LPL-380

1/18/96

Title: Assessment of phosphorus loading, winter anoxia, and stage regulation of Little St. Germain Lake, near St. Germain, Vilas County, Wisconsin

Location: About 10 miles west of Eagle River, Wisconsin

Problem: Little St. Germain Lake consists of three main basins (Northeast Bay, South Bay, and West Bay) separated by narrows. Northeast Bay consists of the combination of what are locally referred to as East Bay and No Fish Bay (Fig. 1). West Bay is the deepest of the three basins with maximum depth of 53 feet, followed by South Bay with a maximum depth of 21 feet, and Northeast Bay is the shallowest with a maximum depth of 10 feet. Muskellunge Creek, the Lake's only inlet stream, enters Northeast Bay. A dam at the Lake's outlet is used to regulate the Lake's stage and flow from South Bay. Hence, the net flow of water is from Northeast Bay to South Bay.

Water quality varied from basin to basin and seasonally, but there were no apparent annual trends during the recently completed USGS water quality monitoring period (1991-94). However, the Lake's water quality during 1991-94 was better than reported by the Wisconsin Department of Natural Resources (WDNR)(1985) for 1983. The average spring total-phosphorus concentration for 1991-94 was 0.016, 0.034, and 0.032 mg/L in the West, South, and Northeast Bays respectively. In spring 1983 total phosphorus concentrations were reported to be 0.030, 0.040, and 0.045 mg/L in the West, South, and Northeast Bays respectively.

Northeast Bay water quality is poor based on the trophic classification developed by Lillie and Mason (1983) (fig. 2). The WDNR (1985) study suggested that the shallow depth and "high nutrient concentrations from the naturally fertile watershed at the inlet" contribute to the poor water quality in Northeast Bay.

Water quality in South Bay was fair-to-good, but poorer quality than water in West Bay, because of relatively shallow water depths in South Bay and circulation of nutrient-rich water from Northeast Bay. Water at the South Bay sampling site was almost devoid of oxygen during late winter each year from 1992-94 (fig. 3). A dissolved oxygen profile measured by the WDNR (1985) shows a similar, but less severe oxygen problem in 1983. The areal extent and cause of the

