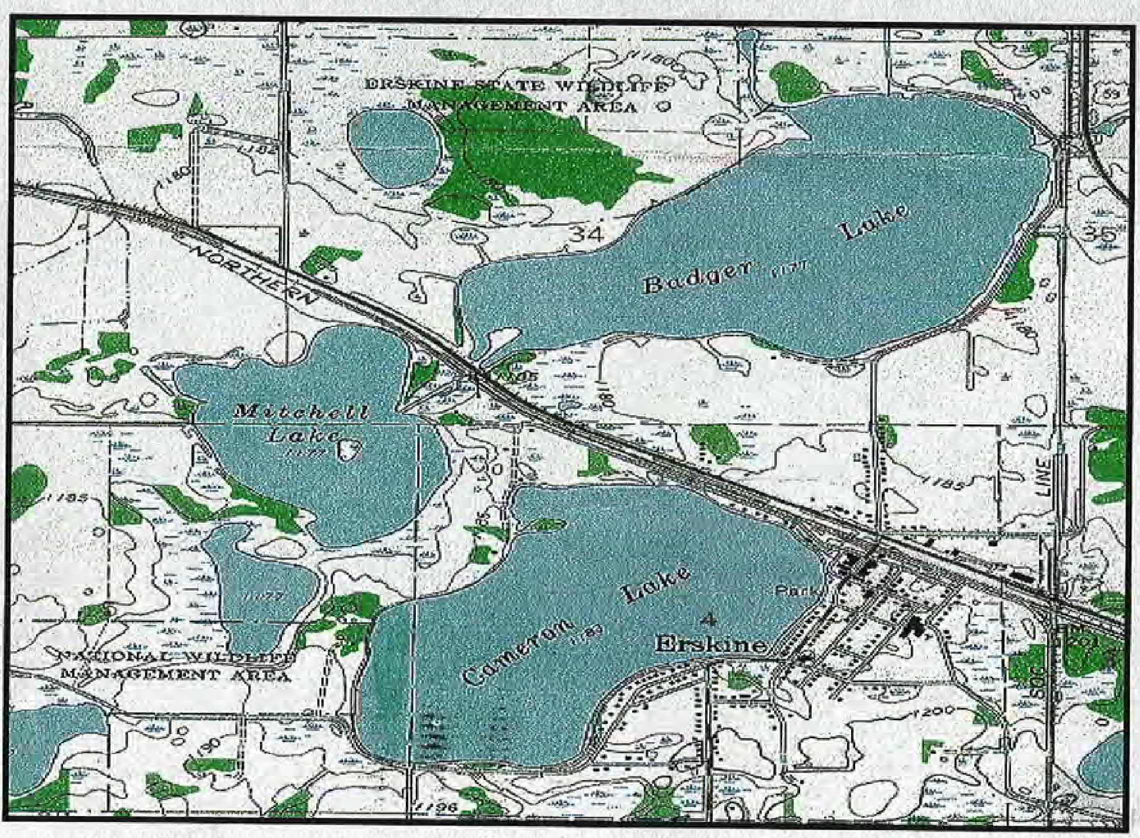
CAMERON LAKE

INVESTIGATIVE STUDY REPORT
FEBRUARY 1997



Cameron Lake Investigative Study

1.0 Introduction

Cameron lake is a rather small shallow lake located in North-Western Minnesota within the Red River Valley Ecoregion. Cameron lake has a surface area of 224 acres, a maximum depth of 8.5 feet and a littoral area (which is the light penetration zone) that encompasses the entirety of the lake. The main water quality problem for Cameron lake seems to be the high levels of nutrients that end up in the water column which in turn cause severe algal blooms. These blooms form dense mats during the growing season and upon decay can cause odor, oxygen and in extreme cases potential human and animal health problems. As a result of the problems that exist, the recreational value which can include fishing, swimming and boating for Cameron lake is essentially zero. The water quality of Cameron Lake deteriorated to the point that the public beach, located on the northeast shore, was diked off from the rest of the lake and filled with city water.

