 09	BPG09	10/4/1979	Total Phosphorus	1	0.18	mg/L
BPG 09	BPG09	2/14/1980	Total Phosphorus	1	0.2	mg/L
BPG 09	BPG09	3/31/1980	Total Phosphorus	1	0.65	mg/L
BPG 09	BPG09	5/2/1980	Total Phosphorus	1	0.12	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	5/2/1980	Total Phosphorus	1	0.12	mg/L
BPG 09	BPG09	6/4/1980	Total Phosphorus	1	0.67	mg/L
BPG 09	BPG09	7/7/1980	Total Phosphorus	1	0.16	mg/L
BPG 09	BPG09	8/11/1980	Total Phosphorus	1	0.2	mg/L
BPG 09	BPG09	4/11/1984	Total Phosphorus	1	0.04	mg/L
BPG 09	BPG09	5/2/1984	Total Phosphorus	1	0.03	mg/L
BPG 09	BPG09	6/21/1984	Total Phosphorus	1	0.07	mg/L
BPG 09	BPG09	7/18/1984	Total Phosphorus	1	0.11	mg/L
BPG 09	BPG09	8/22/1984	Total Phosphorus	1	0.13	mg/L
BPG 09	BPG09	9/19/1984	Total Phosphorus	1	0.11	mg/L
BPG 09	BPG09	11/7/1984	Total Phosphorus	1	0.11	mg/L
BPG 09	BPG09	12/13/1984	Total Phosphorus	1	0.06	mg/L
BPG 09	BPG09	1/16/1985	Total Phosphorus	1	0.04	mg/L
BPG 09	BPG09	3/6/1985	Total Phosphorus	1	0.14	mg/L
BPG 09	BPG09	4/15/1985	Total Phosphorus	1	0.05	mg/L
BPG 09	BPG09	5/23/1985	Total Phosphorus	1	0.06	mg/L
BPG 09	BPG09	7/2/1985	Total Phosphorus	1	0.13	mg/L
BPG 09	BPG09	8/19/1985	Total Phosphorus	1	0.15	mg/L
BPG 09	BPG09	9/16/1985	Total Phosphorus	1	0.17	mg/L
BPG 09	BPG09	10/16/1985	Total Phosphorus	1	0.19	mg/L
BPG 09	BPG09	12/10/1985	Total Phosphorus	1	0.06	mg/L
BPG 09	BPG09	1/29/1986	Total Phosphorus	1	0.04	mg/L
BPG 09	BPG09	2/20/1986	Total Phosphorus	1	0.13	mg/L
BPG 09	BPG09	3/25/1986	Total Phosphorus	1	0.02	mg/L
BPG 09	BPG09	4/30/1986	Total Phosphorus	1	0.1	mg/L
BPG 09	BPG09	6/17/1986	Total Phosphorus	1	0.22	mg/L
BPG 09	BPG09	7/15/1986	Total Phosphorus	1	0.13	mg/L
BPG 09	BPG09	9/10/1986	Total Phosphorus	1	0.08	mg/L
BPG 09	BPG09	10/7/1986	Total Phosphorus	1	0.13	mg/L
BPG 09	BPG09	12/2/1986	Total Phosphorus	1	0.19	mg/L
BPG 09	BPG09	1/13/1987	Total Phosphorus	1	0.03	mg/L
BPG 09	BPG09	2/17/1987	Total Phosphorus	1	0.05	mg/L
BPG 09	BPG09	3/24/1987	Total Phosphorus	1	0.02	mg/L
BPG 09	BPG09	4/28/1987	Total Phosphorus	1	0.04	mg/L
BPG 09	BPG09	6/2/1987	Total Phosphorus	1	0.13	mg/L
BPG 09	BPG09	7/20/1987	Total Phosphorus	1	0.11	mg/L
BPG 09	BPG09	9/9/1987	Total Phosphorus	1	0.12	mg/L
BPG 09	BPG09	11/3/1987	Total Phosphorus	1	0.21	mg/L
BPG 09	BPG09	12/10/1987	Total Phosphorus	1	0.13	mg/L
BPG 09	BPG09	1/21/1988	Total Phosphorus	1	0.46	mg/L
BPG 09	BPG09	3/3/1988	Total Phosphorus	1	0.03	mg/L
BPG 09	BPG09	4/5/1988	Total Phosphorus	1	0.08	mg/L
BPG 09	BPG09	5/19/1988	Total Phosphorus	1	0.07	mg/L
BPG 09	BPG09	6/23/1988	Total Phosphorus	1	0.15	mg/L
BPG 09	BPG09	8/11/1988	Total Phosphorus	1	2.2	mg/L
BPG 09	BPG09	9/15/1988	Total Phosphorus	1	0.14	mg/L
BPG 09	BPG09	11/10/1988	Total Phosphorus	1	0.32	mg/L
BPG 09	BPG09	12/14/1988	Total Phosphorus	1	0.06	mg/L
BPG 09	BPG09	1/19/1989	Total Phosphorus	1	0.03	mg/L
BPG 09	BPG09	2/23/1989	Total Phosphorus	1	0.03	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	4/13/1989	Total Phosphorus	1	0.03	mg/L
BPG 09	BPG09	5/10/1989	Total Phosphorus	1	0.1	mg/L
BPG 09	BPG09	6/20/1989	Total Phosphorus	1	0.09	mg/L
BPG 09	BPG09	8/2/1989	Total Phosphorus	1	0.12	mg/L
BPG 09	BPG09	9/14/1989	Total Phosphorus	1	0.15	mg/L
BPG 09	BPG09	11/8/1989	Total Phosphorus	1	0.062	mg/L
BPG 09	BPG09	12/12/1989	Total Phosphorus	1	0.03	mg/L
BPG 09	BPG09	1/24/1990	Total Phosphorus	1	0.03	mg/L
BPG 09	BPG09	2/28/1990	Total Phosphorus	1	0.16	mg/L
BPG 09	BPG09	3/28/1990	Total Phosphorus	1	0.05	mg/L
BPG 09	BPG09	5/9/1990	Total Phosphorus	1	0.06	mg/L
BPG 09	BPG09	7/3/1990	Total Phosphorus	1	0.12	mg/L
BPG 09	BPG09	8/2/1990	Total Phosphorus	1	0.111	mg/L
BPG 09	BPG09	9/26/1990	Total Phosphorus	1	0.1	mg/L
BPG 09	BPG09	10/31/1990	Total Phosphorus	1	0.04	mg/L
BPG 09	BPG09	12/10/1990	Total Phosphorus	1	0.02	mg/L
BPG 09	BPG09	1/16/1991	Total Phosphorus	1	0.4	mg/L
BPG 09	BPG09	3/5/1991	Total Phosphorus	1	0.03	mg/L
BPG 09	BPG09	4/3/1991	Total Phosphorus	1	0.037	mg/L
BPG 09	BPG09	5/22/1991	Total Phosphorus	1	0.14	mg/L
BPG 09	BPG09	6/26/1991	Total Phosphorus	1	0.066	mg/L
BPG 09	BPG09	8/21/1991	Total Phosphorus	1	0.093	mg/L
BPG 09	BPG09	9/30/1991	Total Phosphorus	1	0.05	mg/L
BPG 09	BPG09	11/14/1991	Total Phosphorus	1	0.05	mg/L
BPG 09	BPG09	12/18/1991	Total Phosphorus	1	0.05	mg/L
BPG 09	BPG09	2/4/1992	Total Phosphorus	1	0.03	mg/L
BPG 09	BPG09	3/17/1992	Total Phosphorus	1	0.02	mg/L
BPG 09	BPG09	6/3/1992	Total Phosphorus	1	0.05	mg/L
BPG 09	BPG09	7/13/1992	Total Phosphorus	1	0.21	mg/L
BPG 09	BPG09	8/12/1992	Total Phosphorus	1	0.06	mg/L
BPG 09	BPG09	9/23/1992	Total Phosphorus	1	0.08	mg/L
BPG 09	BPG09	11/18/1992	Total Phosphorus	1	0.08	mg/L
BPG 09	BPG09	12/16/1992	Total Phosphorus	1	0.26	mg/L
BPG 09	BPG09	2/1/1993	Total Phosphorus	1	0.05	mg/L
BPG 09	BPG09	3/9/1993	Total Phosphorus	1	0.17	mg/L
BPG 09	BPG09	4/7/1993	Total Phosphorus	1	0.04	mg/L
BPG 09	BPG09	5/24/1993	Total Phosphorus	1	0.23	mg/L
BPG 09	BPG09	6/28/1993	Total Phosphorus	1	0.09	mg/L
BPG 09	BPG09	8/18/1993	Total Phosphorus	1	0.08	mg/L
BPG 09	BPG09	9/28/1993	Total Phosphorus	1	0.154	mg/L
BPG 09	BPG09	11/15/1993	Total Phosphorus	1	0.22	mg/L
BPG 09	BPG09	12/20/1993	Total Phosphorus	1	0.06	mg/L
BPG 09	BPG09	3/2/1994	Total Phosphorus	1	0.098	mg/L
BPG 09	BPG09	3/29/1994	Total Phosphorus	1	0.04	mg/L
BPG 09	BPG09	4/28/1994	Total Phosphorus	1	0.22	mg/L
BPG 09	BPG09	6/30/1994	Total Phosphorus	1	0.08	mg/L
BPG 09	BPG09	8/15/1994	Total Phosphorus	1	0.1	mg/L
BPG 09	BPG09	9/6/1994	Total Phosphorus	1	0.13	mg/L
BPG 09	BPG09	9/26/1994	Total Phosphorus	1	0.16	mg/L
BPG 09	BPG09	11/2/1994	Total Phosphorus	1	0.42	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	1/4/1995	Total Phosphorus	1	0.08	mg/L
BPG 09	BPG09	2/1/1995	Total Phosphorus	1	0.03	mg/L
BPG 09	BPG09	2/27/1995	Total Phosphorus	1	0.04	mg/L
BPG 09	BPG09	3/29/1995	Total Phosphorus	1	0.022	mg/L
BPG 09	BPG09	5/11/1995	Total Phosphorus	1	0.09	mg/L
BPG 09	BPG09	6/14/1995	Total Phosphorus	1	0.08	mg/L
BPG 09	BPG09	9/7/1995	Total Phosphorus	1	0.11	mg/L
BPG 09	BPG09	10/16/1995	Total Phosphorus	1	0.08	mg/L
BPG 09	BPG09	12/12/1995	Total Phosphorus	1	0.12	mg/L
BPG 09	BPG09	1/29/1996	Total Phosphorus	1	0.082	mg/L
BPG 09	BPG09	2/29/1996	Total Phosphorus	1	0.06	mg/L
BPG 09	BPG09	3/28/1996	Total Phosphorus	1	0.03	mg/L
BPG 09	BPG09	4/19/1996	Total Phosphorus	1	0.06	mg/L
BPG 09	BPG09	5/20/1996	Total Phosphorus	1	0.12	mg/L
BPG 09	BPG09	7/18/1996	Total Phosphorus	1	0.07	mg/L
BPG 09	BPG09	8/26/1996	Total Phosphorus	1	0.1	mg/L
BPG 09	BPG09	10/28/1996	Total Phosphorus	1	0.13	mg/L
BPG 09	BPG09	12/16/1996	Total Phosphorus	1	0.09	mg/L
BPG 09	BPG09	2/4/1997	Total Phosphorus	1	0.5	mg/L
BPG 09	BPG09	3/4/1997	Total Phosphorus	1	0.16	mg/L
BPG 09	BPG09	4/2/1997	Total Phosphorus	1	0.02	mg/L
BPG 09	BPG09	4/30/1997	Total Phosphorus	1	0.02	mg/L
BPG 09	BPG09	7/9/1997	Total Phosphorus	1	0.1	mg/L
BPG 09	BPG09	9/9/1997	Total Phosphorus	1	0.1	mg/L
BPG 09	BPG09	9/26/1997	Total Phosphorus	1	0.1	mg/L
BPG 09	BPG09	10/30/1997	Total Phosphorus	1	0.05	mg/L
BPG 09	BPG09	11/19/1997	Total Phosphorus	1	0.03	mg/L
BPG 09	BPG09	1/6/1998	Total Phosphorus	1	0.1	mg/L
BPG 09	BPG09	3/13/1998	Total Phosphorus	1	0.06	mg/L
BPG 09	BPG09	4/28/1998	Total Phosphorus	1	0.03	mg/L
BPG 09	BPG09	7/1/1998	Total Phosphorus	1	0.19	mg/L
BPG 09	BPG09	8/4/1998	Total Phosphorus	1	0.35	mg/L
BPG 09	BPG09	8/31/1998	Total Phosphorus	1	0.09	mg/L
BPG 09	BPG09	9/28/1998	Total Phosphorus	1	0.16	mg/L
BPG 09	BPG09	11/23/1998	Total Phosphorus	1	0.02	mg/L
BPG 09	BPG09	12/30/1998	Total Phosphorus	1	0.11	mg/L
BPG 09	BPG09	1/24/2000	Total Phosphorus	1	3	mg/L
BPG 09	BPG09	3/3/2000	Total Phosphorus	1	0.07	mg/L
BPG 09	BPG09	5/23/2000	Total Phosphorus	1	0.11	mg/L
BPG 09	BPG09	6/14/2000	Total Phosphorus	1	0.09	mg/L
BPG 09	BPG09	7/26/2000	Total Phosphorus	1	0.06	mg/L
BPG 09	BPG09	9/28/2000	Total Phosphorus	1	0.24	mg/L
BPG 09	BPG09	11/28/2000	Total Phosphorus	1	0.1	mg/L
BPG 09	BPG09	12/28/2000	Total Phosphorus	1	0.15	mg/L
BPG 09	BPG09	1/30/2001	Total Phosphorus	1	1.8	mg/L
BPG 09	BPG09	3/19/2001	Total Phosphorus	1	0.05	mg/L
BPG 09	BPG09	4/18/2001	Total Phosphorus	1	0.04	mg/L
BPG 09	BPG09	5/14/2001	Total Phosphorus	1	0.1	mg/L
BPG 09	BPG09	6/19/2001	Total Phosphorus	1	0.08	mg/L
BPG 09	BPG09	8/2/2001	Total Phosphorus	1	0.14	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	8/21/2001	Total Phosphorus	1	0.27	mg/L
BPG 09	BPG09	10/29/2001	Total Phosphorus	1	0.11	mg/L
BPG 09	BPG09	11/8/2001	Total Phosphorus	1	0.05	mg/L
BPG 09	BPG09	12/20/2001	Total Phosphorus	1	0.11	mg/L
BPG 09	BPG09	1/30/2002	Total Phosphorus	1	0.1	mg/L
BPG 09	BPG09	3/4/2002	Total Phosphorus	1	0.12	mg/L
BPG 09	BPG09	4/11/2002	Total Phosphorus	1	0.05	mg/L
BPG 09	BPG09	4/18/2002	Total Phosphorus	1	0.04	mg/L
BPG 09	BPG09	4/24/2002	Total Phosphorus	1	0.03	mg/L
BPG 09	BPG09	5/14/2002	Total Phosphorus	1	0.26	mg/L
BPG 09	BPG09	6/5/2002	Total Phosphorus	1	0.11	mg/L
BPG 09	BPG09	6/5/2002	Total Phosphorus	1	0.8	mg/L
BPG 09	BPG09	7/1/2002	Total Phosphorus	1	0.06	mg/L
BPG 09	BPG09	7/11/2002	Total Phosphorus	1	0.11	mg/L
BPG 09	BPG09	7/24/2002	Total Phosphorus	1	0.22	mg/L
BPG 09	BPG09	8/19/2002	Total Phosphorus	1	0.4	mg/L
BPG 09	BPG09	8/31/2002	Total Phosphorus	1	0.14	mg/L
BPG 09	BPG09	9/20/2002	Total Phosphorus	1	0.09	mg/L
BPG 09	BPG09	9/27/2002	Total Phosphorus	1	0.09	mg/L
BPG 09	BPG09	11/12/2002	Total Phosphorus	1	0.09	mg/L
BPG 09	BPG09	11/14/2002	Total Phosphorus	1	0.1	mg/L
BPG 09	BPG09	12/12/2002	Total Phosphorus	1	0.04	mg/L
BPG 09	BPG09	12/19/2002	Total Phosphorus	1	0.3	mg/L
BPGD	BPGD-H-A1	9/23/2002	Total Phosphorus		0.08	mg/L
BPGD	BPGD-H-A2	9/23/2002	Total Phosphorus		0.52	mg/L
BPGD	BPGD-H-C1	9/23/2002	Total Phosphorus		1.91	mg/L
BPGD	BPGD-H-C2	9/23/2002	Total Phosphorus		1.68	mg/L
BPGD	BPGD-H-C3	9/23/2002	Total Phosphorus		0.41	mg/L
BPGD	BPGD-H-D2	9/23/2002	Total Phosphorus		0.58	mg/L
BPGD	BPGD-H-D3	9/23/2002	Total Phosphorus		0.04	mg/L
BPGD	BPGD-H-E1	9/23/2002	Total Phosphorus		2.54	mg/L
RBD	RBD-1	7/2/1977	Total Phosphorus	0	0.06	mg/L
RBD	RBD-1	6/28/1979	Total Phosphorus	1	0.05	mg/L
RBD	RBD-1	6/28/1979	Total Phosphorus	14	0.08	mg/L
RBD	RBD-1	9/5/1979	Total Phosphorus	1	0.05	mg/L
RBD	RBD-1	9/5/1979	Total Phosphorus	12	0.05	mg/L
RBD	RBD-1	5/18/1983	Total Phosphorus	1	0.11	mg/L
RBD	RBD-1	5/18/1983	Total Phosphorus	10	0.123	mg/L
RBD	RBD-1	5/10/1991	Total Phosphorus	1	0.02	mg/L
RBD	RBD-1	6/11/1991	Total Phosphorus	1	0.124	mg/L
RBD	RBD-1	7/16/1991	Total Phosphorus	1	0.07	mg/L
RBD	RBD-1	8/27/1991	Total Phosphorus	1	0.095	mg/L
RBD	RBD-1	9/10/1991	Total Phosphorus	1	0.116	mg/L
RBD	RBD-1	10/9/1991	Total Phosphorus	1	0.149	mg/L
RBD	RBD-1	4/21/1997	Total Phosphorus	1	0.04	mg/L
RBD	RBD-1	4/21/1997	Total Phosphorus	18	0.033	mg/L
RBD	RBD-1	6/9/1997	Total Phosphorus	1	0.107	mg/L
RBD	RBD-1	6/9/1997	Total Phosphorus	18	0.106	mg/L
RBD	RBD-1	8/12/1997	Total Phosphorus	1	0.084	mg/L
RBD	RBD-1	8/12/1997	Total Phosphorus	17	0.101	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-1	10/22/1997	Total Phosphorus	1	0.096	mg/L
RBD	RBD-1	10/22/1997	Total Phosphorus	16	0.082	mg/L
RBD	RBD-1	03/28/01	Total Phosphorus		0.081	mg/L
RBD	RBD-1	03/28/01	Total Phosphorus		0.084	mg/L
RBD	RBD-1	04/19/01	Total Phosphorus		0.087	mg/L
RBD	RBD-1	04/19/01	Total Phosphorus		0.112	mg/L
RBD	RBD-1	04/26/01	Total Phosphorus		0.062	mg/L
RBD	RBD-1	04/26/01	Total Phosphorus		0.069	mg/L
RBD	RBD-2	7/2/1977	Total Phosphorus	0	0.11	mg/L
RBD	RBD-2	6/28/1979	Total Phosphorus	1	0.28	mg/L
RBD	RBD-2	9/5/1979	Total Phosphorus	1	0.06	mg/L
RBD	RBD-2	5/18/1983	Total Phosphorus	1	0.114	mg/L
RBD	RBD-2	10/9/1991	Total Phosphorus	1	0.213	mg/L
RBD	RBD-2	4/21/1997	Total Phosphorus	1	0.035	mg/L
RBD	RBD-2	6/9/1997	Total Phosphorus	1	0.244	mg/L
RBD	RBD-2	7/14/1997	Total Phosphorus	1	0.054	mg/L
RBD	RBD-2	8/12/1997	Total Phosphorus	1	0.069	mg/L
RBD	RBD-2	10/22/1997	Total Phosphorus	1	0.073	mg/L
RBD	RBD-2	03/28/01	Total Phosphorus		0.072	mg/L
RBD	RBD-2	04/19/01	Total Phosphorus		0.098	mg/L
RBD	RBD-2	04/26/01	Total Phosphorus		0.066	mg/L
RBD	RBD-3	7/2/1977	Total Phosphorus	0	0.3	mg/L
RBD	RBD-3	6/28/1979	Total Phosphorus	1	0.24	mg/L
RBD	RBD-3	9/5/1979	Total Phosphorus	1	0.16	mg/L
RBD	RBD-3	5/18/1983	Total Phosphorus	1	0.098	mg/L
RBD	RBD-3	5/10/1991	Total Phosphorus	1	0.059	mg/L
RBD	RBD-3	6/11/1991	Total Phosphorus	1	0.11	mg/L
RBD	RBD-3	7/16/1991	Total Phosphorus	1	0.144	mg/L
RBD	RBD-3	4/21/1997	Total Phosphorus	1	0.035	mg/L
RBD	RBD-3	6/9/1997	Total Phosphorus	1	0.304	mg/L
RBD	RBD-3	7/14/1997	Total Phosphorus	1	0.083	mg/L
RBD	RBD-3	8/12/1997	Total Phosphorus	1	0.142	mg/L
RBD	RBD-3	10/22/1997	Total Phosphorus	1	0.102	mg/L
RBD	RBD-4	6/20/1988	Total Phosphorus	1	0.265	mg/L
RBD	RBD-4	8/27/1991	Total Phosphorus	1	0.222	mg/L
RBD	RBD-4	9/10/1991	Total Phosphorus	1	0.255	mg/L
RBD	RBD-4	4/21/1997	Total Phosphorus	1	0.036	mg/L
RBD	RBD-5	03/28/01	Total Phosphorus		0.029	mg/L
RBD	RBD-5	04/19/01	Total Phosphorus		0.071	mg/L
RBD	RBD-5	04/26/01	Total Phosphorus		0.091	mg/L
RBD	RBD-T1	06/06/01	Total Phosphorus		0.039	mg/L
RBD	RBD-T2	04/09/01	Total Phosphorus		0.046	mg/L
RBD	RBD-T2	04/23/01	Total Phosphorus		0.06	mg/L
RBD	RBD-T2	05/07/01	Total Phosphorus		0.08	mg/L
RBD	RBD-T2	05/21/01	Total Phosphorus		0.099	mg/L
RBD	RBD-T2	06/06/01	Total Phosphorus		0.282	mg/L
RBD	RBD-T2	06/08/01	Total Phosphorus		0.131	mg/L
RBD	RBD-T2	06/13/01	Total Phosphorus		0.082	mg/L
RBD	RBD-1	7/16/2003	Total Phosphorus	15	0.176	mg/L
RBD	RBD-1	7/16/2003	Total Phosphorus	9	0.17	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-1	7/16/2003	Total Phosphorus	1	0.169	mg/L
RBD	RBD-1	8/11/2003	Total Phosphorus	14	0.046	mg/L
RBD	RBD-1	8/11/2003	Total Phosphorus	7	0.083	mg/L
RBD	RBD-1	8/11/2003	Total Phosphorus	1	0.058	mg/L
RBD	RBD-1	10/16/2003	Total Phosphorus	15	0.062	mg/L
RBD	RBD-1	10/16/2003	Total Phosphorus	9	0.064	mg/L
RBD	RBD-1	10/16/2003	Total Phosphorus	1	0.069	mg/L
RBD	RBD-2	7/16/2003	Total Phosphorus	1	0.153	mg/L
RBD	RBD-2	8/11/2003	Total Phosphorus	1	0.064	mg/L
RBD	RBD-2	10/16/2003	Total Phosphorus	1	0.083	mg/L
RBD	RBD-5	7/16/2003	Total Phosphorus	1	0.168	mg/L
RBD	RBD-5	8/11/2003	Total Phosphorus	1	0.103	mg/L
RBD	RBD-5	10/16/2003	Total Phosphorus	1	0.07	mg/L
RBD	RBD-1	6/18/2003	Total Phosphorus	1	0.202	mg/L
RBD	RBD-1	6/18/2003	Total Phosphorus	9	0.183	mg/L
RBD	RBD-1	6/18/2003	Total Phosphorus	15	0.192	mg/L
RBD	RBD-2	6/18/2003	Total Phosphorus	1	0.196	mg/L
RBD	RBD-5	6/18/2003	Total Phosphorus	1	0.131	mg/L
BPG 09	BPG09	3/9/2000	Total Suspended Solids	1	16.14	mg/L
BPG 09	BPG09	3/29/2000	Total Suspended Solids	1	11.97	mg/L
BPG 09	BPG09	4/4/2000	Total Suspended Solids	1	6.92	mg/L
BPG 09	BPG09	4/10/2000	Total Suspended Solids	1	31.82	mg/L
BPG 09	BPG09	4/17/2000	Total Suspended Solids	1	20.08	mg/L
BPG 09	BPG09	4/24/2000	Total Suspended Solids	1	12.51	mg/L
BPG 09	BPG09	5/1/2000	Total Suspended Solids	1	10.74	mg/L
BPG 09	BPG09	5/8/2000	Total Suspended Solids	1	12.02	mg/L
BPG 09	BPG09	5/17/2000	Total Suspended Solids	1	30.52	mg/L
BPG 09	BPG09	5/22/2000	Total Suspended Solids	1	29.75	mg/L
BPG 09	BPG09	5/28/2000	Total Suspended Solids	1	158.34	mg/L
BPG 09	BPG09	5/29/2000	Total Suspended Solids	1	114.22	mg/L
BPG 09	BPG09	5/30/2000	Total Suspended Solids	1	80.98	mg/L
BPG 09	BPG09	6/1/2000	Total Suspended Solids	1	66.27	mg/L
BPG 09	BPG09	6/7/2000	Total Suspended Solids	1	21.97	mg/L
BPG 09	BPG09	6/12/2000	Total Suspended Solids	1	31.82	mg/L
BPG 09	BPG09	6/19/2000	Total Suspended Solids	1	67.35	mg/L
BPG 09	BPG09	6/26/2000	Total Suspended Solids	1	92.43	mg/L
BPG 09	BPG09	7/5/2000	Total Suspended Solids	1	301.97	mg/L
BPG 09	BPG09	7/11/2000	Total Suspended Solids	1	144.33	mg/L
BPG 09	BPG09	7/17/2000	Total Suspended Solids	1	117.36	mg/L
BPG 09	BPG09	7/24/2000	Total Suspended Solids	1	101.45	mg/L
BPG 09	BPG09	7/31/2000	Total Suspended Solids	1	32.35	mg/L
BPG 09	BPG09	8/8/2000	Total Suspended Solids	1	31.75	mg/L
BPG 09	BPG09	8/14/2000	Total Suspended Solids	1	74.11	mg/L
BPG 09	BPG09	8/22/2000	Total Suspended Solids	1	10.78	mg/L
BPG 09	BPG09	8/29/2000	Total Suspended Solids	1	11.48	mg/L
BPG 09	BPG09	9/5/2000	Total Suspended Solids	1	14.53	mg/L
BPG 09	BPG09	9/12/2000	Total Suspended Solids	1	18.67	mg/L
BPG 09	BPG09	9/18/2000	Total Suspended Solids	1	11.49	mg/L
BPG 09	BPG09	9/25/2000	Total Suspended Solids	1	17.62	mg/L
BPG 09	BPG09	10/2/2000	Total Suspended Solids	1	9.73	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	10/10/2000	Total Suspended Solids	1	4.05	mg/L
BPG 09	BPG09	10/17/2000	Total Suspended Solids	1	55.85	mg/L
BPG 09	BPG09	10/24/2000	Total Suspended Solids	1	22.06	mg/L
BPG 09	BPG09	10/30/2000	Total Suspended Solids	1	16.36	mg/L
BPG 09	BPG09	11/6/2000	Total Suspended Solids	1	94.83	mg/L
BPG 09	BPG09	11/13/2000	Total Suspended Solids	1	17.52	mg/L
BPG 09	BPG09	11/20/2000	Total Suspended Solids	1	104.54	mg/L
BPG 09	BPG09	11/27/2000	Total Suspended Solids	1	72.61	mg/L
BPG 09	BPG09	12/4/2000	Total Suspended Solids	1	144.57	mg/L
BPG 09	BPG09	12/14/2000	Total Suspended Solids	1	132.36	mg/L
BPG 09	BPG09	12/18/2000	Total Suspended Solids	1	115.55	mg/L
BPG 09	BPG09	1/2/2001	Total Suspended Solids	1	111.26	mg/L
BPG 09	BPG09	2/5/2001	Total Suspended Solids	1	20.6	mg/L
BPG 09	BPG09	2/9/2001	Total Suspended Solids	1	292.23	mg/L
BPG 09	BPG09	2/10/2001	Total Suspended Solids	1	256.19	mg/L
BPG 09	BPG09	2/12/2001	Total Suspended Solids	1	47.72	mg/L
BPG 09	BPG09	2/13/2001	Total Suspended Solids	1	37.07	mg/L
BPG 09	BPG09	2/20/2001	Total Suspended Solids	1	42.72	mg/L
BPG 09	BPG09	2/25/2001	Total Suspended Solids	1	1680.57	mg/L
BPG 09	BPG09	2/26/2001	Total Suspended Solids	1	295.03	mg/L
BPG 09	BPG09	2/27/2001	Total Suspended Solids	1	186.73	mg/L
BPG 09	BPG09	2/28/2001	Total Suspended Solids	1	105.65	mg/L
BPG 09	BPG09	3/1/2001	Total Suspended Solids	1	68.13	mg/L
BPG 09	BPG09	3/5/2001	Total Suspended Solids	1	40.49	mg/L
BPG 09	BPG09	3/12/2001	Total Suspended Solids	1	118.56	mg/L
BPG 09	BPG09	3/19/2001	Total Suspended Solids	1	104.5	mg/L
BPG 09	BPG09	3/26/2001	Total Suspended Solids	1	81.71	mg/L
BPG 09	BPG09	4/2/2001	Total Suspended Solids	1	74.11	mg/L
BPG 09	BPG09	4/16/2001	Total Suspended Solids	1	67.21	mg/L
BPG 09	BPG09	4/23/2001	Total Suspended Solids	1	94.87	mg/L
BPG 09	BPG09	4/30/2001	Total Suspended Solids	1	82.71	mg/L
BPG 09	BPG09	5/7/2001	Total Suspended Solids	1	38.89	mg/L
BPG 09	BPG09	5/14/2001	Total Suspended Solids	1	74.21	mg/L
BPG 09	BPG09	5/21/2001	Total Suspended Solids	1	81.72	mg/L
BPG 09	BPG09	5/30/2001	Total Suspended Solids	1	66.47	mg/L
BPG 09	BPG09	6/6/2001	Total Suspended Solids	1	212.54	mg/L
BPG 09	BPG09	6/8/2001	Total Suspended Solids	1	120.09	mg/L
BPG 09	BPG09	6/13/2001	Total Suspended Solids	1	122.08	mg/L
BPG 09	BPG09	6/18/2001	Total Suspended Solids	1	115.93	mg/L
BPG 09	BPG09	6/25/2001	Total Suspended Solids	1	123.93	mg/L
BPG 09	BPG09	7/2/2001	Total Suspended Solids	1	90.52	mg/L
BPG 09	BPG09	7/9/2001	Total Suspended Solids	1	72.09	mg/L
BPG 09	BPG09	7/16/2001	Total Suspended Solids	1	108.56	mg/L
BPG 09	BPG09	7/23/2001	Total Suspended Solids	1	68.73	mg/L
BPG 09	BPG09	7/30/2001	Total Suspended Solids	1	58.15	mg/L
BPG 09	BPG09	8/6/2001	Total Suspended Solids	1	42.93	mg/L
BPG 09	BPG09	8/14/2001	Total Suspended Solids	1	28.75	mg/L
BPG 09	BPG09	8/20/2001	Total Suspended Solids	1	44.26	mg/L
BPG 09	BPG09	8/27/2001	Total Suspended Solids	1	24.97	mg/L
BPG 09	BPG09	8/31/2001	Total Suspended Solids	1	402.34	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPG 09	BPG09	9/1/2001	Total Suspended Solids	1	111.7	mg/L
BPG 09	BPG09	9/4/2001	Total Suspended Solids	1	31.55	mg/L
BPG 09	BPG09	9/10/2001	Total Suspended Solids	1	121.81	mg/L
BPG 09	BPG09	9/18/2001	Total Suspended Solids	1	82.15	mg/L
BPG 09	BPG09	9/24/2001	Total Suspended Solids	1	68.94	mg/L
BPG 09	BPG09	10/1/2001	Total Suspended Solids	1	101.54	mg/L
BPG 09	BPG09	10/9/2001	Total Suspended Solids	1	86.47	mg/L
BPG 09	BPG09	10/15/2001	Total Suspended Solids	1	45.58	mg/L
BPG 09	BPG09	10/15/2001	Total Suspended Solids	1	48.24	mg/L
BPG 09	BPG09	10/16/2001	Total Suspended Solids	1	68.62	mg/L
BPG 09	BPG09	10/18/2001	Total Suspended Solids	1	49.72	mg/L
BPG 09	BPG09	10/18/2001	Total Suspended Solids	1	52.56	mg/L
BPG 09	BPG09	10/22/2001	Total Suspended Solids	1	37.8	mg/L
BPG 09	BPG09	10/31/2001	Total Suspended Solids	1	97.38	mg/L
BPG 09	BPG09	11/5/2001	Total Suspended Solids	1	106.22	mg/L
BPG 09	BPG09	11/14/2001	Total Suspended Solids	1	112.73	mg/L
BPG 09	BPG09	11/19/2001	Total Suspended Solids	1	101.43	mg/L
BPG 09	BPG09	11/26/2001	Total Suspended Solids	1	96.95	mg/L
BPG 09	BPG09	12/3/2001	Total Suspended Solids	1	57.02	mg/L
BPG 09	BPG09	12/10/2001	Total Suspended Solids	1	94.07	mg/L
BPG 09	BPG09	12/19/2001	Total Suspended Solids	1	43.71	mg/L
BPG 09	BPG09	12/27/2001	Total Suspended Solids	1	112.89	mg/L
BPG 09	BPG09	1/2/2002	Total Suspended Solids	1	107.19	mg/L
BPG 09	BPG09	1/7/2002	Total Suspended Solids	1	92.61	mg/L
BPG 09	BPG09	1/14/2002	Total Suspended Solids	1	90.19	mg/L
BPG 09	BPG09	1/23/2002	Total Suspended Solids	1	86.68	mg/L
BPG 09	BPG09	1/28/2002	Total Suspended Solids	1	73.74	mg/L
BPG 09	BPG09	1/31/2002	Total Suspended Solids	1	790.47	mg/L
BPG 09	BPG09	1/31/2002	Total Suspended Solids	1	484.54	mg/L
BPG 09	BPG09	2/1/2002	Total Suspended Solids	1	201.32	mg/L
BPG 09	BPG09	2/2/2002	Total Suspended Solids	1	96.14	mg/L
BPG 09	BPG09	2/4/2002	Total Suspended Solids	1	45.04	mg/L
BPG 09	BPG09	2/5/2002	Total Suspended Solids	1	23.51	mg/L
BPG 09	BPG09	2/13/2002	Total Suspended Solids	1	86.76	mg/L
BPG 09	BPG09	2/19/2002	Total Suspended Solids	1	88.51	mg/L
BPG 09	BPG09	2/20/2002	Total Suspended Solids	1	329.46	mg/L
BPG 09	BPG09	2/21/2002	Total Suspended Solids	1	165.63	mg/L
BPG 09	BPG09	2/22/2002	Total Suspended Solids	1	93.84	mg/L
BPG 09	BPG09	2/25/2002	Total Suspended Solids	1	40.53	mg/L
BPG 09	BPG09	3/6/2002	Total Suspended Solids	1	75.24	mg/L
BPG 09	BPG09	3/11/2002	Total Suspended Solids	1	85.11	mg/L
BPG 09	BPG09	3/18/2002	Total Suspended Solids	1	59.5	mg/L
BPG 09	BPG09	3/27/2002	Total Suspended Solids	1	6.29	mg/L
BPG 09	BPG09	4/4/2002	Total Suspended Solids	1	19.98	mg/L
BPGD	BPGD-H-A1	9/23/2002	Total Suspended Solids		29	mg/L
BPGD	BPGD-H-A2	9/23/2002	Total Suspended Solids		11	mg/L
BPGD	BPGD-H-C1	9/23/2002	Total Suspended Solids		17	mg/L
BPGD	BPGD-H-C2	9/23/2002	Total Suspended Solids		12	mg/L
BPGD	BPGD-H-C3	9/23/2002	Total Suspended Solids		13	mg/L
BPGD	BPGD-H-D2	9/23/2002	Total Suspended Solids		10	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPGD	BPGD-H-D3	9/23/2002	Total Suspended Solids		19	mg/L
BPGD	BPGD-H-E1	9/23/2002	Total Suspended Solids		5	mg/L
RBD	RBD-1	03/28/01	Total Suspended Solids		16	mg/L
RBD	RBD-1	03/28/01	Total Suspended Solids		18	mg/L
RBD	RBD-1	04/19/01	Total Suspended Solids		26	mg/L
RBD	RBD-1	04/19/01	Total Suspended Solids		28	mg/L
RBD	RBD-1	04/19/01	Total Suspended Solids			mg/L
RBD	RBD-1	04/26/01	Total Suspended Solids			mg/L
RBD	RBD-1	04/26/01	Total Suspended Solids		14	mg/L
RBD	RBD-1	04/26/01	Total Suspended Solids		23	mg/L
RBD	RBD-2	03/28/01	Total Suspended Solids		16	mg/L
RBD	RBD-2	04/19/01	Total Suspended Solids		21	mg/L
RBD	RBD-2	04/19/01	Total Suspended Solids			mg/L
RBD	RBD-2	04/26/01	Total Suspended Solids			mg/L
RBD	RBD-2	04/26/01	Total Suspended Solids		18	mg/L
RBD	RBD-5	03/28/01	Total Suspended Solids		7	mg/L
RBD	RBD-5	04/19/01	Total Suspended Solids		32	mg/L
RBD	RBD-5	04/19/01	Total Suspended Solids			mg/L
RBD	RBD-5	04/26/01	Total Suspended Solids			mg/L
RBD	RBD-5	04/26/01	Total Suspended Solids		42	mg/L
RBD	RBD-T1	06/06/01	Total Suspended Solids		4	mg/L
RBD	RBD-T2	04/09/01	Total Suspended Solids		10	mg/L
RBD	RBD-T2	04/23/01	Total Suspended Solids		17	mg/L
RBD	RBD-T2	05/07/01	Total Suspended Solids		15	mg/L
RBD	RBD-T2	05/21/01	Total Suspended Solids		41	mg/L
RBD	RBD-T2	06/06/01	Total Suspended Solids		199	mg/L
RBD	RBD-T2	06/08/01	Total Suspended Solids		49	mg/L
RBD	RBD-T2	06/13/01	Total Suspended Solids		46	mg/L
BPGD	BPGD-H-A1	9/23/2002	Turbidity		5.6	NTU
BPGD	BPGD-H-A2	9/23/2002	Turbidity		8.5	NTU
BPGD	BPGD-H-C1	9/23/2002	Turbidity		8.0	NTU
BPGD	BPGD-H-C2	9/23/2002	Turbidity		4.9	NTU
BPGD	BPGD-H-C3	9/23/2002	Turbidity		NA	NTU
BPGD	BPGD-H-D2	9/23/2002	Turbidity		4.8	NTU
BPGD	BPGD-H-D3	9/23/2002	Turbidity		16	NTU
BPGD	BPGD-H-E1	9/23/2002	Turbidity		1.0	NTU
BPGD	BPGD-H-A1	9/23/2002	Unionized Ammonia		#VALUE!	mg/L
BPGD	BPGD-H-A2	9/23/2002	Unionized Ammonia		#VALUE!	mg/L
BPGD	BPGD-H-C1	9/23/2002	Unionized Ammonia		#VALUE!	mg/L
BPGD	BPGD-H-C2	9/23/2002	Unionized Ammonia		#VALUE!	mg/L
BPGD	BPGD-H-C3	9/23/2002	Unionized Ammonia		#VALUE!	mg/L
BPGD	BPGD-H-D2	9/23/2002	Unionized Ammonia		#VALUE!	mg/L
BPGD	BPGD-H-D3	9/23/2002	Unionized Ammonia		#VALUE!	mg/L
BPGD	BPGD-H-E1	9/23/2002	Unionized Ammonia		#VALUE!	mg/L
BPGD	BPGD-H-A1	9/23/2002	Water Temp. (field).		13.8	Deg C
BPGD	BPGD-H-A2	9/23/2002	Water Temp. (field).		18.7	Deg C
BPGD	BPGD-H-C1	9/23/2002	Water Temp. (field).		20.1	Deg C
BPGD	BPGD-H-C2	9/23/2002	Water Temp. (field).		21.5	Deg C
BPGD	BPGD-H-C3	9/23/2002	Water Temp. (field).		14.7	Deg C
BPGD	BPGD-H-D2	9/23/2002	Water Temp. (field).		25.7	Deg C