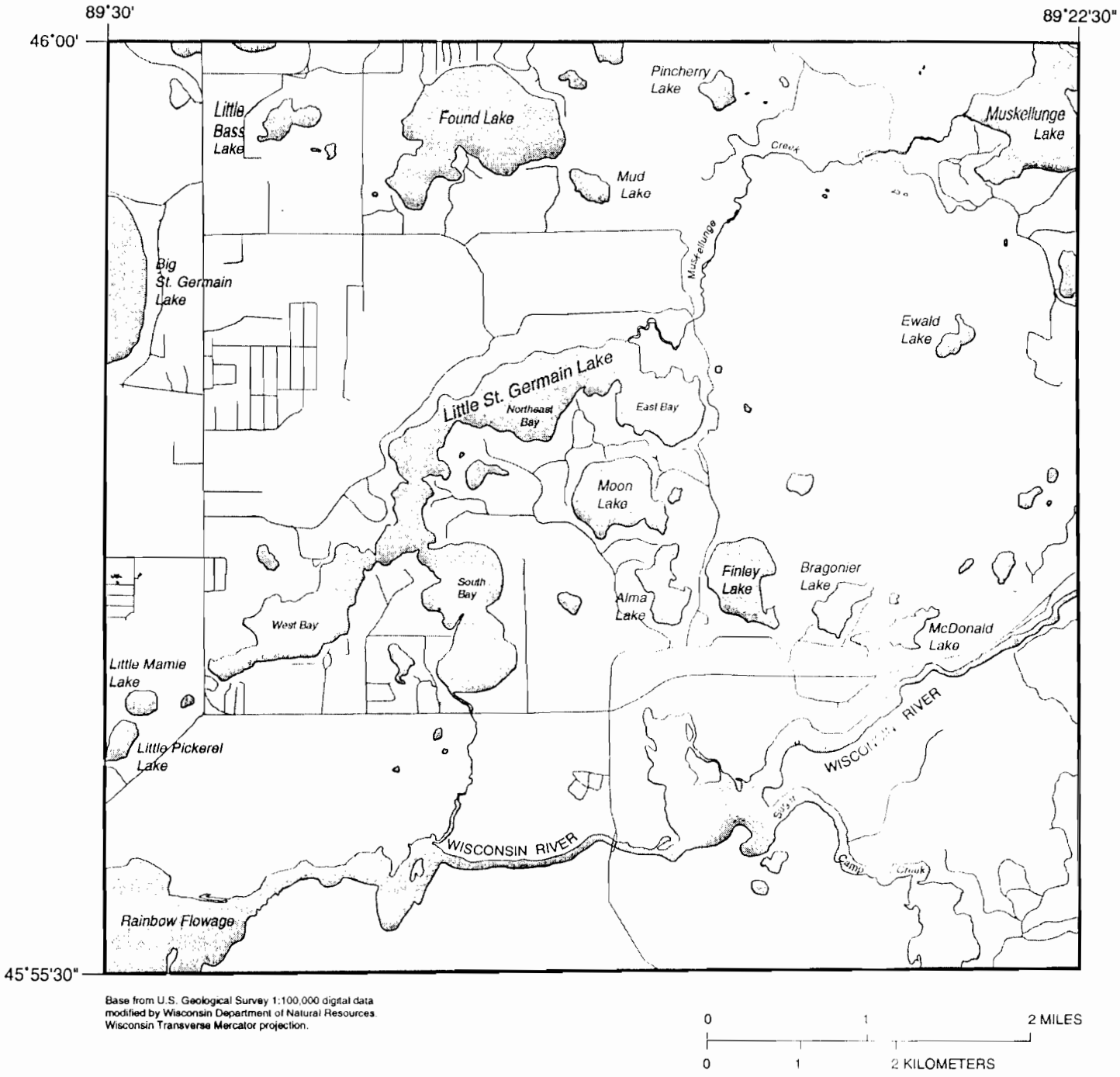


Figure 1. Little St. Germain Lake near St. Germain, Wisconsin.

oxygen problem is not known.

West Bay water quality is good to very good (fig. 3) because of its small watershed runoff, and relative isolation from Northeast and South Bays and the circulation of water from the lake's inlet to outlet. It has been suggested that stage fluctuation resulting from lowering of the lake water level during winter causes nutrient-rich water from Northeast Bay to enter West Bay during refilling in the spring (WDNR, 1985).

The following questions have been raised by past studies:

1. Is the poor water quality in the Northeast and South Bays caused by excessive phosphorus loading from primarily external sources, primarily internal loading from in-lake processes, or from a combination of both?
2. What is the areal extent and cause of winter anoxia?
3. Do stage fluctuations have a significant influence on the water quality of Little St. Germain Lake?

Objectives: In order to address the above questions, the primary objectives of the study will be to

1. estimate the annual total-phosphorus loading from Muskellunge Creek,
2. determine the extent of the dissolved oxygen problem, and
3. estimate the extent of shore area dewatered and rewatered by the annual stage fluctuation cycle.

Benefits: The information gained from the study will provide the Little St. Germain Lake Management District with information needed to evaluate lake management alternatives for maintaining or improving water quality and possibly identify aspects of the Lake needing further study. Quantifying phosphorus loading from Muskellunge Creek will be useful in determining whether loading from the watershed is excessive, and, hence whether to focus improvement efforts on the watershed or on in-lake processes. Knowledge of the extent of the dissolved oxygen depletion will allow the Lake District to know how serious the problem is and whether further study is needed to determine what causes the depletion. Knowledge of the extent of shore area affected by stage fluctuation will aid in evaluating phosphorus cycling and oxygen depletion. The data collected for this study will add significantly to the lake's resource data base, providing a reference against which future conditions can be compared.

Approach:

Phosphorus loading from Muskellunge Creek:

Flow in Muskellunge Creek will be measured and sampled intermittently (approximately monthly). Samples will be analyzed for concentration of total phosphorus. The data will be used to calculate the water and phosphorus loading to the lake.

In-lake water-quality characterization for reference with past monitoring:

The three trend-monitoring sites (those sampled in the USGS program from 1991-94) will be sampled for total-phosphorus and chlorophyll a analysis, depth profiles (temperature, dissolved oxygen, specific conductance, and pH) will be measured with a multiparameter meter, and secchi depths will be measured in April or May, June, July, Aug., and Oct. Samples for total phosphorus analysis will be collected near the surface and near the bottom except for the August sampling, when four samples will be collected in the vertical of the West Bay site and three samples will be collected in the vertical of the Northeast and South Bay sites.

Extent of anoxia:

Dissolved oxygen profiles will be measured monthly throughout the ice period (Dec., Jan., Feb., and Mar.). In addition to dissolved oxygen, profiles of temperature, pH, and specific conductance will be measured. Measurements will be made at the three regular trend-monitoring sites plus a minimum of four additional sites. Water will be sampled for total-phosphorus analysis at sites where there is significant anoxia in the profile during March (locations of measurement sites are shown on figure 4).