The water quality that exists within Cameron lake has prompted area residents, more specifically the people of the city of Erskine to try to do something about it. In January of 1994, the city of Erskine wrote a letter to the Red Lake Watershed District requesting assistance in performing analysis of waters entering Cameron Lake.

The purpose of this report is to examine and compare the external loadings and the output yields of Cameron lake. This comparison will be used to determine whether the problems facing Cameron lake are internal or external.

2.0 Project Goal

The problems that exist within Cameron lake today are largely suspected to be caused by human activities which have occurred in the past. The former activity which is thought to have had the greatest influence on the present water quality was the creamery which deposited its' wastes into Cameron lake. With the build up of nutrient rich sediments over the years, phosphorus and nitrogen release from this internal source can be very significant.

The overall goal of this project was to attempt to quantify the amount of pollution that enters and exits Cameron Lake. This was done to assess whether implementation activities should be focused in the watershed or within the lake. From the data gathered by this study, suggestions will be made so as to attempt to improve the water quality of Cameron Lake.

3.0 Project Overview

Because of funding and other project commitments, sampling for the Cameron Lake Study did not begin until June 26th 1995. The samples were collected on a storm event related basis or essentially every time it rained enough to produce runoff to the lake. The discharge samples continued to be collected whenever a rain event warranted, until freeze-up. A local observer was used to contact the Watershed whenever any such event occurred. The final set of samples were collected on April 18th, 1996. These were collected to model and quantify a spring run-off event to the lake since this didn't take place in 1995. A summary of the water quality information is presented in table 1 below. (Parameter descriptions and abbreviations are located in Annex A).