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
BPGD	BPGD-H-D3	9/23/2002	Water Temp. (field).		14.1	Deg C
BPGD	BPGD-H-E1	9/23/2002	Water Temp. (field).		19.6	Deg C
RBD	RBD-1	25-May-00	Dissolved Oxygen	0	10.6	mg/L
RBD	RBD-1	25-May-00	Dissolved Oxygen	1	10.6	mg/L
RBD	RBD-1	25-May-00	Dissolved Oxygen	3	10.3	mg/L
RBD	RBD-1	25-May-00	Dissolved Oxygen	5	9.3	mg/L
RBD	RBD-1	25-May-00	Dissolved Oxygen	7	9.2	mg/L
RBD	RBD-1	25-May-00	Dissolved Oxygen	9	8.8	mg/L
RBD	RBD-1	25-May-00	Dissolved Oxygen	11	9	mg/L
RBD	RBD-1	25-May-00	Dissolved Oxygen	13	5.3	mg/L
RBD	RBD-1	25-May-00	Dissolved Oxygen	15	3.2	mg/L
RBD	RBD-1	25-May-00	Dissolved Oxygen	17	2.1	mg/L
RBD	RBD-1	25-May-00	Dissolved Oxygen	19	0.8	mg/L
RBD	RBD-1	06-Jun-00	Dissolved Oxygen	0	6.1	mg/L
RBD	RBD-1	06-Jun-00	Dissolved Oxygen	1	6.1	mg/L
RBD	RBD-1	06-Jun-00	Dissolved Oxygen	3	6	mg/L
RBD	RBD-1	06-Jun-00	Dissolved Oxygen	5	6	mg/L
RBD	RBD-1	06-Jun-00	Dissolved Oxygen	7	6	mg/L
RBD	RBD-1	06-Jun-00	Dissolved Oxygen	9	6	mg/L
RBD	RBD-1	06-Jun-00	Dissolved Oxygen	11	5.9	mg/L
RBD	RBD-1	06-Jun-00	Dissolved Oxygen	13	5.9	mg/L
RBD	RBD-1	06-Jun-00	Dissolved Oxygen	15	5.9	mg/L
RBD	RBD-1	06-Jun-00	Dissolved Oxygen	17	5.9	mg/L
RBD	RBD-1	11-Jul-00	Dissolved Oxygen	1	9.1	mg/L
RBD	RBD-1	11-Jul-00	Dissolved Oxygen	3	9	mg/L
RBD	RBD-1	11-Jul-00	Dissolved Oxygen	5	9.3	mg/L
RBD	RBD-1	11-Jul-00	Dissolved Oxygen	7	8.1	mg/L
RBD	RBD-1	11-Jul-00	Dissolved Oxygen	9	8	mg/L
RBD	RBD-1	11-Jul-00	Dissolved Oxygen	11	6.9	mg/L
RBD	RBD-1	11-Jul-00	Dissolved Oxygen	13	4.4	mg/L
RBD	RBD-1	11-Jul-00	Dissolved Oxygen	15	3.8	mg/L
RBD	RBD-1	11-Jul-00	Dissolved Oxygen	17	2	mg/L
RBD	RBD-1	11-Jul-00	Dissolved Oxygen	18	1.6	mg/L
RBD	RBD-1	12-Jul-00	Dissolved Oxygen	0	7.2	mg/L
RBD	RBD-1	12-Jul-00	Dissolved Oxygen	1	7.2	mg/L
RBD	RBD-1	12-Jul-00	Dissolved Oxygen	3	7.2	mg/L
RBD	RBD-1	12-Jul-00	Dissolved Oxygen	5	7	mg/L
RBD	RBD-1	12-Jul-00	Dissolved Oxygen	7	6.8	mg/L
RBD	RBD-1	12-Jul-00	Dissolved Oxygen	9	6.8	mg/L
RBD	RBD-1	12-Jul-00	Dissolved Oxygen	11	6.8	mg/L
RBD	RBD-1	12-Jul-00	Dissolved Oxygen	13	6.8	mg/L
RBD	RBD-1	12-Jul-00	Dissolved Oxygen	15	6.8	mg/L
RBD	RBD-1	12-Jul-00	Dissolved Oxygen	16	6.8	mg/L
RBD	RBD-1	26-Jul-00	Dissolved Oxygen	1	14.1	mg/L
RBD	RBD-1	26-Jul-00	Dissolved Oxygen	3	11.4	mg/L
RBD	RBD-1	26-Jul-00	Dissolved Oxygen	5	8.8	mg/L
RBD	RBD-1	26-Jul-00	Dissolved Oxygen	7	7.4	mg/L
RBD	RBD-1	26-Jul-00	Dissolved Oxygen	9	7.6	mg/L
RBD	RBD-1	26-Jul-00	Dissolved Oxygen	11	3.9	mg/L
RBD	RBD-1	26-Jul-00	Dissolved Oxygen	13	3.2	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-1	26-Jul-00	Dissolved Oxygen	15	1.9	mg/L
RBD	RBD-1	26-Jul-00	Dissolved Oxygen	17	2	mg/L
RBD	RBD-1	26-Jul-00	Dissolved Oxygen	18	1.8	mg/L
RBD	RBD-1	02-Aug-00	Dissolved Oxygen	0	4.7	mg/L
RBD	RBD-1	02-Aug-00	Dissolved Oxygen	1	4.6	mg/L
RBD	RBD-1	02-Aug-00	Dissolved Oxygen	3	4.4	mg/L
RBD	RBD-1	02-Aug-00	Dissolved Oxygen	5	4.3	mg/L
RBD	RBD-1	02-Aug-00	Dissolved Oxygen	7	4.2	mg/L
RBD	RBD-1	02-Aug-00	Dissolved Oxygen	9	4.1	mg/L
RBD	RBD-1	02-Aug-00	Dissolved Oxygen	11	4	mg/L
RBD	RBD-1	02-Aug-00	Dissolved Oxygen	13	3.8	mg/L
RBD	RBD-1	02-Aug-00	Dissolved Oxygen	15	3.1	mg/L
RBD	RBD-1	02-Aug-00	Dissolved Oxygen	17	1.6	mg/L
RBD	RBD-1	08-Aug-00	Dissolved Oxygen	1	6.7	mg/L
RBD	RBD-1	08-Aug-00	Dissolved Oxygen	3	6	mg/L
RBD	RBD-1	08-Aug-00	Dissolved Oxygen	5	5	mg/L
RBD	RBD-1	08-Aug-00	Dissolved Oxygen	7	4.8	mg/L
RBD	RBD-1	08-Aug-00	Dissolved Oxygen	11	4.9	mg/L
RBD	RBD-1	08-Aug-00	Dissolved Oxygen	13	4.8	mg/L
RBD	RBD-1	08-Aug-00	Dissolved Oxygen	15	4.8	mg/L
RBD	RBD-1	08-Aug-00	Dissolved Oxygen	17	4.1	mg/L
RBD	RBD-1	08-Aug-00	Dissolved Oxygen	18	3	mg/L
RBD	RBD-1	29-Aug-00	Dissolved Oxygen	1	5.5	mg/L
RBD	RBD-1	29-Aug-00	Dissolved Oxygen	3	5	mg/L
RBD	RBD-1	29-Aug-00	Dissolved Oxygen	5	4.6	mg/L
RBD	RBD-1	29-Aug-00	Dissolved Oxygen	7	4.2	mg/L
RBD	RBD-1	29-Aug-00	Dissolved Oxygen	9	4.1	mg/L
RBD	RBD-1	29-Aug-00	Dissolved Oxygen	11	3.6	mg/L
RBD	RBD-1	29-Aug-00	Dissolved Oxygen	13	3.6	mg/L
RBD	RBD-1	29-Aug-00	Dissolved Oxygen	15	3.5	mg/L
RBD	RBD-1	29-Aug-00	Dissolved Oxygen	17	2.9	mg/L
RBD	RBD-1	29-Aug-00	Dissolved Oxygen	18	2	mg/L
RBD	RBD-2	06-Jun-00	Dissolved Oxygen	0	7.6	mg/L
RBD	RBD-2	06-Jun-00	Dissolved Oxygen	1	7.8	mg/L
RBD	RBD-2	06-Jun-00	Dissolved Oxygen	3	7.4	mg/L
RBD	RBD-2	11-Jul-00	Dissolved Oxygen	1	9.2	mg/L
RBD	RBD-2	11-Jul-00	Dissolved Oxygen	3	9	mg/L
RBD	RBD-2	11-Jul-00	Dissolved Oxygen	5	8.9	mg/L
RBD	RBD-2	11-Jul-00	Dissolved Oxygen	7	8.7	mg/L
RBD	RBD-2	11-Jul-00	Dissolved Oxygen	9	8.7	mg/L
RBD	RBD-2	12-Jul-00	Dissolved Oxygen	0	8.7	mg/L
RBD	RBD-2	12-Jul-00	Dissolved Oxygen	1	8.7	mg/L
RBD	RBD-2	12-Jul-00	Dissolved Oxygen	3	8.6	mg/L
RBD	RBD-2	12-Jul-00	Dissolved Oxygen	5	7.9	mg/L
RBD	RBD-2	12-Jul-00	Dissolved Oxygen	7	8.1	mg/L
RBD	RBD-2	12-Jul-00	Dissolved Oxygen	9	7.5	mg/L
RBD	RBD-2	26-Jul-00	Dissolved Oxygen	1	14.5	mg/L
RBD	RBD-2	26-Jul-00	Dissolved Oxygen	3	14.8	mg/L
RBD	RBD-2	26-Jul-00	Dissolved Oxygen	5	10.4	mg/L
RBD	RBD-2	26-Jul-00	Dissolved Oxygen	7	7.6	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-2	26-Jul-00	Dissolved Oxygen	9	5.4	mg/L
RBD	RBD-2	02-Aug-00	Dissolved Oxygen	0	5.2	mg/L
RBD	RBD-2	02-Aug-00	Dissolved Oxygen	1	5.2	mg/L
RBD	RBD-2	02-Aug-00	Dissolved Oxygen	3	5.2	mg/L
RBD	RBD-2	02-Aug-00	Dissolved Oxygen	5	5	mg/L
RBD	RBD-2	02-Aug-00	Dissolved Oxygen	7	4.8	mg/L
RBD	RBD-2	02-Aug-00	Dissolved Oxygen	8	4.7	mg/L
RBD	RBD-2	08-Aug-00	Dissolved Oxygen	1	8.4	mg/L
RBD	RBD-2	08-Aug-00	Dissolved Oxygen	3	8.4	mg/L
RBD	RBD-2	08-Aug-00	Dissolved Oxygen	5	8.4	mg/L
RBD	RBD-2	08-Aug-00	Dissolved Oxygen	7	8.3	mg/L
RBD	RBD-2	08-Aug-00	Dissolved Oxygen	9	8.2	mg/L
RBD	RBD-2	29-Aug-00	Dissolved Oxygen	1	7.6	mg/L
RBD	RBD-2	29-Aug-00	Dissolved Oxygen	3	7.6	mg/L
RBD	RBD-2	29-Aug-00	Dissolved Oxygen	5	7.4	mg/L
RBD	RBD-2	29-Aug-00	Dissolved Oxygen	7	7	mg/L
RBD	RBD-2	29-Aug-00	Dissolved Oxygen	9	6.8	mg/L
RBD	RBD-5	06-Jun-00	Dissolved Oxygen	0	7.7	mg/L
RBD	RBD-5	06-Jun-00	Dissolved Oxygen	1	7.6	mg/L
RBD	RBD-5	06-Jun-00	Dissolved Oxygen	3	7.6	mg/L
RBD	RBD-5	06-Jun-00	Dissolved Oxygen	4	7.5	mg/L
RBD	RBD-5	11-Jul-00	Dissolved Oxygen	1	8	mg/L
RBD	RBD-5	11-Jul-00	Dissolved Oxygen	2	7.6	mg/L
RBD	RBD-5	11-Jul-00	Dissolved Oxygen	3	7	mg/L
RBD	RBD-5	11-Jul-00	Dissolved Oxygen	4	6.9	mg/L
RBD	RBD-5	11-Jul-00	Dissolved Oxygen	5	6.7	mg/L
RBD	RBD-5	12-Jul-00	Dissolved Oxygen	0	7	mg/L
RBD	RBD-5	12-Jul-00	Dissolved Oxygen	1	6.9	mg/L
RBD	RBD-5	12-Jul-00	Dissolved Oxygen	3	5.9	mg/L
RBD	RBD-5	12-Jul-00	Dissolved Oxygen	4	5.9	mg/L
RBD	RBD-5	26-Jul-00	Dissolved Oxygen	1	14	mg/L
RBD	RBD-5	26-Jul-00	Dissolved Oxygen	2	14.5	mg/L
RBD	RBD-5	26-Jul-00	Dissolved Oxygen	3	13.9	mg/L
RBD	RBD-5	26-Jul-00	Dissolved Oxygen	4	12.5	mg/L
RBD	RBD-5	02-Aug-00	Dissolved Oxygen	0	5.6	mg/L
RBD	RBD-5	02-Aug-00	Dissolved Oxygen	1	5.6	mg/L
RBD	RBD-5	02-Aug-00	Dissolved Oxygen	3	4.5	mg/L
RBD	RBD-5	02-Aug-00	Dissolved Oxygen	4	4.1	mg/L
RBD	RBD-5	08-Aug-00	Dissolved Oxygen	1	6.9	mg/L
RBD	RBD-5	08-Aug-00	Dissolved Oxygen	2	8	mg/L
RBD	RBD-5	08-Aug-00	Dissolved Oxygen	3	7.9	mg/L
RBD	RBD-5	08-Aug-00	Dissolved Oxygen	4	7.7	mg/L
RBD	RBD-5	29-Aug-00	Dissolved Oxygen	1	6.7	mg/L
RBD	RBD-5	29-Aug-00	Dissolved Oxygen	2	6	mg/L
RBD	RBD-5	29-Aug-00	Dissolved Oxygen	3	5.2	mg/L
RBD	RBD-5	29-Aug-00	Dissolved Oxygen	4	3.5	mg/L
RBD	RBD-5	29-Aug-00	Dissolved Oxygen	5	3.3	mg/L
RBD	RBD-1	5/8/2000	Total Phosphorus	1	0.037	mg/L
RBD	RBD-1	5/8/2000	Nitrite + Nitrate	1	2.4	mg/L
RBD	RBD-1	5/25/2000	Total Phosphorus	1	0.039	mg/L