Extent of shore area dewatered by current stage-regulation policy:

Near-shore, shallow (<2 feet) bathymetry will be measured at about 50 transects transverse to the shoreline in Northeast and South Bays. Macrophyte presence or absence in the shallow areas will be noted. The transect data will be used to delineate areas subject to dewatering. Lake-stage measurements will be compiled and the datum will be verified by level survey.

Data collected in this study will be entered into the US Geological Survey's surface- and water-quality data bases where it will be readily available for future retrieval. In addition, data will be published in the Wisconsin District's annual lake data report, "Water-Quality and Lake-Stage Data for Wisconsin Lakes".

References:

Holmstrom, B.K., and others, 1992, Water resources data--Wisconsin, water year 1991: U.S. Geological Survey Water-Data Report WI-92-1, 607 p.

_____1993, Water resources data--Wisconsin, water year 1992: U.S. Geological Survey Water-Data Report WI-93-1, 545 p.

_____1994, Water resources data--Wisconsin, water year 1993: U.S. Geological Survey Water-Data Report WI-94-1, 406 p.

_____1995, Water resources data--Wisconsin, water year 1994: U.S. Geological Survey Water-Data Report WI-95-1, 388 p.

Lillie, R.A., and Mason, J.W., 1983 Limnological characteristics of Wisconsin lakes: Wisconsin Department of Natural Resources Technical Bulletin No. 138, 116 p.

Wisconsin Department of Natural Resources, 1985, Little St. Germain, Vilas County--Feasibility study results and management alternatives: 22 p.

Work schedule:

Work element	Activity Date
Design study	Jan.-Feb. 1996
Survey near-shore lake bottom	July-Aug. 1996
Open-water water quality monitoring	Aug.-Oct. 1996
	May-Aug. 1997
Monitor lake stage	Oct. 1996 - Sept. 1997
Monitor flow and sample Muskellunge Creek	Oct. 1996 - Sept.1997
Measure DO profiles during ice-cover period	Dec. 1996 - March 1997
Maintain data base, and process data	July 1996 - Nov. 1997
Analyze and interpret data, prepare summary	Oct. 1997 - Mar. 1998
Transmit data summary to Lake District	Mar. 1998

Cost summary:

(Federal fiscal year Oct. 1 - Sep. 30)

Study element	FY 1996	FY 1997	FY 1998	Project Total
Field operations and data collection	$2,000	$11,600		$13,600
Data analysis, compilation, and interpretation		1,600	3000	4,600
Travel and vehicle costs	600	2,600	350	3,550
Services and supplies		200		200
Data summary preparation and distribution		500	2,650	3,150
Laboratory costs*	100	1,400		1,500
Total	$2,700	$17,900	$6,000	$26,600
Funding Source:				
USGS share	$1,350	$8,950	$3,000	$13,300
Little St. Germain Lake District share	338	2,237	750	3,325
WDNR planning grant	1,012	6,713	2,250	9,975

* Wisconsin State Laboratory of Hygiene to be paid by Little St. Germain Lake District for direct services credit. Costs may be revised after grants are awarded.