Table 1. CAMERON LAKE WATER QUALITY DATA

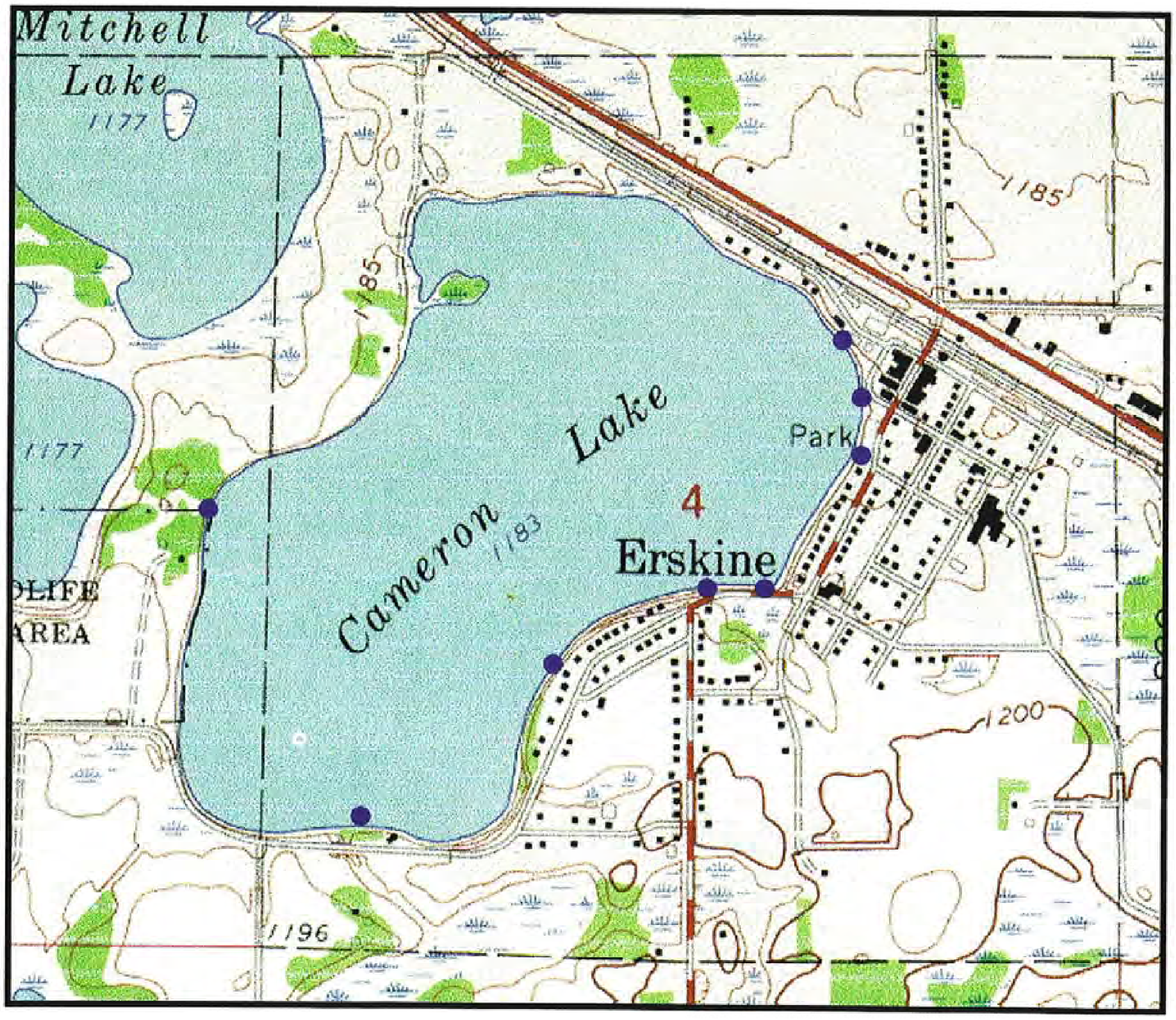
Site	Date	H2O Temp. °C	Cond. mg/L	pH	D.O. mg/L	Alk. mg/L	Turb. NTU's	C.O.D. mg/L	NO3- + NO2- mg/L	TKN mg/L	OP mg/L	TP mg/L	Fecal MPN	TSS mg/L
SS1	6/26/95	24	450	9.6	8.2	221	16	57	0.024	4.28	0.01	0.18	504	9.1
	7/6/95							NST						
	7/14/95	21	173	6.8	10.8	N.T.	51	59	0.27	1.08	0.01	0.14	N.T.	21
	9/6/96							NST						
	9/29/96	16.1	136	8.55	10	N.T.	14	27	0.26	1.33	0.12	0.21	N.T.	15.6
	4/18/96							NST						
SS2	6/26/95	23.2	430	8.37	11	140	7.4	42	0.039	1.67	0	0.13	TNTC	10.6
	7/6/95	18.4	403	6.92	5.1	N.T.	1.5	59	0.007	1.43	0.02	0.25	1000	7.7
	7/14/95	20.5	417	6.95	10	N.T.	2.9	68	0.01	1.6	0.01	0.15	N.T.	16.7
	9/6/96	21.1	359	9.5	6.2	159	11	57	0.094	1.34	0	0.25	110	24.3
	9/29/96	14.8	148	7	7	N.T.	9.3	23	0.46	0.69	0.21	0.34	N.T.	7.3
	4/18/96	2.5	153	8.05	9.2	80	1.6	3	0.2	BDL	0.05	0.09	0	14.6
SS3	6/26/95	23.8	450	9.62	10.2	238	13	40	0.001	2.92	0	0.03	95	12.2
	7/6/95	18.3	533	8.64	8.4	N.T.	4.5	45	0.077	BDL	0	0.08	283	7.6
	7/14/95	21	354	9.15	10.6	N.T.	3.6	40	0.13	1.96	0.02	0.15	N.T.	10.5
	9/6/96	21.1	354	9.51	4.9	157	8.9	40	0.139	0.58	0	0.11	910	15.7
	9/29/96	14.8	143	7.33	8	N.T.	3.9	17	0.14	1.23	0.2	0.26	N.T.	1
	4/18/96	10.3	364	7.9	9.5	200	8.5	24	0.37	BDL	0.18	0.38	N.T.	9.6
SS4	6/26/95	24.7	444	9.76	13.1	246	33	85	0.002	1.65	0.01	0.12	39	54
	7/6/95	18.4	596	7.6	8	N.T.	1.5	105	0.14	0.93	0.01	0.14	368	3
	7/14/95	22	627	7.29	10.9	N.T.	1.8	130	0.12	2.8	0.01	0.14	N.T.	76.7
	9/6/96	21	402	7.95	7.2	149	20	36	0.143	1.49	0.01	0.18	900	21.7