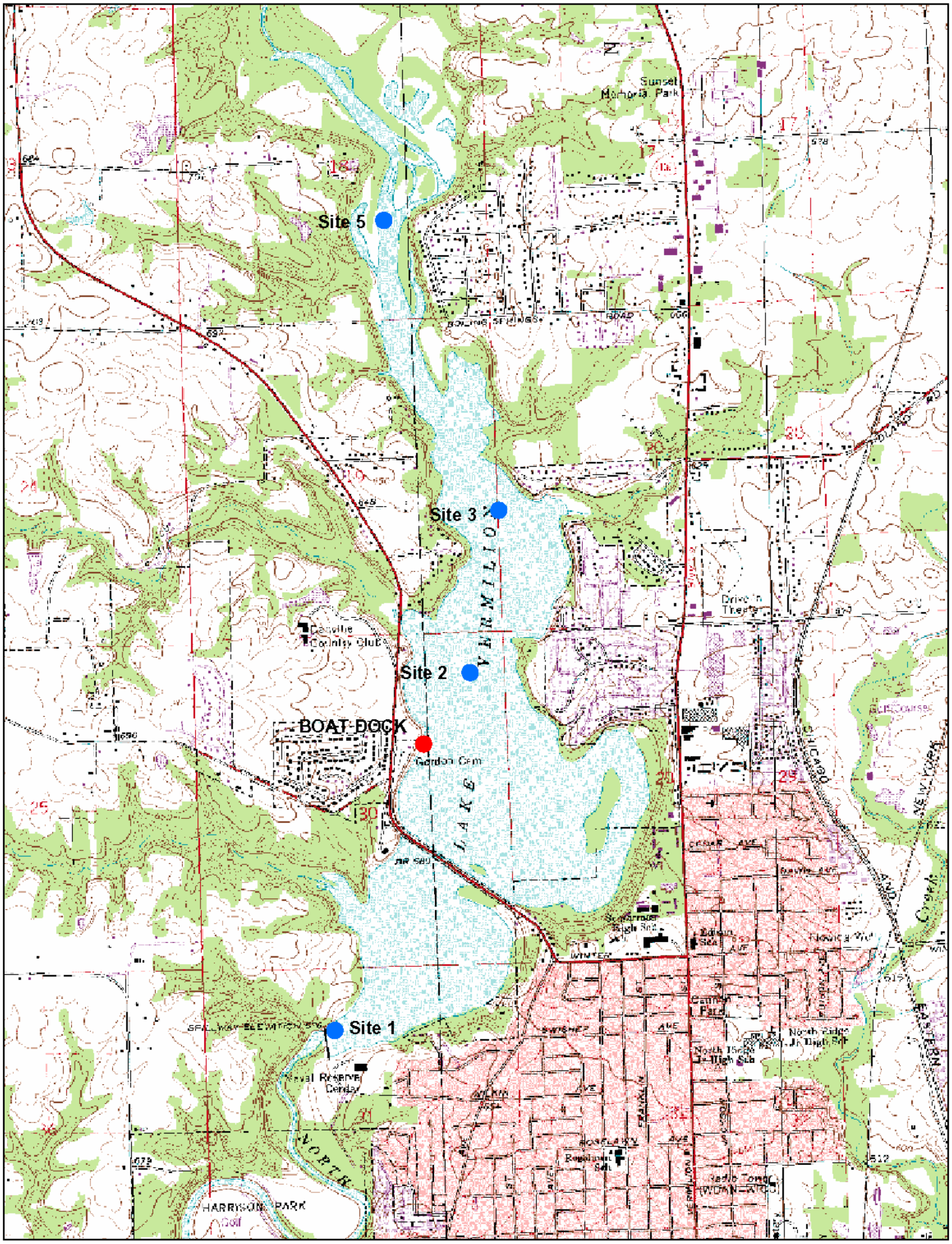
WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-1	5/25/2000	Nitrite + Nitrate	1	2.7	mg/L
RBD	RBD-1	6/6/2000	Total Phosphorus	1	0.134	mg/L
RBD	RBD-1	6/6/2000	Nitrite + Nitrate	1	12	mg/L
RBD	RBD-1	6/22/2000	Nitrite + Nitrate	1	10	mg/L
RBD	RBD-1	7/12/2000	Total Phosphorus	1	0.029	mg/L
RBD	RBD-1	7/12/2000	Nitrite + Nitrate	1	9.3	mg/L
RBD	RBD-1	7/26/2000	Total Phosphorus	1	0.04	mg/L
RBD	RBD-1	7/26/2000	Nitrite + Nitrate	1	7.7	mg/L
RBD	RBD-1	8/2/2000	Total Phosphorus	1	0.024	mg/L
RBD	RBD-1	8/2/2000	Nitrite + Nitrate	1	6.39	mg/L
RBD	RBD-1	9/13/2000	Total Phosphorus	1	0.046	mg/L
RBD	RBD-1	9/13/2000	Nitrite + Nitrate	1	1.3	mg/L
RBD	RBD-1	9/28/2000	Total Phosphorus	1	0.063	mg/L
RBD	RBD-1	9/28/2000	Nitrite + Nitrate	1	1.05	mg/L
RBD	RBD-1	10/3/2000	Total Phosphorus	1	0.042	mg/L
RBD	RBD-1	10/3/2000	Nitrite + Nitrate	1	0.87	mg/L
RBD	RBD-1	10/24/2000	Total Phosphorus	1	0.032	mg/L
RBD	RBD-1	10/24/2000	Nitrite + Nitrate	1	0.25	mg/L
RBD	RBD-1	11/15/2000	Total Phosphorus	1	0.062	mg/L
RBD	RBD-1	11/15/2000	Nitrite + Nitrate	1	0.43	mg/L
RBD	RBD-2	5/8/2000	Total Phosphorus	1	0.041	mg/L
RBD	RBD-2	5/8/2000	Nitrite + Nitrate	1	0.44	mg/L
RBD	RBD-2	5/25/2000	Total Phosphorus	1	0.037	mg/L
RBD	RBD-2	5/25/2000	Nitrite + Nitrate	1	3.3	mg/L
RBD	RBD-2	6/6/2000	Total Phosphorus	1	0.095	mg/L
RBD	RBD-2	6/6/2000	Nitrite + Nitrate	1	14	mg/L
RBD	RBD-2	6/22/2000	Total Phosphorus	1	0.029	mg/L
RBD	RBD-2	6/22/2000	Nitrite + Nitrate	1	9.9	mg/L
RBD	RBD-2	7/12/2000	Total Phosphorus	1	0.035	mg/L
RBD	RBD-2	7/12/2000	Nitrite + Nitrate	1	9.7	mg/L
RBD	RBD-2	7/26/2000	Total Phosphorus	1	0.046	mg/L
RBD	RBD-2	7/26/2000	Nitrite + Nitrate	1	7.2	mg/L
RBD	RBD-2	8/2/2000	Total Phosphorus	1	0.042	mg/L
RBD	RBD-2	8/2/2000	Nitrite + Nitrate	1	5.7	mg/L
RBD	RBD-2	9/13/2000	Total Phosphorus	1	0.053	mg/L
RBD	RBD-2	9/13/2000	Nitrite + Nitrate	1	1.1	mg/L
RBD	RBD-2	9/28/2000	Total Phosphorus	1	0.052	mg/L
RBD	RBD-2	9/28/2000	Nitrite + Nitrate	1	0.86	mg/L
RBD	RBD-2	10/3/2000	Total Phosphorus	1	0.04	mg/L
RBD	RBD-2	10/3/2000	Nitrite + Nitrate	1	0.63	mg/L
RBD	RBD-2	10/24/2000	Total Phosphorus	1	0.03	mg/L
RBD	RBD-2	10/24/2000	Nitrite + Nitrate	1	0.17	mg/L
RBD	RBD-2	11/15/2000	Total Phosphorus	1	0.061	mg/L
RBD	RBD-2	11/15/2000	Nitrite + Nitrate	1	0.21	mg/L
RBD	RBD-5	5/25/2000	Total Phosphorus	1	0.041	mg/L
RBD	RBD-5	5/25/2000	Nitrite + Nitrate	1	9.5	mg/L
RBD	RBD-5	6/6/2000	Total Phosphorus	1	0.097	mg/L
RBD	RBD-5	6/6/2000	Nitrite + Nitrate	1	14	mg/L
RBD	RBD-5	6/22/2000	Total Phosphorus	1	0.163	mg/L
RBD	RBD-5	6/22/2000	Nitrite + Nitrate	1	12	mg/L

WB_ID	StationID	Date	Parameter	Sample Depth (ft)	Value	Units
RBD	RBD-5	7/12/2000	Total Phosphorus	1	0.085	mg/L
RBD	RBD-5	7/12/2000	Nitrite + Nitrate	1	11	mg/L
RBD	RBD-5	7/26/2000	Total Phosphorus	1	0.035	mg/L
RBD	RBD-5	7/26/2000	Nitrite + Nitrate	1	6.6	mg/L
RBD	RBD-5	8/2/2000	Total Phosphorus	1	0.033	mg/L
RBD	RBD-5	8/2/2000	Nitrite + Nitrate	1	4	mg/L
RBD	RBD-5	9/28/2000	Total Phosphorus	1	0.067	mg/L
RBD	RBD-5	9/28/2000	Nitrite + Nitrate	1	0.41	mg/L
RBD	RBD-5	10/3/2000	Total Phosphorus	1	0.055	mg/L
RBD	RBD-5	10/3/2000	Nitrite + Nitrate	1	0.29	mg/L
RBD	RBD-5	10/24/2000	Total Phosphorus	1	0.046	mg/L
RBD	RBD-5	10/24/2000	Nitrite + Nitrate	1	0.04	mg/L
RBD	RBD-5	11/15/2000	Total Phosphorus	1	0.102	mg/L
RBD	RBD-5	11/15/2000	Nitrite + Nitrate	1	8.1	mg/L

APPENDIX B
BATHTUB INPUT AND OUTPUT

Available Upon Request
Contact Illinois EPA at 217-782-3362

APPENDIX C
WATER QUALITY SITE MAP IN LAKE VERMILION



(Source: IEPA; Site 1,2,3, and 5 stand for RBD-1,-2,-3, and -5)

APPENDIX D
RESPONSIVENESS SUMMARY

Responsiveness Summary

This responsiveness summary responds to substantive questions and comments received during the public comment period from August 8, 2006 to August 30, 2006 postmarked, including those from the August 16, 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 North Fork Vermilion River Watershed TMDL report contains a plan detailing the actions necessary to reduce pollutant loads to the impaired water bodies and ensure compliance with applicable water quality standards. The Illinois EPA implements the TMDL program in accordance with Section 303(d) of the federal Clean Water Act and regulations there under.

Background

The watershed targeted for TMDL development is the North Fork Vermilion River watershed, which originates in western Indiana and flows into Vermilion County, Illinois. The watershed encompasses an area of approximately 295 square miles. Land use in the watershed is predominately agriculture. TMDLs developed for impaired water bodies in this watershed include North Fork Vermilion River segments BPG-05 (9.82 miles) and BPG-09 (5.91 miles), and Lake Vermilion (880 acres). In the *Illinois Integrated Water Quality Report and Section 303(d) List-2006*, North Fork Vermilion River segment BPG-05 was listed for nitrates, while BPG-09 was listed for total fecal coliform. Lake Vermilion was listed for nitrates, TSS, and aquatic algae. During TMDL development, we determined the lake is also impaired for total phosphorus. 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 EM, Inc. to prepare a TMDL report for the North Fork Vermilion River watershed.

Public Meetings

Public meetings were held in the City of Danville on December 14, 2005, and in the Village of Rossville on August 16, 2006. The Illinois EPA provided public notice for the August 16, 2006 meeting 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 338 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 16, 2006. It was attended by approximately 15 people and concluded at 7:30 p.m. with the meeting record remaining open until midnight, August 30, 2006.

Questions and Comments

1. What are the point sources of concern in this watershed?

   Response: Discussion of the point sources in the watershed are presented in Section 5.2 of the draft report.

2. Is IEPA looking at the BPG10 segment?

   Response: While segment BPG-10 is listed as impaired, the cause of impairment is total nitrogen, which does not have a numeric water quality standard. Illinois EPA is currently developing TMDLs for pollutants with numeric water quality standards. Therefore, this report does not specifically address this segment. However, TMDLs are developed for downstream segment BPG-05 and Lake Vermilion for nitrates. A watershed-based implementation plan that addresses nitrates could potentially improve the total nitrogen impairment for segment BPG-10.