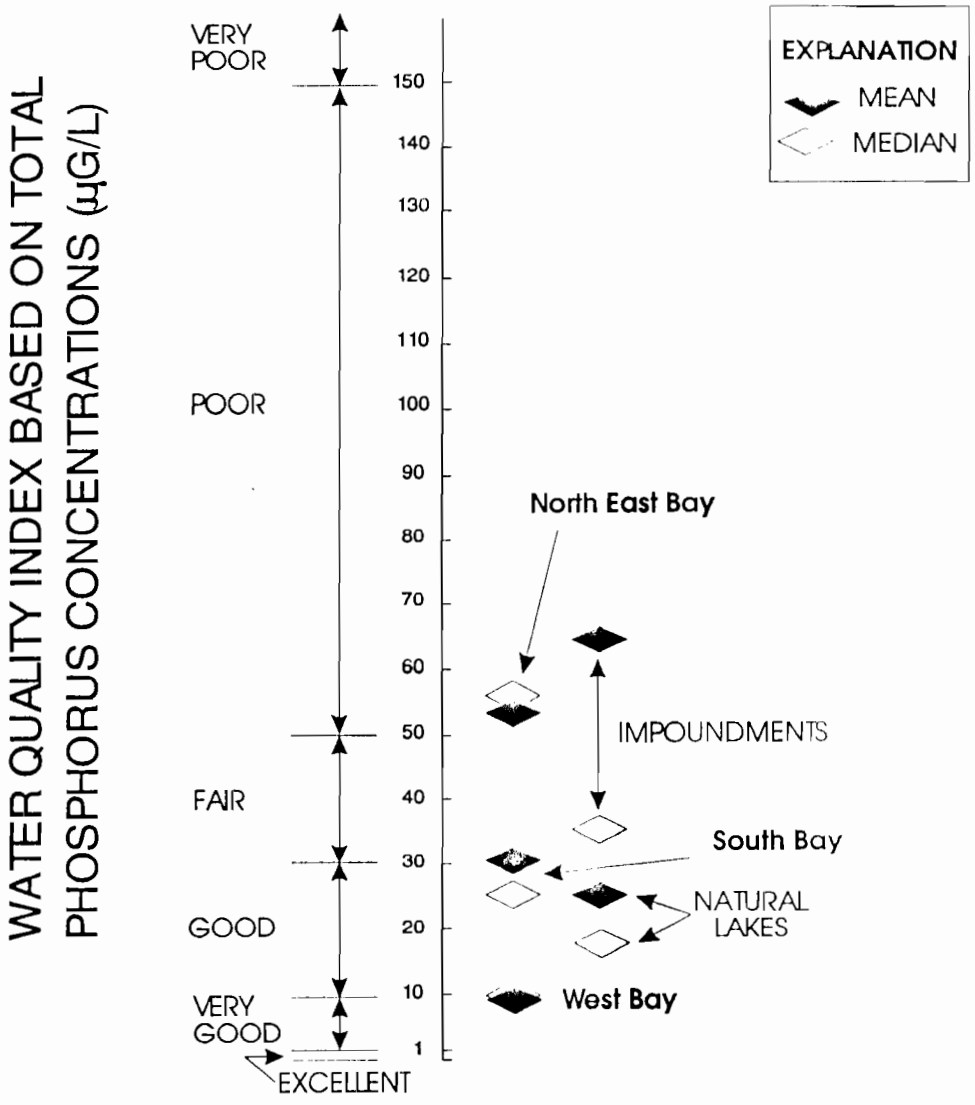
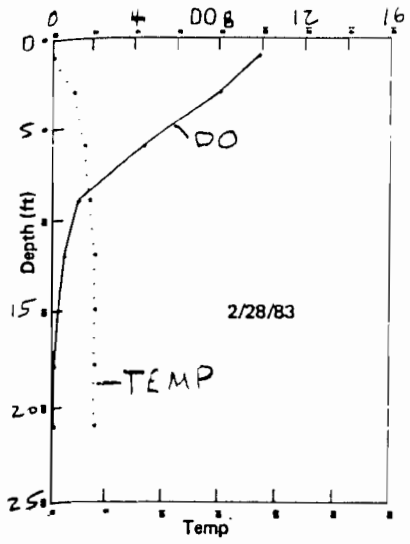


Figure 2. Classification of Little St. Germain Lake's TP Concentration (Jul.-Aug. 1991-94) and Relation to Other Lakes