3. What is the source(s) of fecal coliform between the Village of Alvin and Lake Vermilion?

   Response: The Bismarck Community Unit School discharges below Alvin. Other sources would include nonpoint sources. A discussion of nonpoint sources in the watershed is found in Section 5.1 in the draft report.

4. Is the IEPA going to address where the fecal coliform is coming from?

   Response: Section 5 of the draft report discusses general sources for the pollutants of concern. As stated in the report, there are very little data available from the point sources for the pollutants of concern (total fecal coliform, total phosphorus, and nitrate). The implementation plan will detail additional monitoring that would be necessary to quantify the nonpoint source contributions.

5. Are failing septic systems something that should be addressed in the implementation phase?

   Response: Yes, septic systems will be addressed in the implementation plan.

6. Can the fecal coliform be distinguished between animal and human?

   Response: Laboratory analysis of the DNA of the fecal material can be used to distinguish between human and animal species. DNA analysis of this type is expensive, and Illinois EPA currently does not perform this analysis. This analysis could be utilized in the monitoring component of the implementation plan.

7. What percentage of nitrogen reduction are we shooting for--the entire percentage or would a portion of that percentage be good enough?

   Response: The model indicated that a 33% reduction is necessary to meet the water quality standards for nitrates in the lake, and an 18-43% reduction in North Fork Vermilion segment BPG-05. These reductions are based on historic water quality data and flows. The implementation plan will use an adaptive management approach. This means that as practices are implemented in the watershed, further monitoring should be conducted to gauge the results of those practices, until water quality standards are met for the long term.

8. Are point sources contributing to the nitrate?

   Response: While the point sources may contribute nitrates, they are not believed to be the main contributor. The load duration curve (Figure 6-2) showed that the water quality standard for nitrates was only violated once during low flow conditions. Point sources typically have the largest impact on water quality during low flow. Therefore, the nitrate loads appear to be largely driven by nonpoint sources during wet-weather events.

9. In order to solve the problem, will this be on a voluntary basis or will there be a mandate?

   Response: Illinois EPA only has the authority to regulate NPDES permits held by the point sources. Any Best Management Practice recommended for nonpoint sources in the implementation plan will be strictly voluntary.

10. Why was the total nitrogen data modeled only for 2000 and 2001 data?

    Response: Total Nitrogen (or Nitrate) concentrations were only simulated for years 2000 and 2001 because the measured concentrations at the tributary and at the lake on the same date are available for the two years. The report has been revised accordingly.

North Fork Vermilion River Watershed TMDL Implementation Plan

June 19, 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

The Illinois Environmental Protection Agency (IEPA) has identified the North Fork Vermilion River and Lake Vermilion as impaired waterbodies. The North Fork Vermilion River segment BPG05 is impaired by nitrate, the North Fork Vermilion River segment BPG09 is impaired by fecal coliform, and Lake Vermilion is impaired by nitrate and total phosphorus. As required by the Clean Water Act, a Total Maximum Daily Load (TMDL) was developed to address these impairments. The TMDL report was approved by the U.S. Environmental Protection Agency in December 2006.

The TMDLs for North Fork Vermilion River segments BPG05 and BPG09 were based on the application of load duration curves and reductions of up to 48 percent for nitrate and 70 percent for fecal coliform were found to be necessary. The TMDL for Lake Vermilion was based on the application of the U.S. Army Corps of Engineers BATHTUB model and resulted in necessary load reductions of 77 percent for phosphorus and 34 percent for nitrate.

The major sources of nitrate and phosphorus loads in the North Fork Vermilion River watershed are estimated to be agriculture and onsite wastewater treatment systems. There are approximately 163,000 acres of cropland in the watershed and phosphorus loadings from this source are estimated to range from 43,975 lb/yr to 109,122 lb/yr. Nitrogen loadings are estimated to range from 1,400,673 lb/yr to 4,723,201 lb/yr. The most cost-effective best management practices that have been identified for agricultural land are nutrient management plans, conservation tillage, grassed waterways, and controlled drainage, These BMPs can each be implemented at a cost ranging from $1.00 to $6.50/ac/yr and may be sufficient to meet the water quality standards if they are used widely across the watershed.

There are approximately 3,300 septic tank systems in the watershed. Phosphorus loadings from failing systems are estimated to range from 1,008 to 4,319 lb/yr and nitrogen loadings are estimated to range from 29,673 to 29,835 lb/yr. The most cost-effective BMPs for failing septic systems include maintenance and replacement of failing systems, which can be implemented at a cost ranging from $168 to $459/system/yr.

This plan recommends a phased approach to implementation to achieve the water quality standard. Phase I should focus on continuing to educate landowners of the water quality issues and the available BMPs. Phase II should focus on continuing to increase the voluntary adoption of the BMPs, including assessing which BMPs are found to be most effective, as well as water quality monitoring. Phase III may or may not be required, depending on the results of Phase II monitoring, but should involve additional adoption of the most effective BMPs and the re-assessment of management strategies if goals are not being met.

As agricultural BMPs are implemented and failing septic systems are corrected, water quality in the North Fork Vermilion River and Lake Vermilion should improve accordingly and should ultimately result in achieving the required water quality standards.

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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. Several waterbodies in the North Fork Vermilion River watershed were included on the Illinois' 2006 303(d) list as described in Table 1-1.

Table 1-1. 2006 303(d) List Information for the North Forth Vermilion River Watershed.

Segment	Designated Use (Support Status)	Parameter Targeted in TMDL
North Fork Vermilion River (BPG05)	Aquatic life (fully supporting) Drinking water supply (not supporting)	Nitrogen, Nitrate (NO_3)
North Fork Vermilion River (BPG09)	Aquatic life (fully supporting) Primary contact (not supporting)	Fecal Coliform
Lake Vermilion (RBD)	Aquatic life ((fully supporting) Fish consumption (fully supporting) Drinking water supply (not supporting) Aesthetic Quality (not supporting)	Total Phosphorus (TP) Nitrogen, Nitrate (NO_3)

This project is being initiated in three stages. Stage One was completed in the winter of 2006 and involved the characterization of the watershed, an assessment of the available water quality data, and identification of potential technical approaches (IEPA, 2006a). Stage Two involved the collection of additional water quality data. Stage Three involved model development and calibration, TMDL scenarios, and implementation planning (IEPA, 2006b). The North Fork Vermilion River TMDL Stage Three report was approved by USEPA in December 2006. This implementation plan is the last component of Stage Three.

This report presents an implementation plan that identifies feasible and cost effective management measures capable of reducing pollutant 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), and incorporates adaptive management concepts. The remaining sections of this report discuss the description of the waterbodies and watershed characteristics (Section 2.0), the applicable water quality standards and findings of the TMDL (Section 3.0), the various pollutant sources and implementation activities (Section 4.0), the prioritization for implementation (Section 5.0), the process for measuring and documenting progress (Section 6.0), reasonable assurance (Section 7.0), and the implementation time line (Section 8.0). References are included after Section 8.0.

The Stage One report identified Hoopeston Branch (BPGD) as impaired for dissolved oxygen. However, additional water quality data collected for BPGD in Stage Two indicated that water quality standards were met. Therefore, a dissolved oxygen TMDL was not developed for this segment of the North Fork Vermillion River.

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2.0 DESCRIPTION OF WATERBODY AND WATERSHED CHARACTERISTICS

This chapter describes the general characteristics of the North Fork Vermilion River watershed. A detailed description of the watershed can be found in the Stage One report.

The North Fork Vermilion River watershed is located in central Illinois along the Illinois-Indiana border, as illustrated in Figure 2-1. Most of the watershed is located in Vermilion County, Illinois, with portions extending to Iroquois County in Illinois, and to Warren and Benton Counties in Indiana. The watershed drains approximately 295 square miles, with about 200 square miles in Illinois and 95 square miles in Indiana. The distribution of watershed area by county is shown in Table 2-1.

Table 2-1. Counties in the North Fork Vermilion River Watershed.

County, State	Area of Watershed in County (Square Miles)	Percentage of Watershed in County (Percent)
Vermilion County, Illinois	190	64
Iroquois County, Illinois	10	3
Warren County, Indiana	66	23
Benton County, Indiana	29	10

The North Fork Vermilion River flows about 62 miles from its headwaters in Benton County, Indiana, to Lake Vermilion in Danville, Illinois, then into the Vermilion River. The mean slope of the river is 0.071 percent based on data from the Illinois State Water Survey. Segment BPG05 is located immediately upstream of Lake Vermilion, and extends about 9.82 miles. Segment BPG09 starts at the confluence with Painter Creek and extends downstream 5.91 miles, directly flowing into BPG05.

Lake Vermilion (segment RBD) is located in the southern portion of the watershed, approximately one mile northwest of the City of Danville and approximately 5.2 miles upstream of the confluence of the North Fork Vermilion River and the Vermilion River. Lake Vermilion is a drinking water reservoir with an average discharge of 100 cfs. The lake surface water area is 800 acres and the lake volume is approximately 8,000 acre-feet. The average depth near the center of the lake is 12 feet and near the northern end the average depth is 6 feet. Water is released through the dam’s spillway to a holding basin 2.5 river miles downstream near the water treatment plant, and then pumped into the plant. The plant’s design capacity is 14 million gallons per day (MGD).

Figure 2-2 presents land use and land cover in the North Fork Vermilion River watershed. The land use upstream of Lake Vermilion includes approximately 86 percent cropland, 7 percent pasture, 3 percent forest, 2 percent urban, and 2 percent other land uses (e.g., wetland, grassland, water, upland shrub, barren or mining, and transitional). No land use or water quality data exist for the portion of the watershed that lies in Indiana. However, BMPs suggested for the rest of the watershed could also be adopted by landowners in Indiana as well.

The average annual precipitation at Danville, Illinois is about 40.8 inches with monthly average precipitation of about 3.4 inches. The months from March through August are wet months, with average precipitation between 3.2 and 4.7 inches per month. The months from September to February are relatively dry, with average precipitation of 2.5 inches for the normally driest months of October and February. On average, there are 122 days of precipitation in a year.

Six facilities in the watershed received total phosphorus wasteload allocations (some of which are zero) as a result of the TMDL. These facilities and the wasteload allocations are shown in Table 2-2.

Table 2-2. Wasteload allocations for the North Fork Vermilion River watershed TMDLs.

Facility	NPDES Permit ID	Fecal Coliform WLA (10^9 cfu/day)	Total Phosphorus WLA (lb/day)
Hoopeston Foods, Inc.	IL0022250	0	0
Hoopeston STP	IL0024830	12.52	48.25
Rossville STP	ILG580064	1.37	5.26
Alvin WTP	ILG640002	0	0
Bismarck Community Unit School	IL0067156	0.05	0.12
Bismarck Community Water District	ILG640101	0	0
Total		14	53.63

Note: This table has been updated to be consistent with North Fork Vermilion River errata sheet.

Additional details on the characteristics of the watershed (e.g., soil types, topography) can be found in the Stage One report.

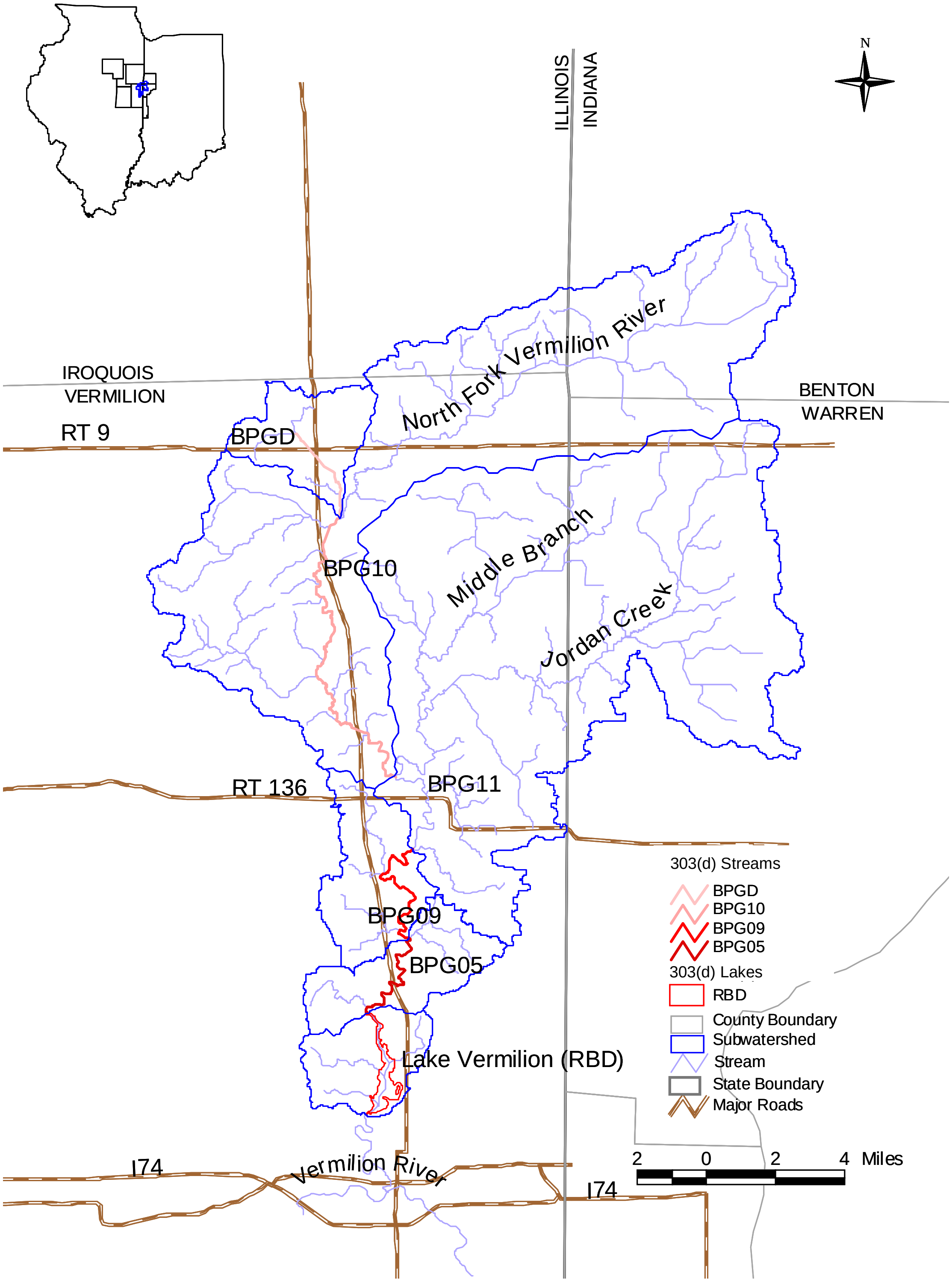


Figure 2-1. North Fork Vermilion River Watershed

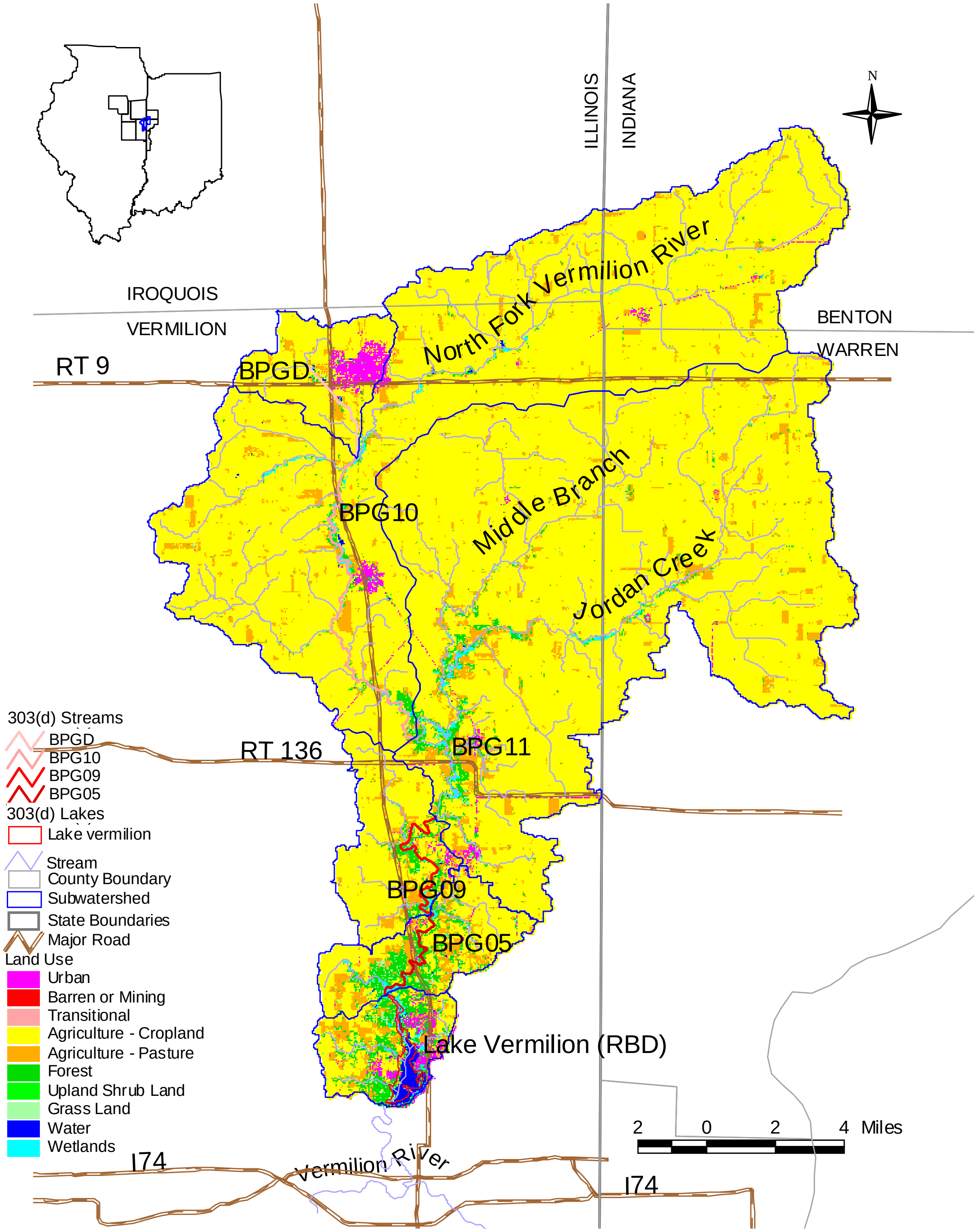


Figure 2-2. Land Use and Land Cover Map

3.0 WATER QUALITY STANDARDS AND TMDL SUMMARY

This section presents the applicable water quality standards, a summary of the historic water quality data for the North Fork Vermilion River and Lake Vermilion, and a summary of the TMDL. A more detailed discussion of the available water quality data and the TMDL allocations is included in the Stage Three Report.

3.1 Applicable Water Quality Standards

Table 3-1 summarizes the water quality standards that were used in the TMDL development for the North Fork Vermilion River and Lake Vermilion.

Table 3-1. Water quality standards that apply to the North Fork Vermilion River TMDLs.

Parameter	Impaired Water Bodies	
	North Fork Vermilion River	Lake Vermilion
Total Phosphorus (mg/L)	Not Applicable	<0.05
Fecal Coliform (cfu/100 mL)	<200 as a geomean < 400 for any individual sample	Not Applicable
Nitrate (mg/L)	<10	<10

A total of 218 fecal coliform samples were available for TMDL development on segment BPG09 of the North Fork Vermilion River and more than half (57 percent) of these samples exceeded 200 cfu/100 mL.

Approximately 42 percent of the available nitrate samples (129 samples) exceeded the water quality standard of 10 mg/L.

A total of 67 total phosphorus and nitrate samples were available in Lake Vermilion for TMDL development with 82 percent of the phosphorus and 16 percent of the nitrate samples exceeding the applicable water quality standards.

3.2 TMDL Summary

The TMDL results for the two stream segments of the North Fork Vermilion River are summarized in Table 3-2 and Table 3-3 and the Lake Vermilion TMDL is summarized in Table 3-4. Nitrate reductions are approximately 48 percent for the river and 34 percent for the lake; fecal coliform reductions range from 8 to 70 percent (depending on the flow zone); and phosphorus reductions for the lake are 77 percent.

Table 3-2. North Fork Vermilion River (BPG05) TMDL for Nitrate.

Category	Flow Zone		
	High	Medium	Low
Allowable Load (lb/day)	35,514	7,470	1,067
Load Allocation (lb/day)	31,963	6,723	960
Waste Load Allocation (lb/day)	0	0	0
Margin of Safety (lb/day)	3,551	747	107
% Reduction Needed	18%	43%	0%

Table 3-3. North Fork Vermilion River (BPG09) TMDL for Fecal Coliform.

Category	Flow Zone		
	High	Medium	Low
Allowable Load (10^9 cfu/day)	3,150	645	93
Load Allocation (10^9 cfu/day)	3,136	631	79
Wasteload Allocation (10^9 cfu/day)	14	14	14
Margin of Safety (10^9 cfu/day)	0	0	0
% Reduction Needed	70%	47%	8%

Table 3-4. Lake Vermilion (RBD) TMDL for TP and TN.

Category	Total Phosphorus (TP)	Total Nitrogen (TN)
Existing Load (lb/day)	581.9	14,627.4
Loading Capacity (lb/day)	133.8	9,719.7
Wasteload Allocation (lb/day) *	53.6	-
Margin of Safety (lb/day)	13.4	972.0
Load Allocation (lb/day) *	66.8	8,747.7
% Reduction Needed	77%	34%

* Wasteload and Load Allocations updated to be consistent with North Fork Vermilion River errata sheet.

4.0 POLLUTION SOURCES AND IMPLEMENTATION ACTIVITIES

This section describes the potential pollution sources, typical pollutant loading rates from each source category, and the appropriate best management practices (BMPs) to achieve the necessary load reductions.

Table 4-1 lists the BMPs presented in this section of the report and identifies which TMDL pollutants they are most effective at controlling.

Table 4-1. Summary of proposed BMPs and associated impairment.

Source	BMP	Nitrogen	Phosphorus	Fecal Coliform
Agricultural Land Uses	Nutrient Management Plan	✓	✓	
	Conservation Tillage	✓	✓	
	Cover Crops	✓	✓	
	Filter Strips	✓	✓	
	Grassed Waterways	✓	✓	
	Restoration of Riparian Buffers	✓	✓	✓
	Controlled Drainage	✓	✓	
	Animal Operations	✓	✓	✓
Onsite Wastewater Treatment Systems	Pumping		✓	✓
	Inspection		✓	✓
	Replacement		✓	✓
	Public outreach		✓	✓
Stream Channel Erosion	Filter Strips	✓	✓	
	Grassed Waterways	✓	✓	
	Restoration of Riparian Buffers	✓	✓	✓

4.1 Agricultural Land Uses

The North Fork Vermilion River watershed is predominantly agricultural with 86 percent of the watershed land being cropland and 7 percent being pasture. Row crop agriculture is a common nonpoint source of nutrient loads and sediments with rain and snow melt events delivering the majority of pollutant loads to streams and lakes. Agriculture is believed to be the primary source of phosphorus and nitrate loads to the North Fork Vermilion River and Lake Vermilion. Approximately 70 percent of the crops are devoted to corn and soybean rotations. There are reportedly no large livestock operations in the watershed (Lin et. al., 2005).

This section of the implementation plan describes the mechanisms of nutrient loading from farmland and the best management practices that have been employed in similar watersheds to reduce loadings. This report contains only cost-effective practices with proven nutrient removal rates.

4.1.1 Source Description and Approximate Loading

Accumulation of nutrients on farmland occurs from decomposition of residual crop material, fertilization with chemical and manure fertilizers, atmospheric deposition, wildlife excreta, and application of waste products from municipal and industrial wastewater treatment facilities. Nutrient losses and transport occur through soil erosion, infiltration to groundwater, infiltration to subsurface flow systems, and surface runoff. Agricultural practices such as application of fertilizers and tile drainage systems are the primary potential source of nutrient loads.

In Illinois, the majority of the soybean and corn crops rely on commercial fertilizer rather than animal manure to enhance soil fertility. In heavily fertilized areas, nutrient loads may have increased significantly over background levels, leading to increased nutrient loses.

Tile drainage systems are used extensively in Illinois to lower the water table below the root zone to maximize crop yields on fields that otherwise would not be suitable for crop production. Approximately 80 to 90 percent of agricultural cropland in Vermilion County has tile drainage systems (Franke, 2006) (comparable information for the other counties was not available but is expected to be similar). Infiltration is enhanced 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 tile water tend to be higher relative to typical surface runoff. The concentrations in tile systems increase significantly following large rain events (Gentry et al., 2007).

The amount of nutrient loss to surface and groundwater is directly related to excessive nutrient levels in the soil. Soil phosphorus tests are used to measure the phosphorus available for crop growth. 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 North Fork Vermilion River drainage area, typically range from 40 to 50 lb/ac (80 to 100 ppm) (Franke, 2006). Soil tests for nitrogen are not as widely used as they are for phosphorus, although the University of Illinois has created a system to determine nitrogen rates based on yield potential (IAH, 2002).

Soil erosion is another source of nonpoint pollution from agricultural land uses in the watershed with approximately 20 percent of the watershed (mostly cropland) having been identified as inadequately protected from erosion (Lin et. al., 2005).

Fecal coliform loading from agricultural fields comes from land applied manure and grazing animals. There are reportedly no large confined livestock operations in the watershed that would be used to apply manure on croplands. However, there are few grazing beef operations (Franke, 2006).

Phosphorus loadings rates from surface runoff and tile drain systems in agricultural cropland have been measured at three heavily tiled watersheds in east-central Illinois with extensive row crop production.

The average annual total phosphorus loading to streams from agricultural runoff was estimated to be 0.41 to 0.67 lb/ac/yr. Loads from one tile system were also measured directly over a 2-year period. The tile system transported 0.27 to 0.62 lb/ac/yr of total phosphorus (Gentry et al., 2007). In addition, the Champaign County SWCD reported phosphorus loading rates of 0.5 lb/ac/yr for cropland and 0.25 lb/ac/yr for pasture and hayland (Lin et. al., 2005).

Nitrate loading rates from surface runoff were measured at four stations in Vermilion River and Little Vermilion River watersheds during a 2 year period. The average annual nitrate loading to the streams ranged from 19 lb/ac/yr to 29 lb/ac/yr (Keefer, 2003). The Champaign County SWCD reported nitrogen loading rates of 8.6 lb/ac/yr for cropland and 3.2 lb/ac/yr for pasture and hayland (Lin et. al., 2005).

Loading rates for fecal coliform in Illinois are not available.

4.1.2 Appropriate BMPs

Several structural and non-structural best management practices (BMPs) have been developed and studied for use in agricultural areas. Below are the descriptions of these BMPs including their removal mechanisms, effectiveness, and cost.

4.1.2.1 Nutrient Management Plans

The development of nutrient management plans optimizes the efficient use of all sources of nutrients, including soil reserves, fertilizers, crop residue, and organic sources and minimizes the potential of water quality degradation by excess nutrient loads. The plan should address amount, source, placement, methods, and timing of nutrient applications. Plans for nutrient management should be developed and comply with applicable federal, state and local NRCS regulations (NRCS, 2002). A significant number of acres within the North Fork Vermilion River watershed (45,000 acres) are already reported to be operating under nutrient management plans.

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, the starting soil test phosphorus concentration for the field, and the crop type and expected yield. The North Fork Vermilion River watershed is located in the low zone for inherent phosphorus availability. In the low zone, maximum crop yields are obtained when the available phosphorus levels are maintained at 50 lb/ac. If the soil test phosphorus concentration is less than 50 lb/ac, the IAH suggests building up the phosphorus levels over a four year period to achieve a soil test phosphorus concentration of 50 lb/ac. If the soil test phosphorus concentrations are between 50 lb/ac and 70 lb/ac, maintenance-only application rates are recommended. At starting concentrations greater than 70 lb/ac, the IAH recommends that no phosphorus be applied until subsequent crop uptake reduces the starting value to 50 lb/ac (IAH, 2002). Table 4-2 and Table 4-3 summarize the buildup, maintenance, and total application rates of fertilizer 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.

Table 4-2. Suggested Fertilizer Application Rates for Corn Production in the Low Inherent Phosphorus Availability Zone (IAH, 2002).

Starting Soil Test P ppm (lb/ac)	Buildup P_2O_5 (lb/ac)[1]	Maintenance P_2O_5 (lb/ac)[2]	Total P_2O_5 (lb/ac)
10 (20)	68	71	139
15 (30)	45	71	116
20 (40)	22	71	93
22.5 (45)	11	71	82
25 (50)	0	71	71
30 (60)	0	71	71
32.2 (65) or higher	0	71	71

[1] Rates based on buildup for four years to achieve target soil test phosphorus of 50 lb/ac.

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

Table 4-3. Suggested Fertilizer Application Rates for Soybean Production in the Low Inherent Phosphorus Availability Zone (IAH, 2002).

Starting Soil Test P ppm (lb/ac)	Buildup P_2O_5 (lb/ac)[1]	Maintenance P_2O_5 (lb/ac)[2]	Total P_2O_5 (lb/ac)
10 (20)	68	51	119
15 (30)	45	51	96
20 (40)	22	51	73
22.5 (45)	11	51	62
25 (50)	0	51	51
30 (60)	0	51	51
32.2 (65) or higher	0	51	51

[1] Rates based on buildup for four years to achieve target soil test phosphorus of 50 lb/ac.

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

Most nitrogen soil test procedures used in Illinois have not been calibrated to provide a reliable estimate of nitrogen rates needed for optimum corn production; the use of these tests is not encouraged. Based on research trials conducted at the University of Illinois, IAH recommends fertilizer nitrogen rates to be determined according to the yield potential by applying 1.2 lbs/bu per target yield (IAH, 2002). In addition, the Iowa State University hosts a Web site that includes a corn nitrogen rate calculator to find the optimum nitrogen rate application based on the economic return. Using this calculator, the user selects the state, corn rotation, type of fertilizer and price, and corn grain price. The calculator will estimate the suggested rate for maximizing the return to N application, the percent of maximum yield that might be produced at the suggested rate, and the amount and cost of nitrogen at that rate. The Web site is located at:

http://extension.agron.iastate.edu/soilfertility/nrate.aspx

NRCS guidelines specify that nutrients should not be applied to frozen, snow-covered or saturated soils if there is a potential risk of runoff (NRCS, 2002). 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).

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.

The effectiveness of nutrient management plans (application rates, methods, and timing) in reducing nutrient loading from agricultural land is site specific. Average reductions of nutrient loads are reported at 35 percent for total phosphorus and 15 percent for total nitrogen using nutrient management plans (USEPA, 2003). Incorporation of fertilizer to a minimum depth of two inches prior to planting has shown a decrease in total phosphorus runoff concentrations of 20 percent. Reductions for subsurface application, such as deep placement, are reported to be 20 to 50 percent for total phosphorus (HRWCI, 2005). Figure 4-1 shows a deep placement attachment unit.

(Photo Courtesy of CCSWCD)

Figure 4-1. Deep Placement Phosphorus Attachment Unit for Strip-till Toolbar.

4.1.2.2 Conservation Tillage Practices

Conservation tillage practices are used to control erosion and surface transport of pollutants from crop fields. Conservation tillage is 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 increase the organic and nutrient content in the soil and reduce the amount of carbon in the atmosphere by storing it in the soil.

Tillage practices including no-till systems, strip till, ridge till, and mulch till are commonly used to maintain the suggested 30 percent cover. Table 4-4 shows the most recent county-wide Illinois Soil Transect Survey (IDOA, 2006) for Vermilion County and indicates that conservation tillage is commonly used for soybeans but rarely used for corn and small grains. Figure 4-2 shows a comparison of ground cover under conventional and conservation tillage practices.

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

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, 2006.

Figure 4-2. Comparison of conventional (left) and conservation (right) tillage practices.

Czapar et al. summarize tillage practices in the Midwest and their impacts on erosion control and nutrient delivery. Compared to conventional tillage, strip till practices reduced phosphorus loads by 68 percent and nitrogen loads by 64 percent. No till practices reduced phosphorus loads by 76 percent and nitrogen loads by 73 percent (Czapar et al., 2006). Conservation tillage practices have been reported to reduce total phosphorus loads by 45 percent and total nitrogen loads by 55 percent compared to sites where soil erosion is not controlled (USEPA, 2003).

4.1.2.3 Cover Crop

Cover crops are grasses and legumes established for seasonal cover and conservation purposes to reduce soil erosion, improve soil organic matter, and manage excess nutrients (NRCS, 2002). 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. The National Sustainable Agriculture Information Service recommends planting ryegrass after corn harvest and hairy vetch after soybeans (Sullivan, 2003).

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. 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). The use of cover crop in Oklahoma resulted in a phosphorus loss reduction of 70 to 85 percent (HRWCI, 2005). The use of cover crops is illustrated in Figure 4-3.

(Photo Courtesy of CCSWCD)

Figure 4-3. Use of Cover Crops.

4.1.2.4 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 or nitrogen loading, but rather as supplemental management measures following operational strategies. USEPA (2003) lists the percent effectiveness of vegetative controls on phosphorus removal of up to 75 percent.

Vegetated Filter Strips

Filter strips are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils. 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 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 is 30 ft (NRCS 2002). 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. Loading reductions of 75 percent in total phosphorus and 70 percent in total nitrogen have been reported (USEPA, 2003). Field research on filter strips in Virginia and Maryland showed removal efficiencies for total phosphorus ranged from 0 to 83 percent and for total nitrogen ranged from 27 to 87 percent (OSUE, 1994). A grass filter strip is shown in Figure 4-4.

(Photo Courtesy of CCSWCD)

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

The effectiveness of buffer strips depends on many variables including overland flow velocity and depth, vegetation, and width. The choice of vegetation should be based on climate conditions, intended functions of the buffer, desired by-products, and soil characteristics. Filter strips are most effective on sites with mild slopes of less than 6 percent. The NRCS recommends filter widths based on slope and soil texture, as shown in Table 4-5 (NRCS 2004).

Table 4-5. Filter Strip Widths Based on Land Slopes.

Percent Slope	Width (Feet)	
	Soil Texture A	Soil Texture B
1-3%	25	25
4-7%	35	40
8-10%	50	55

* USDA soil texture A includes sandy loams, loamy very fine sand, and fine sand. Soil texture B includes clay loam, sandy clay, silty clay, silty clay loam, sandy clay, silt, loam, silt loam, very fine sandy loam.

Grassed Waterways

Grassed waterways are natural or constructed channels lined with vegetation. The channel is designed to convey surface water at a non-erosive velocity and to improve water quality by providing infiltration of pollutants. Soil erodibility, slope, runoff velocity, channel depth, vegetation selection, and habitat should be considered during design. Routine maintenance includes regular inspection and repair of damaged vegetation, erosion control, periodic mowing, and weed control. The bottom width of grassed waterways shall not exceed 100 feet (NRCS, 2000).

Load reductions in grassed waterways are reported at 29 percent for total phosphorus (Winer, 2000) and 38 percent for nitrogen (USEPA, 2000). A grassed waterway providing surface drainage for a corn field is shown in Figure 4-5

(Photo Courtesy of CCSWCD)

Figure 4-5. Grassed Waterway.

Creation of Riparian Buffers

Riparian buffers are corridors of trees, shrubs and/or grasses located adjacent to and up-gradient from streams and water bodies. Preserving natural vegetation along stream corridors can effectively reduce water quality and habitat degradation associated with development and agricultural practices. The root structure of the vegetation in a buffer enhances infiltration of runoff and subsequent trapping of nonpoint source pollutants. It also serves as reinforcements in streambank soils, which helps to hold streambank material in place and minimize erosion. The riparian buffers are most effective when the runoff enters the buffer as sheet flow allowing for retention and uptake of pollutants.

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. However, higher removal rates are provided with greater buffer widths (NCSU, 2002). The NRCS recommends riparian buffers consisting of two zones with a minimum width of 66 feet to effectively remove nutrients and sediments from runoff. The first zone consist of tree/shrubs at least 40 feet wide followed by a seeded or grass zone at least 20 feet wide (NRCS, 1999). Riparian corridors typically treat a maximum of 300 ft of adjacent land before runoff forms small channels that short circuit treatment.

Buffers with forest and grass zones of 60 to 90 feet wide were studied. Load reductions for phosphorus were estimated at 70 to 80 percent and load reductions for nitrogen were estimated at 74 to 80 percent (NCSU, 2002). Nitrogen reductions of 85 percent and phosphorus reduction of 30 to 40 percent were reported for buffers with forested vegetation (Lowrance et. al., 1984). Riparian buffers also reduce bacteria from fecal coliform. Bacteria removal efficiencies of 43 to 57 percent were reported in Virginia (Commonwealth of Virginia, 2003). A riparian buffer protecting the stream corridor from adjacent agricultural areas is shown in Figure 4-6.

(Photo Courtesy of CCSWCD)

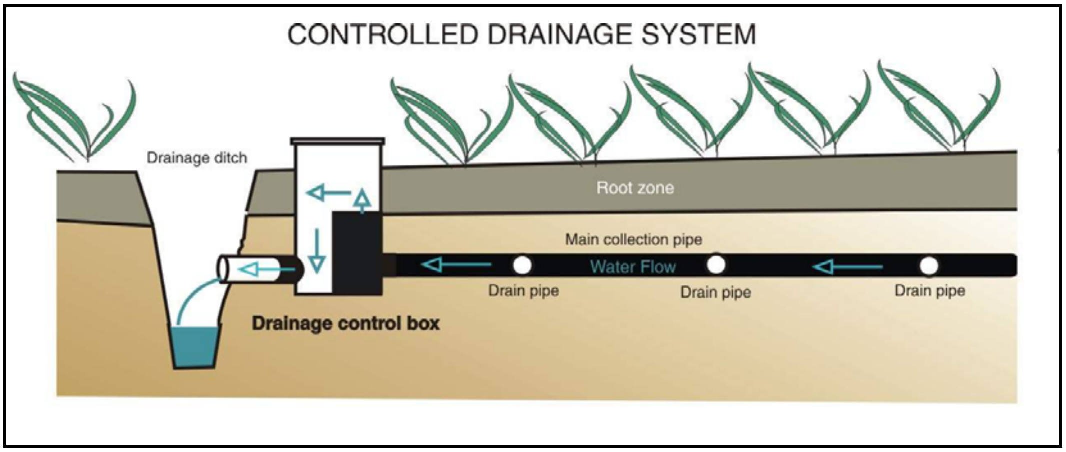
Figure 4-6. Riparian Buffer between Stream Channel and Agricultural Areas.

4.1.2.5 Drainage Control Structures for Tile Drain Outlets

Drainage control structures are placed at the outlet of a tile system to control the water table in the soil. Control structures collect water that has infiltrated from agricultural fields into the root zone. This practice can be used to raise the water level after harvest, thereby reducing nitrate loading from tile effluent, or to retain water in the soil during the growing season. The retained 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.

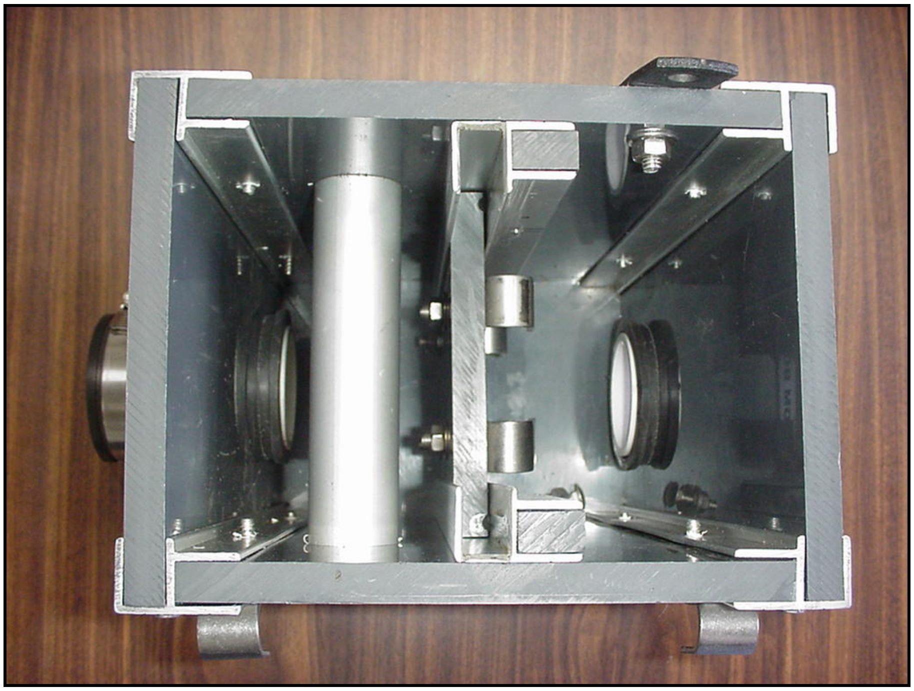
Controlled drainage reduces the volume of drainage water leaving a field by 20 to 30 percent on average. However, outflow varies widely depending on soil type, rainfall, type of drainage system, and management intensity. Controlled drainage also provides a higher field water table level, which promotes denitrification within the soil profile. In some cases, nitrate-nitrogen concentrations have been 10 to 20 percent lower in outflow from controlled systems compared to uncontrolled-free draining systems. Load reductions have been reported as 45 percent for nitrogen and 35 percent for phosphorus (NCSU, 2002).

During tests of controlled drainage structures in Illinois, the water table control height was set to within 6 inches of the soil surface on November 1 and lowered to the level of the tile on March 15 to hold back the water during the fallow period. Reductions of up to 47 percent for nitrate and 83 percent for phosphorus were reported (Cooke, 2005). Drainage water management is illustrated in Figure 4-7 and Figure 4-8.



(Illustration Courtesy of the Agricultural Research Service Information Division)

Figure 4-7. Drainage Water Management for a Tile Drain System.



(Photo Courtesy of CCSWCD)

Figure 4-8. Interior View of a Control Structure with Adjustable Baffle Height.

Table 4-6 summarizes the best management practices with the estimated nutrient reductions for agricultural land uses.

Table 4-6. Nutrient Removal BMPs for Agricultural Land Uses.

BMP	Nitrogen Reduction	Phosphorus Reduction
Nutrient Management Plan	15% (USEPA, 2003)	20% - 50% (HRWCI, 2005) 35% (USEPA, 2003)
Conservation Tillage	64%- 73% (Czapar et al., 2006) 55% (USEPA, 2003)	68%- 76% (Czapar et al., 2006) 45% (USEPA, 2003)
Cover Crop		70% - 85% (HRWCI, 2005).
Filter Strips	70% (USEPA, 2003) 27% - 87% (OSUE, 1994)	75% (USEPA, 2003) 0% - 83% (OSUE, 1994)
Grassed Waterway	38% NO_3 (USEPA, 2000)	29% (Winer, 2000).
Riparian Buffers	74% - 80% (NCSU, 2002) 85% (Lowrance et. al., 1984)	70% - 80% (NCSU, 2002) 30%-40% (Lowrance et. al., 1984)
Controlled Drainage (outlet structure on tile system)	45% (NCSU, 2002) 47% NO_3 (Cooke, 2005)	35% (NCSU, 2002) 83% PO_4 (Cooke, 2005)

4.1.3 Estimated Cost of Implementation

The cost of implementation of agricultural BMPs includes the cost of construction (for structural BMPs), maintenance costs (seeding, grading, etc.), and operating costs (electricity, fuel, labor, etc). Where applicable, an additional net cost is added to account for the conversion of farm production land into treatment land for some agricultural BMPs. This section presents an estimate of the annualized cost per acre, uniformly divided over the service life of the BMP. The cost does not account for the difference between the initial capital cost and the cost incurred over the life span of the BMP.

The costs presented in this section include a 3 percent inflation rate and are discussed in year 2006 dollars for which income estimates for corn and soybean production are available. Gross and net 2006 income estimates for corn and soybean in Illinois are presented in Table 4-7. The average yield is applicable to Vermilion County.

Table 4-7. Net income from corn and soybean crops in Illinois (IASS, 2006).

Production	Yield[1] (bushel/ac)	Price[2] ($/bushel)	Gross Income ($/ac)	Cost to Grow Crop ($/ac)	Net Income ($/ac)
Corn	173	3.30	571	372	199
Soybean	52	6.25	325	261	64
Average	113	4.78	448	316	132

[1] Yield is for Vermilion County.

[2] Price is reported for the State of Illinois.

The average net annual income of $132/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 landowners operate on a two-year crop rotation. However, it should be noted that factors influencing net annual income such as yield, input and operational costs, and market prices can vary from year to year.