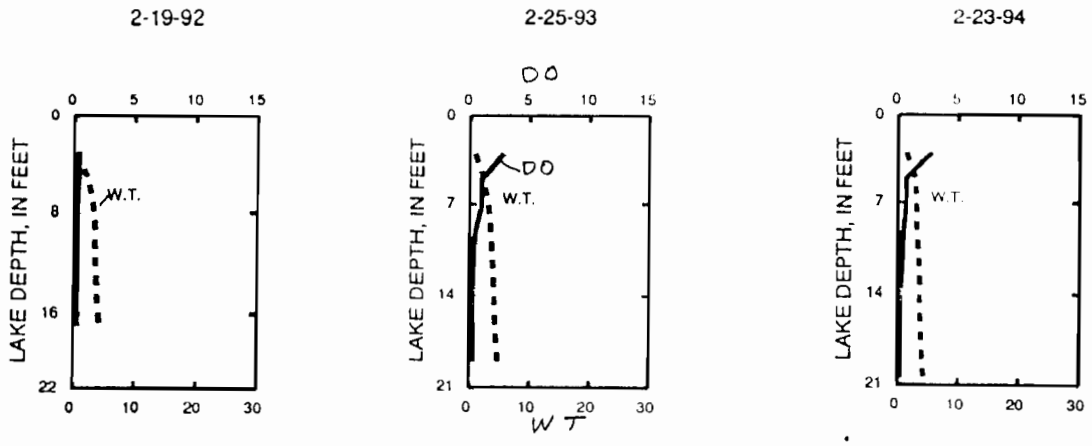
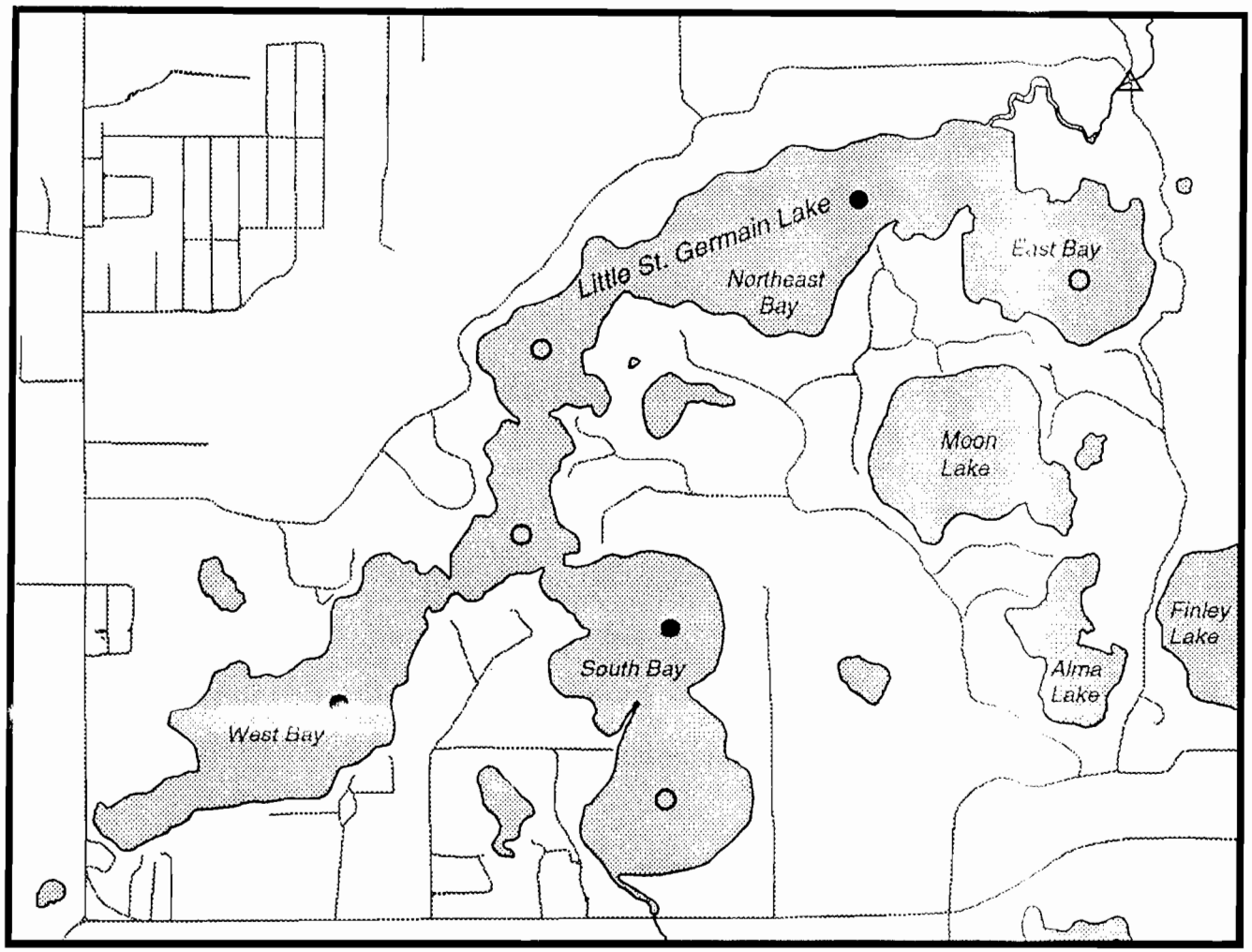


Figure 3. Dissloved oxygen and temperature profiles for sampling site in South Bay, Little St. Germain Lake. Profiles for 2/28/83 from WDNR (1985), and profiles for 2/19/92, 2/25/93, and 2/23/94 from Holmstrom and others (1993-95).



Base from U.S. Geological Survey 1:100,000 digital data modified by Wisconsin Department of Natural Resources. Wisconsin Transverse Mercator projection.

EXPLANATION

△ Streamflow and Water-quality monitoring site

● Long-term trend water-quality monitoring site

○ Auxiliary (winter only) water-quality monitoring site

0 1 Mile

0 1 Kilometers

Figure 4. Locations of proposed monitoring sites at Little St. Germain Lake near St. Germain, WI.