4.1.3.1 Nutrient Management Plans

The success of a nutrient management plan is highly dependent on the rates, methods, and timing of the fertilizer application. Consultants in Illinois typically charge $6.50 to $19 per acre to determine the appropriate fertilizer rates. This fee includes soil testing, manure analysis, scaled maps, and site specific recommendations for fertilizer management (USEPA, 2003). The savings associated with using less fertilizer are approximately $10.75/ac during each plan cycle (4 years) as estimated by the Champaign County Soil and Water Conservation District. For subsurface application using deep placement, the Heartland Regional Water Coordination Initiative lists the cost of phosphorus fertilizer at $3.75/ac per application, over a 2 year cycle (HRWCI, 2005). This cost, however, may be higher due to recent increases in fertilizer prices. Table 4-8 summarizes the annualized cost for this BMP. The average cost of using nutrient management plans ranges from $1.00/ac/yr to $4.00/ac/yr.

Table 4-8. Costs Calculations for Nutrient Management Plans.

Item	Costs (Savings) ($/ac/yr)
Soil Testing and Determination of Rates	$1.75 - $4.75
Savings on Fertilizer	($2.75)
Deep Placement of Phosphorus	$2.00
Average Annual Costs	**$1.00 - $4.00**

4.1.3.2 Conservation 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 (Czapar, 2006). The HRWCI (2005) lists the operating cost for conservation tillage at $0/ac.

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 landowner. Converting conventional equipment to no-till equipment costs approximately $1.25 to $2.50/ac/yr. For new equipment, purchasing no-till equipment is less expensive than conventional equipment (Al-Kaisi et al., 2000). Table 4-9 summarizes the average annual cost for this BMP. The average cost of using conservation tillage practices ranges from $1.25/ac/yr to $2.50/ac/yr.

Table 4-9. Costs Calculations for Conservation Tillage.

Item	Costs (Savings) ($/ac/yr)
Conversion of Conventional Equipment to Conservation Tillage Equipment	$1.25 - $2.50
Operating Costs of Conservation Tillage Relative to Conventional Costs	$0
Average Annual Costs	**$1.25 - $2.50**

4.1.3.3 Cover Crop

Researchers at Purdue University estimate the seed cost of ryegrass and hairy vetch at $12.75 and $32.00/ac/yr, respectively. Annual savings in nitrogen fertilizer are $4.00/ac for ryegrass and $30.25/ac for hairy vetch (from Champaign County Soil and Water Conservation District). Herbicide application is estimated to cost $15.25/ac/yr. These costs do not account for yield increases which may offset the overall cost. Table 4-10 summarizes the annual costs and savings associated with ryegrass and hairy vetch. The average cost of using cover crop range from $17.00/ac/yr to $24.00/ac/yr.

Table 4-10. Costs Calculations for Cover Crops.

Item	Ryegrass Cost ($/ac/yr)	Hairy Vetch Cost ($/ac/yr)
Seed Costs	$12.75	$32.00
Nitrogen Fertilizer Savings	($4.00)	($30.25)
Herbicide Costs	$15.25	$15.25
Average Annual Cost:	**$17.00 - $24.00**	

4.1.3.4 Vegetative Controls

Vegetative control BMPs are farm management strategies that are applied usually over large areas. Therefore, to compare with other agricultural BMPs, the costs are estimated for each acre of agricultural land operating with the BMP. In addition, the cost of converting farm land to BMP treatment land is included for each BMP.

Filter Strips

Filter strips are seeded with grass and cost approximately $0.35 per sq ft to construct. Assuming the filter strip area is 2 percent of the area drained (OSUE, 1994), 870 square feet of filter strip are required for each acre of agricultural land treated. The construction cost to treat one acre of land is therefore $305/ac for a seeded filter strip. Assuming a system life of 20 years (Weiss et al., 2007), the construction costs is $15.25/ac/yr for seeded strips to treat one acre of land. Annual maintenance of filter strips is estimated at $0.01 per sq ft (USEPA, 2002b) for an additional cost of $9.25/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 $2.75 (2 percent of annual net income). Table 4-11 summarizes the cost to treat one acre of agricultural runoff using a seeded filter strip. The average cost of using filter strips is approximately $27.25/ac/yr.

Table 4-11. Costs Calculations for Seeded Filter Strips.

Item	Seeded Filter Strip ($/ac/yr)
Construction Costs	$15.25
Maintenance Costs	$9.25
Income Loss	$2.75
Average Annual Costs	**$27.25**

Grassed Waterways

Grassed waterways costs approximately $0.55 per sq ft to construct (USEPA, 2002b). These stormwater conveyances are best constructed where existing bare ditches transport stormwater, so no income loss from land conversion is expected with this practice. It is assumed that the average area required for a grassed waterway is approximately 0.1 to 0.3 percent of the drainage area, or between 44 and 131 sq ft per acre. Waterways are assumed to remove phosphorus effectively for 20 years before soil, vegetation, and drainage material need to be replaced (Weiss et al., 2007). Assuming a system life of 20 years, the construction costs range from $1.25/yr to $3.75/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 ranging from $1.00/yr to $2.75/yr for each acre of agricultural land treated. Table

4-12 summarizes the annual costs to treat one acre of agricultural runoff using grassed waterways. The average cost of using grassed waterways ranges from $2.25/ac/yr to $6.50/ac/yr.

Table 4-12. Costs Calculations for Grassed Waterways.

Item	Costs ($/ac/yr)
Construction Costs	$1.25 - $3.75
Maintenance Costs	$1.00 - $2.75
Income Loss	$0
Average Annual Costs	**$2.25 - $6.50**

Riparian Buffers

The cost to construct riparian buffers is approximately $165/ac over the life of the buffer. The annual maintenance cost is $42/ac of buffer or $12.75/ac/yr to treat on acre of land (Wossink and Osmond, 2001). Maintenance of a riparian buffer decreases if forested and native vegetation is used. 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. Assuming a system life of 30 years, the annual average construction cost is $5.50/ac of buffer or $1.75/ac/yr to treat one acre of land. The estimate income loss to convert farm land to riparian buffer is $40.40 (30 percent of the annual net income). Table 4-13 summarizes the cost to treat one acre of agricultural runoff with riparian buffers. The average cost of using riparian buffers ranges from $2.25/ac/yr to $6.50/ac/yr.

Table 4-13. Costs Calculations for Riparian Buffers.

Item	Costs ($/ac/yr)
Construction Costs	$1.75
Maintenance Costs	$12.75
Income Loss	$40.40
Average Annual Costs	**$59.25**

4.1.3.5 Drainage Control Structures for Tile Drain Outlets

The cost of mapping services to identify the location of the tile drain systems is approximately $2.25/ac using color infrared photography. 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 (Cooke, 2005). The yield increases associated with installation of tile drain systems are expected to offset the cost of installation (Cooke, 2005). Assuming that the outlet control structures have a system life of 30 years, the construction cost ranges from $0.75/ac/yr to $1.50/ac/yr for retrofitting and $2.50/ac/yr for new systems. Table 4-14 summarizes the cost of retrofitting and installing tile drain systems with outlet control devices. The average cost of using control structures in tile drain outlets ranges from $2.50/ac/yr to $3.75/ac/yr.

Table 4-14. Costs Calculations for Outlet Control Devices on Tile Drain Systems.

Item	Costs to Retrofit Existing Systems ($/ac/yr)	Costs to Install a New System ($/ac/yr)
Mapping Costs per Acre	$2.25	$0
Construction Costs	$0.75 - $1.50	$2.50
Average Annual Costs	**$2.50 - $3.75**	

4.1.4 BMP Effectiveness and Estimated Load Reductions

Numerous BMPs applicable to the North Fork Vermilion River watershed are discussed in detail in the previous sections. These BMPs are suitable to reduce nutrient loads from agricultural areas. The selection of BMPs is determined by the removal efficiencies, overall cost and effectiveness. Table 4-15 summarizes the removal efficiencies and annualized costs for each BMP including construction, maintenance, and operation to treat one acre of agricultural runoff.

Table 4-15. Cost and Removal Efficiencies for Agricultural BMPs.

BMP	Nitrogen Reduction %	Phosphorus Reduction %	Cost ($/ac/yr)
Nutrient Management Plan	35	20 - 50	$1.00 - $4.00
Conservation Tillage	55 - 73	45 - 76	$1.25 - $2.50
Cover Crops	5 - 15	70 - 85	$17.00 - $24.00
Filter Strips	27 - 87	0 - 83	$27.25 - $44.75
Grassed Waterways	38	29	$2.25 - $6.50
Restoration of Riparian Buffers	74 - 85	30 - 80	$59.25
Controlled Drainage	45 - 47	35 - 83	$2.50 - $3.75

Table 4-15 indicates that nutrient management plans, conservation tillage, grassed waterways and controlled drainage are the least expensive BMPs that could be implemented in the North Fork Vermilion watershed to reduce pollution from agricultural land. The table also shows that the BMPs that provide the maximum benefit are the most expensive to implement.

4.2 Onsite Wastewater Treatment Systems

Onsite wastewater treatment systems are a potential source of nutrients and fecal coliform loading in the North Fork Vermilion watershed. Septic systems can potentially leach nutrients and pathogens into the groundwater and can contaminate surface water if the system is not functioning properly.

Nearly 2,600 individual residential septic system treatment permits have been issued for the watershed area in Vermilion County since 1971 (See Table 4-16). Using non-sewered watershed population numbers and 2.3 people per household, it does appear that a large majority of present septic systems have been permitted. It is not known how many of these systems are still operating properly, nor how many additional systems were never permitted and have never been inspected.

Proper operation and maintenance is necessary for all septic systems to protect water quality. This applies not only to active systems like aeration and sand filters, but also passive tank absorption field systems. The closer the home site is to a lake or stream, the more important it is to be sure the system is operating properly. At this time the number of failing septic systems in the NFVR watershed is unknown.

Table 4-16. Number of Septic Systems Permitted Since 1971 in the NFVR Watershed

Township	Total Number of Permits	Discharging Systems (aeration or sand filter)
Blount	735	194
Grant	143	34
Newell	1,439	380
Ross	87	11
South Ross	194	37
TOTAL	**2,598**	**656**

4.2.1 Source Description and Approximate Loading

In a properly functioning septic system, wastewater effluent leaves the septic tank and percolates through the system drainfield. Phosphorus and fecal coliform are removed from wastewater by adsorption to soil particles whereas nitrogen is converted to nitrate and transported to the streams by groundwater. Some of the nitrogen is removed by plant uptake from vegetation growing over the drainfield. Nutrient loading rates from onsite wastewater systems were calculated based on the watershed area, the estimated population served by septic systems, and the septic loading rates reported in the Generalized Watershed Loading Function (GWLF) User's manual.

It is estimated that approximately 7,560 people in the watershed upstream of Lake Vermilion are served by septic systems. In addition, there are about 70 houses located around the shoreline of Lake Vermilion and about 60 percent of these houses use septic systems (Lin and Bogner, 2005).

The GWLF user's manual (Haith et al., 1992) reports septic tank effluent loading rates for phosphorus with phosphate detergent at 2.5 g/capita/day and for nitrogen at 12 g/capita/day. The plant uptake rates for phosphorus are 0.4 and for nitrogen is 1.6 g/capita/day during the growing season. During the dormant season, there is no plant uptake. Assuming a 6-month growing season, the average annual plant uptake rates are 0.2 and 0.8 g/capita/day for phosphorus and nitrogen, respectively.

Properly-functioning systems were assumed to produce no loads of phosphorus or fecal coliform and nitrogen loads that were reduced only due to plant uptake. Failing systems were assumed to be evenly divided into three categories: short circuiting, ponding, and direct discharge. Septic systems where the effluent short circuit the soil adsorption field or causes the effluent to pond at the ground surface are assumed to retain nutrients through plant uptake only (0.2 g/capita/day). Septic systems with direct discharge bypass the drainfield and no soil zone treatment or plant uptake occurs. For all failing systems, fecal coliform loads were assumed to bypass the septic system. Fecal coliform effluent rates from human are estimated at 1.95 x 10^9 cfu/capita/day (Yagow et. al., 2001).

The national average rate of failure for septic systems is 7 percent as reported in the USEPA Onsite Wastewater Treatment Systems Manual (2002a). No data are available to determine the proportion of septic systems that fail in the North Fork Vermilion watershed. Therefore, loading rates were calculated under three scenarios. Table 4-17 shows the nutrient and fecal coliform loads if 7, 15, and 30 percent of the septic systems in the watershed are failing. The phosphorus loads from septic systems range from 1,008 to 4,319 lb/yr, the nitrogen loads range from 29,673 to 29,835 lb/yr, and the fecal coliform loads range from 376,658 to 1,614,250 x 10^9 cfu/yr, depending on the percentage of septic system failure.

Table 4-17. Failure Rate Scenarios and Resulting Loads

Failure Rate (%)	Average Phosphorus Load (lb/yr)	Average Nitrogen Load (lb/yr)	Average Fecal Coliform Load (10^9 cfu/yr)
7	1,008	29,673	376,658
15	2,160	29,729	807,125
30	4,319	29,835	1,614,250

4.2.2 Appropriate BMPs

The most effective BMPs for managing loads from onsite wastewater systems is a comprehensive management program that includes inspection, regular maintenance, and public outreach. Important measures to reduce pollutant loading from septic systems are listed below (CWP, 2004):

- Inspect system annually even if they don't show failure and pump system every 3 to 5 years, depending on the tank size and number of residents per household (USEPA 2002a)
- Keep heavy equipment and vehicles off the system and drainfield.
- 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.
- Don't cover the drainfield with impervious surfaces

Public outreach 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. In addition, an inspection program would help identify failing systems and those systems that are currently connected to tile drain systems. All tanks discharging to tile drainage systems should be disconnected immediately.

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

The cost of this BMP includes maintenance, inspection, replacement and public outreach. Maintenance of septic systems is performed by pumping the sludge that has accumulated at the bottom of the tank. The system fails due to overloading if the tank is not pumped out regularly. Pumping cost for septic tank ranges from $250 to $350 based on the tank size and disposal fees. Assuming the septic system is pumped once every four years, on average, the annual cost ranges from $65 to $90.

Inspection of septic systems involves developing and maintaining a database of the onsite wastewater treatment systems 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. The cost for each inspection is approximately $175 per septic system (Hajjar, 2000). Assuming there are approximately 3,287 households with septic systems in the watershed and all systems are inspected once every five years, the cost per system is $35/yr.

When replacement of septic tanks is needed, the estimated replacement cost ranges from $2,000 to $10,000. Assuming the expected useful life of a septic system is 30 years, the replacement cost per year ranges from $67 to $333.

A public outreach program can be accomplished through public meetings; mass mailings; radio, newspaper, and TV announcements to educate the homeowner about their systems and maintenance. The costs associated with outreach programs will vary depending on the level of effort. Assuming education will be given through annual public reminders, the annual cost is estimated at $1 per septic system. Table 4-18 summarizes the average annual cost per septic system. The average cost to implement an onsite wastewater treatment management program ranges from $168/system/yr to $459/system/yr.

Table 4-18. Costs Associated with Maintaining and Replacing an Onsite Wastewater Treatment System.

Action	Cost ($/system/yr)
Pumping	$65 - $90
Inspection	Up to $35
Replacement	$67 -$333
Public outreach	$1
Average Annual Cost	**$168 - $459**

4.2.4 Effectiveness and Estimated Load Reductions

The average annual cost to implement a septic system management program that includes pumping, inspection, replacement, and public outreach cost between $168 and $459 per system. If this management program is implemented, 100 percent load reduction is expected for phosphorus and fecal coliform assuming that all systems in the watershed are maintained properly (inspected every 5 years and pumped every 3 to 5 years) and are replaced once every 30 years. Minimal load reductions are expected for nitrogen as even properly functioning septic systems do not control nitrogen very effectively.

4.3 Stream Channel Erosion

Erosion on the banks and beds of tributary streams has been identified as a potential source of pollutants. Stream channel erosion causes sedimentation in Lake Vermilion and contributes to the phosphorus and nitrate loading to the watershed. An Aerial Assessment Report for the North Fork Vermilion River was conducted in March 2004 to identify channel conditions and provide recommendations for channel improvement due to erosion. This assessment found that North Fork Vermilion River has two distinct channel cross sections. One has a width depth ratio of 10 to 12 with no channel armoring of the bed. The other has a width depth ration of 20 to 25 with an armored bed composed of heavy cobble eroded from the glacial till. These sections are very stable vertically but are moving laterally because the bank material is more mobile than the bed material (Kinney, 2005).

4.3.1 Source Description and Approximate Loading

The Aerial Assessment Report for the North Fork Vermilion River (Kinney, 2005) does not provide a quantitative estimate of stream channel erosion. Therefore, nutrient loadings from stream channel erosion in the North Fork Vermilion River could not be quantified. However, they are expected to be less significant than the load from agriculture or failing septic systems.

4.3.2 Appropriate BMPs

Several BMPs are appropriate to stabilize stream channels impacted by erosion. The BMPs discussed here include engineering controls, vegetative stabilization, and restoration of riparian areas. Engineering controls include armoring with materials that straighten the banks and deflection of the water course with rock or log structures. The Aerial Assessment Report (Kinney, 2005) recommended treating the eroding banks in the upper half of the watershed with Stone Toe Protection (STP) due to the narrow width-depth ratio. The eroding banks in the lower reaches can be treated with STP and/or Stream Barbs and Bendway Weirs to protect the toe of the bank (Kinney, 2005).

Peak flows from runoff areas and channel velocities can be reduced by directing runoff through riparian buffers, grassed waterways and filter strips before entering the streams. Using vegetative controls also enhance infiltration, which reduces high flows that cause erosion. These BMPs are located adjacent to the stream banks.

4.3.3 Estimated Cost of Implementation

The Aerial Assessment Report for North Fork Vermilion River estimated a cost of $132,000 per mile of lateral bank protection using Stone Toe Protection (Kinney, 2005).

4.3.4 Effectiveness and Estimated Load Reductions

Specific load reductions for stream channel erosion have not been identified in the North Fork Vermilion watershed because the extent of the stream bank erosion is unknown.

4.4 Animal Operations

Fecal coliform and nutrient loading from animal operations can be a problem in both confined and pasture-based systems. Although there are not a large number of livestock in the watershed, they are still a potential source that should be addressed during implementation activities.

4.4.1 Source Description and Approximate Loading

Insufficient data exist to estimate the nutrient or fecal loading from animal operations in the North Fork Vermilion River watershed. Approximately seven percent of the watershed is categorized as pasture lands, but the number of animals that may be located in those pasture lands is not known. There are reportedly no large confined livestock operations in the watershed (Franke, 2006).

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.

Beef and other cattle are likely contained on pastureland in the watershed. Approximately 14,102 ac are classified by the USGS land use coverage as pasture. Phosphorus export rates for pasture range from 0.12 to 4.4 lb-P/ac/yr (Lin, 2004), yielding approximate loads of 1,692 to 62,049 lb-P/yr from pastured animals in this watershed. 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.

4.4.2 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.

4.4.2.1 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 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).

4.4.2.2 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 4-9 and Figure 4-10.

Figure 4-9. Typical Stream Bank Erosion in Pastures with Cattle Access to Stream.

Figure 4-10. 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. Reductions of 29 to 46 percent for fecal coliform and 15 to 49 percent for phosphorus concentrations are reported (USEPA, 2003).

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.

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

4.4.2.3 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 4-11 shows a centralized watering tank allowing access from rotated grazing plots and a barn area.

(Photo courtesy of USDA NRCS.)

Figure 4-11. 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

4.4.3 Estimated Cost of Implementation

The net costs associated with the animal operations BMPs described in Section 4.4.2 depend on the cost of construction (for structural BMPs), maintenance costs 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 per head.

4.4.3.1 Manure Handling, Storage, and Treatment

The NRCS (2003) has developed cost estimates for the various tasks and facilities typically used to transport, store, and dispose of manure. Table 4-19summarizes 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.

Table 4-19. 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
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
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
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

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

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

4.4.3.2 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 4-20.

Table 4-20. 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 4-21 presents the capital, maintenance, and annualized costs per head of cattle for four fencing materials based on the NRCS assumptions.

Table 4-21. 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

4.4.3.3 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 4-22 lists the capital, maintenance, and annualized costs for a well, pump, and storage system assuming a system life of 20 years.

Table 4-22. 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**

4.4.4 Effectiveness and Estimated Load Reductions

Several BMPs are available to control fecal coliform and nutrient loads from animal operations in the North Fork Vermilion River watershed. Selecting a BMP will depend on estimated removal efficiencies, construction and maintenance costs, and individual preferences. Table 4-23 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 4-23. Cost and Removal Efficiencies for Agricultural Fecal Coliform BMPs

BMP	Fecal Coliform Reduction	Phosphorus 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
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)	15 to 49 percent (USEPA, 2003)	Beef cattle: $5.50 to $9
Alternative Drinking Water Sources	29 to 46 percent (USEPA, 2003)	-	cattle: $3.15

Because the existing loads from livestock in the North Fork Vermilion River watershed could not be quantified, the estimated load reductions are not known.

4.5 WWTP/NPDES Permittees

The Hoopeston, Rossville, and Bismark School sewage treatment plants (STP) are considered potential point sources of fecal coliform load to North Fork Vermilion River - segment BPG09. The three plants have been granted disinfection exemptions by IEPA as part of each facility's NPDES permit. Each facility should be meeting the 200 cfu/100ml at the end of their respective disinfection exemption stream reach as identified in the permits under all flow conditions.

The City of Hoopeston’s disinfection exemption length runs from its outfall into Hoopeston Branch to the confluence with the North Fork Vermilion River. The Village of Rossville’s disinfection exemption ends at the point where the effluent enters the North Fork Vermilion River (the outfall discharges directly into the North Fork Vermilion River). Since it is such a small discharge, the standard is met due to dilution, not die off. The Bismark Community Unit School District’s disinfection exemption length runs from its discharge into an unnamed ditch to the confluence with Painter Creek.

Facilities with year-round disinfection exemptions may be required to provide IEPA with updated information to demonstrate compliance with these requirements. Facilities directly discharging into a impaired segment may have their year-round disinfection exemption revoked through future NPDES permitting actions or may be required to begin submitting monthly phosphorus and fecal values. These monitoring requirements can be included as a condition in the NPDES permit upon renewal. Following this monitoring IEPA can evaluate the need for point source controls through the NPDES permitting program.

Wasteload allocations (WLA) for Hoopeston, Rossville, and Bismark School sewage treatment plants (STP) were estimated based on the assumption that each facility should be meeting the 200 cfu/100ml at the end of their respective disinfection exemption stream reach. Daily fecal coliform concentrations from the three point sources were calculated by multiplying the average effluent discharges with the fecal coliform standard of 200 cfu/100ml and a unit conversion factor. An average TP concentration of 3.5 mg/L and average flows from the point sources were used to calculate the WLA for total phosphorus in Lake Vermilion. Table 4-24 shows a summary of the WLA for the three permitted STPs.

Table 4-24. Waste Load Allocations for Facilities Permitted in the Watershed.

Facility Name	NPDES No.	Average Discharge (MGD)	TP WLA (lb/day)	Fecal Coliform WLA (10^9 cfu/day)
Hoopeston STP	IL0024830	1.652	48.25	12.52
Rossville STP	ILG580064	0.18	5.26	1.37
Bismarck Community Unit School STP	IL0067156	0.004	0.12	0.05

The nitrate concentration in the North Fork Vermilion River segment BPG05 rarely exceed 10 mg/l standard during low flow conditions, which suggests the STPs are not a significant cause of the impairment.

The three sewage treatment plants discharging to North Fork Vermilion River, are also considered potential sources of total phosphorus to the lake. However, no data are available on the effluent phosphorus concentration from the plants and it is recommended that sampling be conducted to obtain this information prior to the implementation of any potentially costly plant upgrades.

4.6 Golf Courses

In addition to the sources listed, there are also two golf courses located within the NFVR watershed close to the river channel or to the lake itself, both of which could potentially be adding to the nutrient load. The Hubbard Trail Course (approximately 70 acres) is located just north of Rossville, IL. The Danville Country Club Course (approximately 175 acres) sits just west of Lake Vermilion (see Figure 4-12).

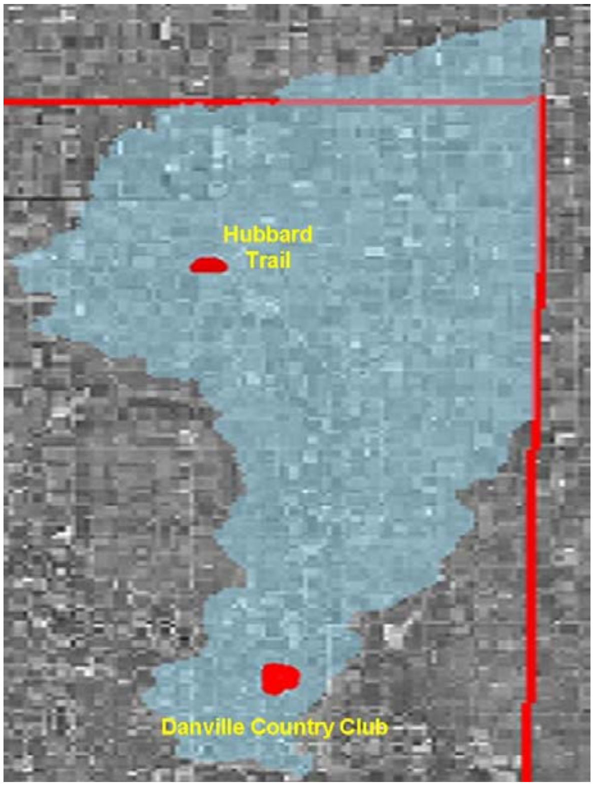


Figure 4-12. Location of Golf Courses

4.7 Lake Bottom Sediments

Sedimentation in lakes is a natural process that can be accelerated or slowed by human interaction in the watershed. Sediments accumulate in lakes as a result of watershed erosion, sediment transport by streams, and sediment deposition into the bottom of the lake. Nutrient release from lake-bottom sediments are a potential source of pollutants.

Nutrient release from sediments occurs during lake stratification when the soil water interface becomes anoxic (depleted of oxygen). Internal recycling including direct flux from the sediment and re-suspension of sediments could contribute significant load of phosphorus to the water column.

Sediment samples were collected from three locations in Lake Vermilion during 2000. The samples were analyzed for nutrients and metals and the results indicate that concentrations of phosphorus and Kjeldahl nitrogen are within the normal range according to the Illinois classification system (Lin and Bogner, 2005). Based on this, lake bottom sediments are not considered a significant source of nutrients to Lake Vermilion.

4.8 Shoreline Erosion

Lake Vermilion has approximately 14 miles of shoreline, which equates to 73,920 linear feet. Approximately 40 percent is residential, 40 percent is woodland, and 20 percent is wetland and developed recreation areas. Most undeveloped shoreline is accessible for bank fishing (Lin and Bogner, 2005)

In 2002 a shoreline survey was conducted on Lake Vermilion and the shoreline condition was rated according to IEPA guidelines. The investigation found that 25,429 linear feet of shoreline was considered to have severe erosion (Figure 4-13). Approximately 7 percent of the shoreline was rated to be in severe condition (more than 8 feet exposed bank), 3 percent of the shoreline showed moderate condition (3 to 8 feet exposed bank), 6 percent of the shoreline had slight condition (0 to 3 feet exposed bank), and 17 percent of the shoreline was artificially armored by rock or shore wall (Lin and Bogner, 2005). Funding through an IEPA Section 319 Grant as well as an Illinois Clean Lakes Program Grant was utilized to stabilize all of the severely eroding shoreline. Riprap, geo-textile fabric, and vegetation were the primary means of stabilizing these banks. There are still areas of shoreline with slight and moderate erosion that are contributing to the sediment load in Lake Vermilion. These areas may be targeted for stabilization in the future as they still need to be addressed. Suggested shoreline protection and stabilization measures include Stone Toe Protection (STP) and armor stone breakwaters. STP applied along the eroding sections provides stability and prevent additional recession of the bank line. Armor stone breakwaters are riprap apron placed on the fore slope with transitional wetlands.

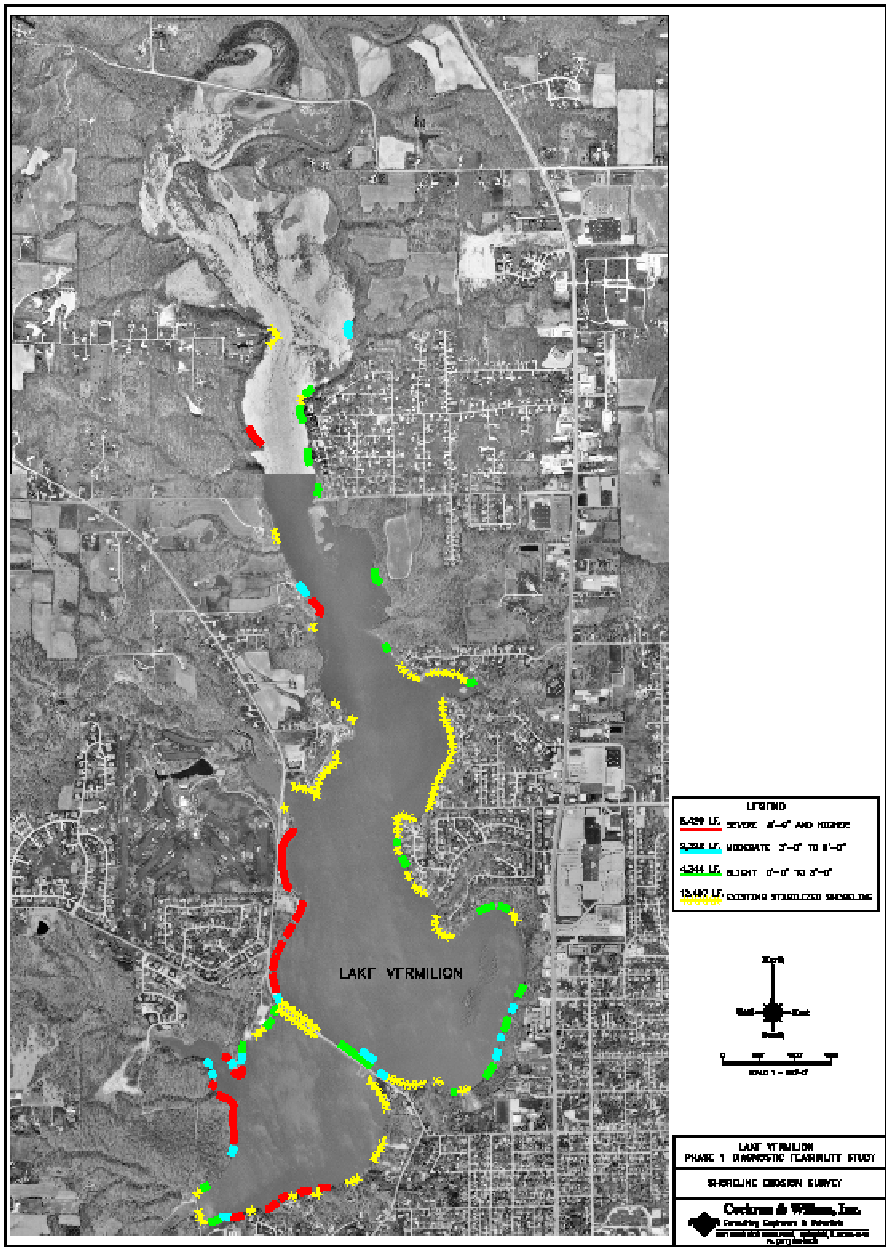


Figure 4-13. Lake Vermillion Shoreline Survey

5.0 PRIORITIZATION OF IMPLEMENTATION

In 1987, a “NFVR Watershed Work Plan” was prepared under agreement with the Illinois Department of Transportation, Division of Water Resources. The purpose of this work plan was to “identify the problems, recommend solutions, estimate costs, and evaluate impacts of drainage and channel improvement of the North Fork Vermilion River in Vermilion County”.

This plan addressed the following identified watershed problems: inadequate land and water management, erosion, and inadequate drainage (i.e. NFVR channel blockages). There are approximately 9,750 acres of highly erodible land located within the NFVR watershed. The vast majority of these soils are located adjacent to Lake Vermilion, the main channel of the NFVR, and its two main tributaries, as well as a few areas located throughout the watershed (see Figure 5-1). Table 5-1 is included to identify those soil types that are considered to be highly erodible. Recommended measures included the removal of log jams and trees, silt bars, and stream bank stabilization. Funding was also requested to provide fencing for livestock exclusion, tile outlet renovation or replacement, and a 20 foot wide maintained grass strip planted adjacent to the channel where cropping extends to the channel edge. These practices were completed and paid for by an Illinois General Assembly appropriation of approximately $2,332,300.

The current North Fork Special Service Area Committee and associated activities grew out of the above mentioned plan. After the initial construction phase of the North Fork Project in the early 1990’s, the North Fork Special Service Area Committee was tasked with the ongoing care and maintenance of the Vermilion County portions of the NFVR, the Middle Branch (Miller Creek), and the East Branch (Jordan Creek). This committee is governed by a board of nine (9) commissioners, one of which is appointed by the Board of Directors of the Vermilion County SWCD, one is appointed by the Vermilion County Board, and seven (7) of which are appointed from the NFVR watershed.

Table 5-2 summarizes the load reductions needed within the North Fork Vermilion River watershed.

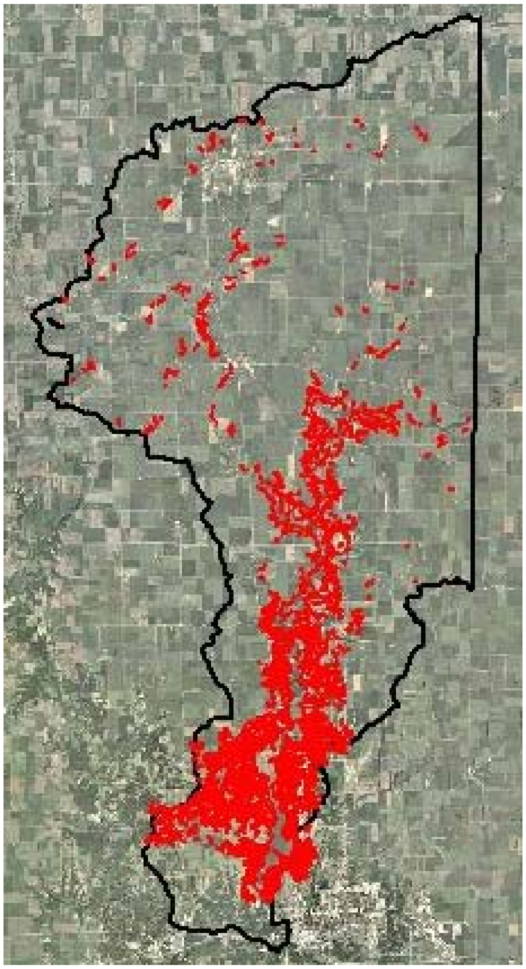


Figure 5-1. Highly Erodible Soils within the North Fork Vermilion River Watershed

Table 5-1. Highly Erodible Soils

Soil Name	Soil Map Symbol	Average Slope	Tolerable Soil Loss
Blount	23B2 & 2023B	4 %	3
Chatsworth	241C	8%	3
Clarence	147B2	4%	3
Jasper	440C2	8%	5
Martinsville	570C2 & 570F	9% - 26%	5
Morley	194D3, 194F, 194G	14% - 50%	4
Onarga	150C2	7%	4
Ozaukee	194C2	8%	4
Parr	221C3	9%	4
Varna	223C2	7%	5

Table 5-2. TMDL Required percentage in Load Reduction

Waterbody	Impairment	% Reductions in Stream			% Reduction in Lake
		High	Medium	Low	
North Fork Vermilion River -BPG05	Nitrate	26%	48%	0%	-
North Fork Vermilion River -BPG09	Fecal Coliform	70%	47%	8%	-
Lake Vermilion - RBD	Total Phosphorus	-	-	-	77
Lake Vermilion - RBD	Nitrate	-	-	-	34

Section 4 provides the loading estimates by pollutant source and describes best management practices options in terms of cost and load reduction capabilities. This section compares all the BMPs discussed in Section 4 so they can be prioritized based on cost, effectiveness, and loading reduction.

5.1 Comparison of BMPs

Based upon the information presented in Section 4, implementing nutrient management plans, conservation tillage, grassed waterways, and installing outlet control structures in tile drain systems are the most cost effective agricultural BMPs. The potential load reductions for these BMPs range from 8,800lb/yr to 90,570 lb/yr for phosphorus and from 490,240 lb/yr to 3,447,940 lb/yr for nitrogen.

Implementing the septic tank management program to reduce failure of septic systems in the North Fork Vermilion River watershed would likely reduce phosphorus loads by 1,008 lb/yr to 4,319 lb/yr and fecal coliform loads by 376,658 10^9 cfu/yr to 1,614,250 10^9 cfu/yr cfu/yr, assuming that the current failure rate is no more than 30 percent. In terms of phosphorus load reduction, this management measure results in slightly higher cost compared to agricultural BMPs such as nutrient management plans, conservation tillage, grassed waterways, and controlled drainage. However, the cost of this BMP is still lower that some other agricultural BMPs such as cover crops, filter strips and restoration of riparian buffers.

The most cost effective BMP for reducing fecal coliform loads from animal operations is cattle exclusion from streams with alternative drinking sources.

5.2 Existing BMPs

Some best management practices have already been implemented or are currently being implemented in the North Fork Vermilion River watershed. Watershed management measures currently in place in the watershed include the following (Johnston and Pervely, 2008):

5.2.1 Conservation Easements

In August 2001, the Illinois Department of Natural Resources (IDNR) awarded the Vermilion County Soil and Water Conservation District (SWCD) two grants to acquire permanent conservation easements. A conservation easement is a voluntary, legally binding agreement that allows the landowner to retain ownership of the property, but limits certain types of uses and prevents development from taking place on the piece of property. These grants, also known as the Habitat Enhancement Project (HEP) allowed the SWCD to acquire a total of 333.18 acres from nine (9) landowners. This acreage is located within the HEP project area (outlined in red) and located in the NFVR watershed and the location of the acreage can be seen in Figure 5-2. The principal goals of this project were to protect existing habitat, reduce habitat fragmentation, improve & protect water quality of , grassland dependent species, create large blocks of contiguous forest & grasslands, and establish grass or tree cover along both sides of streams.

Also, there are eleven (11) active Environmental Quality Incentive Programs (EQIP) within the NFVR watershed as shown in Figure 5-3. Current conservation practices in the watershed are shown in Table 5-3.

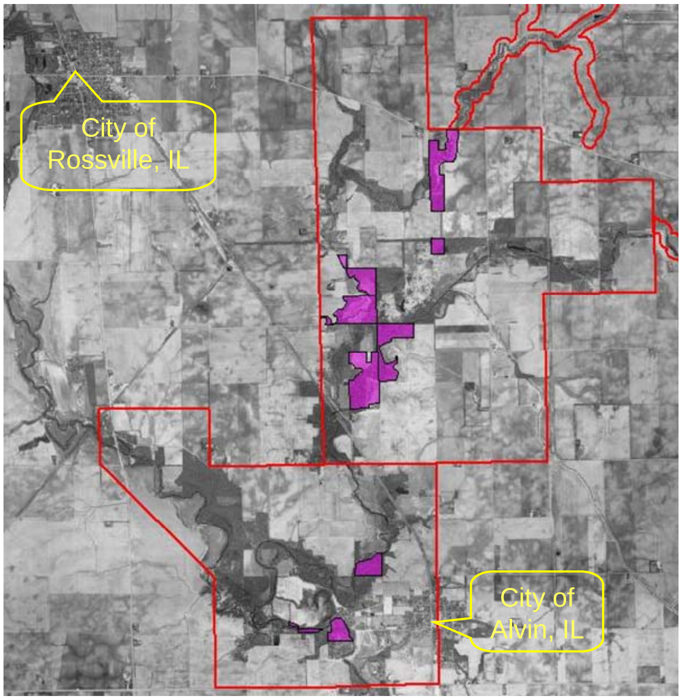


Figure 5-2. Location of Permanent Conservation Easements Purchased through HEP

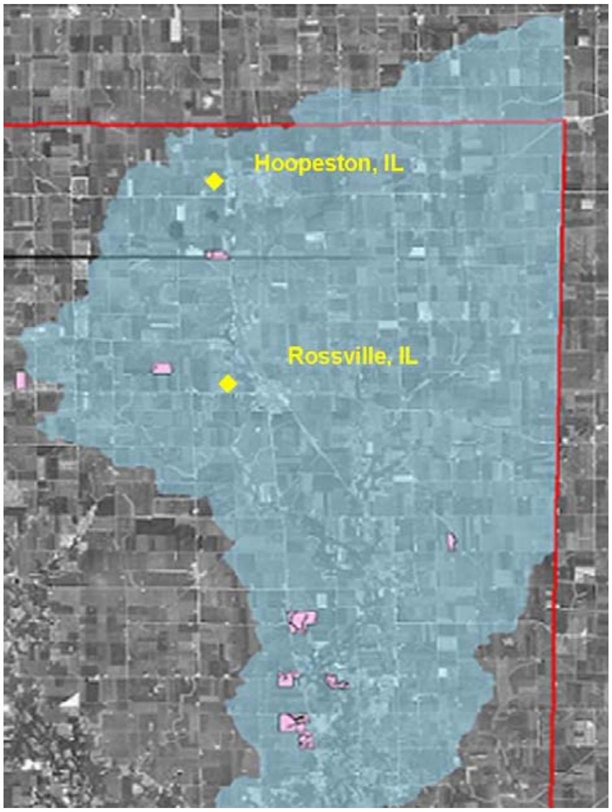


Figure 5-3. Location of acreage enrolled into the EQIP Program

Table 5-3. Summary of Current Conservation Practices and the Watershed Acreages Enrolled into the Conservation Reserve Program as of 2007.

Program	Practice	Pollutants addressed	Acres enrolled in Iroquois County, IL	Acres enrolled in Vermilion County, IL	Acres enrolled in Benton County, IN	Total Acres Enrolled
CRP (USDA)	Grass filter strips along stream channels	Filters sediment and pollutants bound to sediment such as Phosphorus & some pesticides. Plant roots also uptake dissolved forms of Nitrogen & Phosphorus.	50.55	804.17	83.8	854.72
CRP (USDA)	Riparian Forest Buffers (trees) along stream channels	Filters sediment and pollutants bound to sediment such as Phosphorus & some pesticides. Plant roots also uptake dissolved forms of Nitrogen and Phosphorus. Trees also provide shading which increases dissolved oxygen levels in streams.	0	269.81	0	269.81
CRP (USDA)	Grassed waterways	Prevents transport of sediment by healing or preventing formation of gullies in cropped fields.	11.23	373.48	29.5	384.71
CRP (USDA)	Shallow water areas and wetland buffers	Traps sediment. Aquatic plants take up nutrients.	0	34.92	11.4	34.92
CRP (USDA)	Other grass, tree, and / or shrub planting practices	Such practices include field borders, windbreaks & wildlife food plots. While these are not implemented for the benefit of water quality, land used for these practices are taken out of crop production thus reducing erosion & fertilizer losses.	0	0	13.4	13.4

5.2.2 Nutrient Management

Nutrient runoff from the approximately 104,000 tilled acres in the watershed has historically been a problem. In 2001, the IEPA approved a Section 319 Grant (Agreement No. 3190010) for the AISWCD to help local producers reduce the amount of nitrogen being applied to cropped fields in the watershed. This grant offered incentive payments to producers to implement nutrient management plans on their corn acreage in 2001 and 2002. A total of twelve (12) producers participated in the program. Table 5-4 shows the total acreage participation rates within the watershed. Table 5-5 shows a comparison of the amount of nitrogen that had typically been applied prior to using a nutrient management plan and the amount of nitrogen that was applied by implementing the nutrient management plan. Figure 5-4 shows the location of where the nutrient management plans were implemented over that two year period. It is also important to note that this particular program was only available to landowners located in one small sub-watershed of the NFVR watershed consisting of approximately 19,000 acres. Although this information is somewhat dated we will assume that the current rate of individuals following a nutrient management plan is similar to what it was a few years ago.

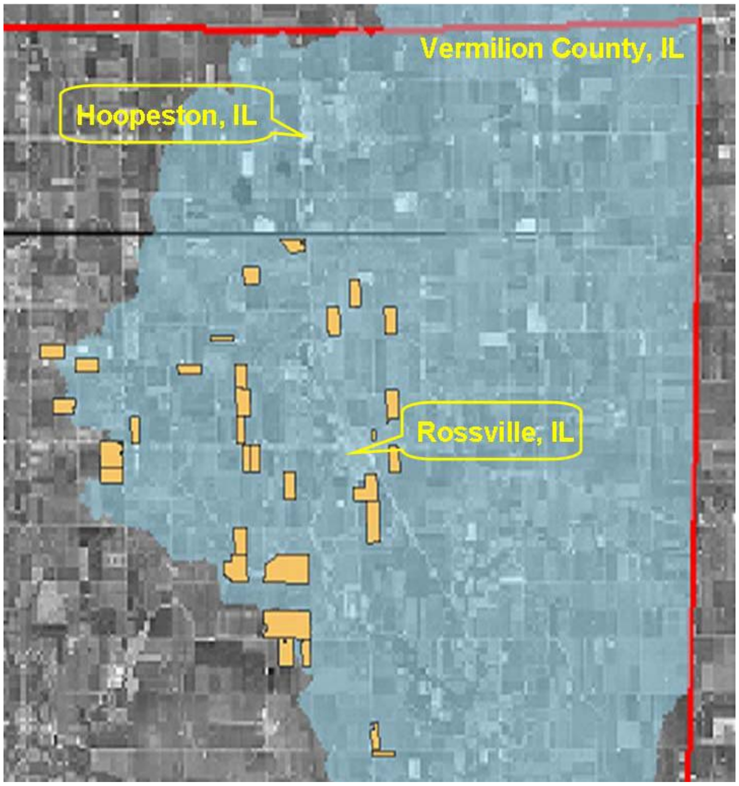


Figure 5-4. Location of nutrient management plans that were implemented in 2001 & 2002 through an IEPA 319 Nutrient Management Project - Agreement No. 3190010

Table 5-4. Nutrient Management Participation Rates in Project in 2001 & 2002
(taken from 319 Nutrient Management Project Agreement No. 3190010 Final Results – Crop Years 2001-2003)

Number of Acres Implementing Nutrient Management Plans		Percentage of Acres Implementing Nutrient Management Plans	
2001	2002	2001	2002
1,377	2,728	15 %	29.7 %

Table 5-5. Comparison of Nitrogen Normally Applied and Amount Applied in Project
(taken from 319 Nutrient Management Project Agreement No. 3190010 Final Results – Crop Years 2001-2003)

Nitrogen Normally Applied			Nitrogen Applied in Project			Load Reduction for Project	
2001 lb/acre	2002 lb/acre	Average for Project (lb/acre)	2001 lb/acre	2002 lb/acre	Average for Project (lb/acre)	Average N Reduction (lb/acre)	Load Reduction for Project (total lbs)
166.2	146.0	156.1	141.7	134.8	138.3	17.8	64,290

5.2.3 Sediment and Nutrient Reduction

A total of ten (10) sediment and nutrient reduction structures were recently installed throughout the North Fork Vermilion River watershed (Figure 5-5). These structures were funded through an IEPA Section 319 Grant which began on May 19, 2004 and ended on December 31, 2007. Eight (8) of the structures were ponds, one (1) was a water and sediment control basin (WASCB), and one (1) was a large terrace system. The location of the 10 projects can be seen in Figure 20. Through the completion of this project the total sediment load in the North Fork Vermilion River watershed was reduced by approximately 1,014 tons per year. In addition the phosphorus load was reduced by 451 lbs/year and the nitrogen load by 900 lbs/year.

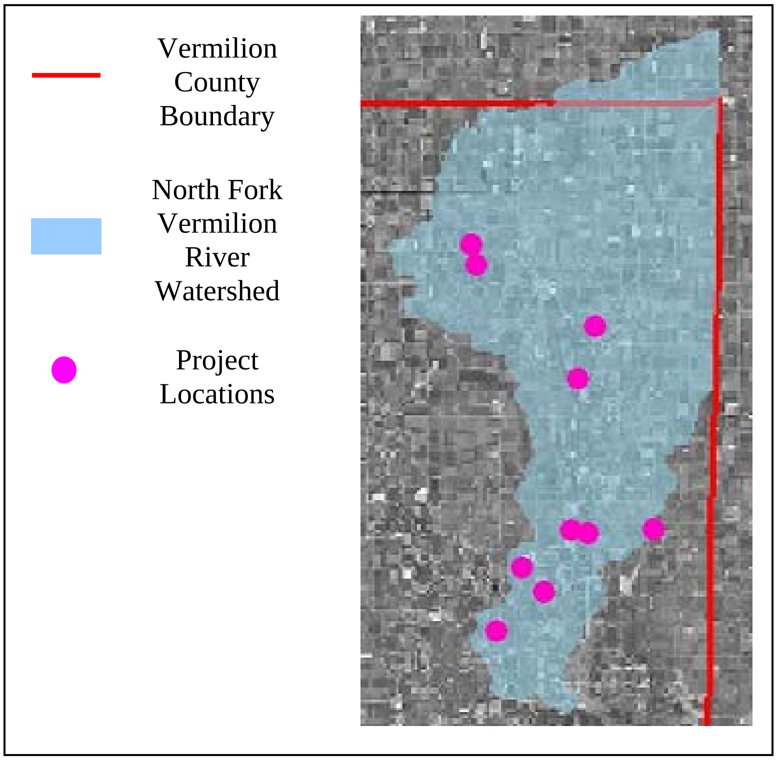


Figure 5-5. Location of Installed Sediment and nutrient reduction structures funded through an IEPA Section 319 Grant

5.3 Implementation Strategy for BMPs

Focusing on the low cost – high reduction options presented in this plan first will likely result in greater participation in the community. Nutrient management planning to determine appropriate fertilizer application rates is currently being used on 28 percent of the cropland in the watershed. Extending this practice to the remaining fields, and using deep placement technology could reduce phosphorus loading to Lake Vermilion by 20 to 50 percent and nitrogen loading by 35 percent.

Increased use of conservation tillage practices is also recommended. Approximately 50 percent of soybean fields in Vermilion County use some form of conservation tillage. However, no conservation tillage practices are being used on corn fields or small grain fields. Extending conservation tillage practices to the remaining 50 percent of soybean fields and all corn fields and small grain fields could reduce phosphorus loading by 45 to 76 percent and nitrogen loadings by 55 to 73.

Approximately 42 acres of grassed waterway have been planted in the watershed. This practice is applicable watershed-wide and is capable of reducing phosphorus loads by 29 percent and nitrogen by 38 percent.

There are very few outlet control structures in the tile drain systems in Vermilion County. With approximately 80 to 90 percent of cropland having tile drainage systems, it is estimated that installing the outlet control systems could reduce phosphorus loading by 35 to 83 percent and nitrogen loading by 45 to 47 percent.

Nutrient management planning, conservation tillage practices, grassed waterways, and controlled drainage structures have relatively low implementation cost ranging from $1.00/ac/yr to $6.50/ac/yr. The use of cover crops, filter strips, and restoration of riparian buffers would be as part of supplemental strategies due to their higher cost. Expected costs for these practices range from $17 to $59.25/yr/ac treated.

Proper maintenance and replacement of septic systems is also encouraged. Up to 100 percent phosphorus reductions could be obtained if this BMP is implemented correctly. The expected cost for this practice ranges from $168 to $459/yr per septic system.

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6.0 MEASURING AND DOCUMENTING PROGRESS

The success of this implementation plan will be dependent on good monitoring that is able to measure and document progress toward improving water quality. The following type of data will be useful in accomplishing this goal:

- Sampling of fecal coliform data at a temporal interval of five-samples-per-month (as stated in the Illinois Water Quality Standards) during the months of May to October in North Fork Vermilion River.
- Continuous (ideally every two weeks) sampling of nitrate, total phosphorous and total nitrogen at the inlet to Lake Vermilion to monitor trends in loads over time.
- Periodic sampling of water quality within Lake Vermilion to assess overall water quality.

The installation, maintenance, and effectiveness of BMPs should also be tracked. The different agencies including SWCD, NRCS, FSA, and IEPA Nonpoint Source Program that assist landowners, keep records of conservation practices and other BMPs that are installed under their respective programs. For example, the NRCS annually conducts status review in small portions of the watershed to verify that the BMPs are properly installed and maintained (Johnston, 2007).

Data collection should take place at periodic intervals upstream and downstream of BMPs to evaluate their effectiveness in reducing pollutant loads. Measuring the effectiveness of these BMPs will require continued sampling of water quality in North Fork Vermilion River and Lake Vermilion over the next several years. Measurements should continue for a minimum of two monitoring cycles to document progress and direct future management strategies.

To support the ongoing assessment of water quality within the watershed the Illinois EPA receives federal funds through USEPA to conduct various monitoring programs. Some of the water quality monitoring programs available to the North Fork Vermilion River watershed are listed below.

6.1 Ambient Water Quality Monitoring Network

Illinois EPA operates an Ambient Water Quality Monitoring Network (AWQMN) consisting of fixed stations to support surface water chemistry data needs, including a site on the North Fork Vermilion River north of Danville near Bismark. Various parameters like metals, nutrients, fecal coliform are analyzed from samples collected at this station (Ettinger, 2007).

6.2 Intensive River Basin Surveys

Intensive river basin surveys are executed on a five-year rotational basis in cooperation with the Illinois Department of Natural Resources (IDNR). The sample stations are decided based on various criteria where exhaustive or missing information is required. Data is collected on water quality, stream discharge, biological (fish and macro invertebrate) and habitat information. Fish tissue contaminant and sediment chemistry sampling are also conducted to screen for the accumulation of toxic substances. There are five monitoring stations in the North Fork Vermilion River and its tributaries where sampling was last conducted in 2006 (Ettinger, 2007). The location of these stations is shown in Figure 4-1 of the Stage One report (IEPA, 2006a).

6.3 Ambient Lake Monitoring Program

Illinois EPA conducts an Ambient Lake Monitoring Program (ALMP) annually in approximately 50 lakes throughout the state. This is an intensive monitoring program that collects samples for large number of parameters. Certain core lakes are monitored every three years. The data is annually summarized and distributed to managers of related lake resources. For Lake Vermilion, the monitoring is done in three to five year cycles. There are three stations at which samples are collected to analyze water quality parameters. The first station is located near the dam, the second station is in middle of the lake and the third station is near the upper end of the lake close to the major inflow stream (see Figure 4-2 of the Stage One report). Data are collected for parameters including nutrients, suspended solids, depth, sediments, and aquatic plant survey (Ettinger, 2007).

6.4 Volunteer Lake Monitoring Program

IEPA established the Volunteer Lake Monitoring Program (VLMP) in 1981. The VLMP serves as an educational program for citizens to learn about lake ecosystems, as well as a cost-effective method of gathering fundamental information on Illinois inland lakes. The VLMP utilizes funds provided by the federal Clean Water Act and the state-funded Conservation 2000 Program that increase citizen knowledge and awareness of the factors that affect lake quality and encourage development and implementation of sound lake protection. Lake Vermilion is currently not included in the VLMP, but was as recently as 2001.

The VLMP operates under three levels of monitoring as summarized below:

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

6.5 The Vermillion Water Quality Coalition

The Lake Vermilion Water Quality Coalition (LVWQC) was formed in 1992 in response to nitrate concentrations in Lake Vermilion that exceeded the EPA standard for safe drinking water. Current membership is at about 38 individuals and organizations and is open to any concerned citizen with an interest in water quality and nutrient and sediment management in the watershed. Member volunteers include farmers, homeowners, and several county agency staff with responsibilities for water quality and erosion management.

Funding for the LVWQC has come from the state and Aqua Illinois Water Company, Inc., in addition to private contributions. Activities have focused on crop plot demonstrations for nitrate management, watershed tours for landowners/public/students to show conservation practices, and sponsoring workshops and seminars on pond construction and biology, stream bank stabilization, forest land management, and the role of farm tile in drainage and water quality. Most recently, efforts have been focused on outreach information via local media, and classroom presentations to 5th and 7th graders with the Enviroscape model (watershed and erosion) as well as the Rainfall Simulator for tillage and water quality demonstrations. These activities will continue as requested and as resources become available.

Members of the LVWQC have also undertaken limited water quality sampling of the NFVR as well as tile outfalls along the NFVR channel to measure nitrate concentrations at five sites between the state line and Lake Vermilion. Intermittent sampling began in 1996 and has continued through 2005. This data, available through the Lake Vermilion Water Quality Coalition, has supplemented other official water quality sampling for a variety of pollutants. The results have shown substantial losses of nitrate from crop fields through agricultural tile drains during high flow events. These losses could account for up to several pounds of nitrogen per acre during a one inch rainfall event. This would correspond to 20-30 mg/L of nitrate nitrogen at tile outfalls which exceeds the IEPA drinking water standard of 10 mg/L. See Resource Inventory, page 40, Table 16 (Johnston and Pervely, 2008).

Currently, the LVWQC is serving as the technical advisory committee for the NFVR Watershed Plan. Once this document is complete, the LVWQC will become instrumental in the implementation of the plan’s goals and objectives. Other planned activities include a conservation tour in the fall of 2008 as well as a conservation program workshop.

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.

Two of the incentive programs discussed below, EQIP and CRP were administered under the 2002 Farm Bill, which expired September 30, 2007. The Conservation Reserve Program (CRP) 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 (EQIP) 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.

Some of the cost-sharing programs available in the North Fork Vermilion River watershed are described below. The Illinois state programs are not applicable to parts of the watershed in Indiana. However, the federal programs may be applicable.

7.1 Environmental Quality Incentives Program (EQIP)

Several cost share programs are available to landowners who voluntarily implement resource conservation practices in the watershed. The most comprehensive is the NRCS Environmental Quality Incentives Program (EQIP) which offers cost sharing and incentives to landowners 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 landowner).
- Use of vegetated filter strips will earn the landowner $100/ac/yr for three years (up to 50 acres per landowner).
- 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 landowner $15/ac for three years (up to 400 acres per landowner).
- Installation of drainage control structures on tile outlets will earn the landowner $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 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 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 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 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/

7.4 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

7.5 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/

7.6 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 landowners 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/

7.7 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

7.8 Pheasants Forever

The Vermilion County Chapter of Pheasants Forever has been active in the NFVR watershed for over 20 years, assisting landowners in wildlife habitat development. Assistance includes providing food plot seed as well as native grasses, forbs (herbaceous flowering plants), and shrubs at no cost to landowners. Technical assistance is also available. The chapter has also supported seminars, workshops, the development of Heron Park at Lake Vermilion, hunting opportunities for youth, environmental ethics and technique training for school teachers, and the purchase of no-till drills. The chapter's goals include increased wildlife habitat, improved water quality, and decreased soil erosion.

7.9 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 0.6 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 1.0 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 North Fork Vermilion River watershed.

Table 7-1. Summary of Assistance Programs Available for Landowners in the North Fork Vermilion River 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 landowners 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 Fax: (217) 442-6998 Iroquois County **USDA Service Center** 1001 E. Grant St. Ste. A, Watseka, IL 60970 Phone: 815/432-6055 Fax: 815/432-5740
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.	
VCSWCD	Provides incentives for individual components of resource management.	

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. CPP: $10/ac, 200 ac. max.
Conservation Tillage	EQIP: $15/ac for three years, 400 ac. max. ICCI: earns 0.6 mt/ac/yr of carbon trading credit CPP: $20/ac for three years, 40 ac. max.
Cover Crops	CPP: $20/ac
Filter Strips	EQIP: $100/ac for three years, 50 ac. max. CPP: up to 60 percent of installation costs CRP: 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years ICCI: earns 1.0 mt/ac/yr of carbon trading credit for each acre planted
Grassed Waterways	EQIP: 60 percent of construction costs CPP: up to 60 percent of installation costs CRP: 50 percent of the upfront cost to establish vegetative cover and $185/ac/yr for up to 15 years ICCI: earns 1.0 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 1.0 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 1.0 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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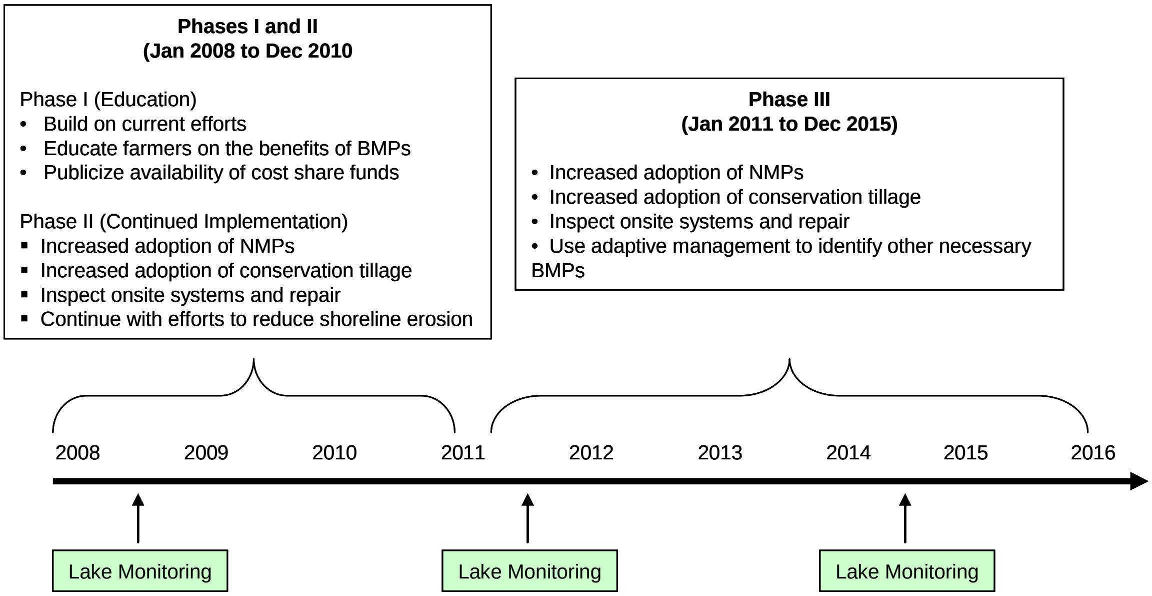
8.0 IMPLEMENTATION TIME LINE

The implementation plan for the North Fork Vermilion River watershed should follow a phased approach to allow for information learned during earlier phases to inform the later phases of the project. A potential time line is described below:

- Phase I of this implementation plan should build on the efforts being conducted in the watershed and continue to focus on education. Educating landowners about the benefits of agricultural BMPs on crop yield, soil quality, and water quality as well as cost share programs available in the watershed is highly important. Informing property owners about onsite wastewater treatment systems and 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.
- Phase II of the implementation schedule should focus on the voluntary implementation of BMPs such as nutrient management planning, conservation tillage, grassed waterways, and outlet control for tile drain systems. 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 should be conducted. Monitoring of water quality in North Fork Vermilion River and Lake Vermilion should continue. This phase of the plan will likely take one to three years.
- Phase III of this implementation plan should include the evaluation of the Phase I and II BMPs to identify those most effective at improving water quality. Strategic placement of the more expensive BMPs should also be considered. This phase could last for five to ten years or until the water quality standards are ultimately met.



Phases I and II
(Jan 2008 to Dec 2010

Phase I (Education)
- Build on current efforts
- 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
- Inspect onsite systems and repair
- Continue with efforts to reduce shoreline erosion

Phase III
(Jan 2011 to Dec 2015)

- 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. Proposed Schedule for North Fork Vermilion River Watershed TMDL Implementation.

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REFERENCES

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

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

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

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

Ettinger, Bill. 2007. Personal communication via telephone dated July 03, 2007. Bill Ettinger, Central Monitoring Manager of Field office, Illinois EPA, Springfield, IL

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

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

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

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

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

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

IASS. 2006. Illinois Farm Report Vol 27 No. 15 and No.16. Illinois Department of Agriculture, National Agricultural Statistics Service.

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

Illinois Environmental Protection Agency (IEPA). 2006a. North Fork Vermilion River and Lake Vermilion TMDL - Stage 1 Report: Watershed Characterization, Data Analysis, and Methodology Selection. Prepared by Tetra Tech EM Inc. February 27.

IEPA. 2006b. North Fork Vermilion River and Lake Vermilion TMDL – Draft Final Report for USEPA Approval. September 6.

IEPA. 2006c. State of Illinois Section 319 – Biannual Report, Appendix 1 – Project Summaries for Completed Grants. Illinois Environmental Protection Agency, Bureau of Water. Springfield, IL. March.

Iowa State University. weblink. Corn Nitrogen Rate Calculator - Finding the Maximum Return To N and Most Profitable N Rate, A Regional (Corn Belt) Approach to Nitrogen Rate Guidelines. http://extension.agron.iastate.edu/soilfertility/nrate.aspx

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

Johnston, Cindy.2007. Personal communication via telephone dated July 02, 2007. Cindy Johnston, Resource Conservationist, Vermilion County Soil and Water Conservation District, Danville, IL

Johnston, Cindy and Peverly, John. 2008. Watershed Implementation Plan for Lake Vermillion and the North Fork Vermillion River. Vermillion County Soil and Water Conservation District.

Keefer, Laura. 2003. Sediment and Water Quality Monitoring for the Vermilion River and Little Vermilion River Watersheds. Prepared for the Conservation 2000 Vermilion River Ecosystem Partnership. Champaign, Illinois.

Kinney, Wayne. 2005. Aerial Assessment Report for North Fork Vermilion River, Vermilion County. Prepared for Illinois Department of Agriculture. September.

Kizil, U. and J.A. Lindley. 2000. Spatial Evaluation of Feedlot Runoff and FeHyd Computer Program. North Dakota State University, Agricultural and Biosystems Engineering Department.

Lin, J.P. 2004. Review of Published Export Coefficient and Event Mean Concentration (EMC) Data. Published by the Wetlands Regulatory Assistance Program, ERDC TN-WRAP-04-3.

Lin, S.D. and W. Bogner, 2005, Phase I: Diagnostic Study of Lake Vermilion, Vermilion County, Illinois. Prepared for the Consumers Illinois Water Company and IEPA. Champaign, Illinois. October.

Lowrance, R. R., R. A. Leonard, L. E. Asmussen, and R. L. Todd. 1985. Nutrient budgets for agricultural watersheds in the Southeastern Coastal Plain. Ecology 66:287–296.

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

Meals, D.W. and D.C. Braun. 2006. Demonstration of Methods to Reduce E. coli Runoff from Dairy Manure Application Sites. J Environ Qual 35:1088-1100. American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America.

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

NRCS. 1999. Natural Resources Conservation Service Conservation Practice Standard. Riparian Forest Buffer (acre) Code 391. NRCS - Iowa. August

NRCS. 2002. Natural Resources Conservation Service Conservation Practice Standard. Nutrient Management (acre) Code 590; Cover Crop (acre) Codel 340.

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

NRCS. 2004. Natural Resources Conservation Service Conservation Practice Standard. Filter Strip (acre) Code 393.

Ohio EPA (OEPA), 2006. Recreational Use Water Quality Survey for the Sugar Creek Watershed 2005.Holmes, Stark, Tuscarawas, and Wayne Counties, Ohio. Ohio EPA Technical Report NEDO/2006-02-01. February 13, 2006.

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

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

Riggle, Kolby. 2007. Personal communication via email to Alix Matos dated May 9, 2007. Vermilion County Health Department.

Roos, K.F. 1999. Animal Wastes Management Systems, Feedlot Workgroup Review Draft. EPA/OAR 1/99.

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

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

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

Thomann, R.V., and J.A. Mueller. 1987. Principles of Surface Water Quality Modeling and Control. Harper & Row, New York.

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

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

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

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

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

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

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

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

Yagow, Gene and et. al. 2001. TMDL Modeling of Fecal Coliform Bacteria with HSPF. American Society of Agricultural Engineering. 2001 ASAE Annual International Meeting. Sacramento, California. July 30 – August 1.