	9/29/96	14.2	190	7.43	7.2	N.T.	26	33	0.13	0.5	0.06	0.19	N.T.	15.9
	4/18/96	4.6	423	7.75	9.2	260	2	42	0.084	BDL	0.07	0.11	0	6.1
SS5	6/26/95							NST						
	7/6/95	18.4	503	7.68	8.2	N.T.	1.7	34	0.039	1.33	0.01	0.1	321	2.7
	7/14/95	21	423	8.3	11.2	N.T.	3.2	49	0.022	1.59	0.01	0.12	N.T.	36.9
	9/6/96							NST						
	9/29/96	15	125	7.53	8.8	N.T.	9.6	33	0.084	0.45	0.14	0.29	N.T.	24.7
	4/18/96	11.9	298	7.95	11.2	16	1.8	9	0.29	BDL	0.15	0.2	21	6.1
Inlet #1	6/26/95	21	600	7.77	2.5	337	17	41	0.001	1.57	0.01	0.09	704	10.1
	7/6/95	18.5	535	7.42	7.5	N.T.	5.8	60	0.007	1.66	0	0.07	247	3.9
	7/14/95	20	544	7.16	10.4	N.T.	7.8	58	0.003	1.92	0	0.14	N.T.	20
	9/6/96	18.2	636	7.47	2.3	257	19	39	0.001	1.41	0.01	0.17	820	15.4
	9/29/96	13.5	472	7.45	6	N.T.	6.7	40	0.18	0.71	0.05	0.1	N.T.	4.5
	4/18/96	4.5	380	7.53	7	220	2.4	21	0.16	0.54	0.04	0.05	0	6.2
Inlet #2	6/26/95							NST						
	7/6/95	18.5	658	7.02	7.4	N.T.	1.5	57	0.001	0.02	0.01	0.15	TNTC	5.6
	7/14/95	20	526	7.14	10.4	N.T.	2.3	63	BDL	2.06	0.01	0.14	N.T.	15
	9/6/96							NST						
	9/29/96	13.5	511	7.29	2.8	N.T.	4.6	37	0.36	0.92	0.58	0.67	N.T.	3
	4/18/96	3.7	303	7.72	7	160	3.5	15	0.14	BDL	0.16	0.29	0	10.1

Site	Date	H2O Temp. °C	Cond. mg/L	pH	D.O. mg/L	Alk. mg/L	Turb. NTU's	C.O.D. mg/L	NO3- + NO2- mg/L	TKN mg/L	OP mg/L	TP mg/L	Fecal MPN	TSS mg/L
Outlet	6/26/95	24.7	490	9.45	8.2	244	12	44	0.006	2.21	0.01	0.07	49	20.7
	7/6/95	18.7	470	8.67	8.1	N.T.	4.5	30	BDL	0.6	0	0.06	25	12.4
	7/14/95	20	434	8.65	11.4	N.T.	5.3	42	BDL	2.22	0	0.07	N.T.	18
	9/6/96	21.4	412	9.56	5.2	189	6	53	0.001	2.18	0	0.06	500	15.3
	9/29/96	15.2	410	9.5	9.6	N.T.	4.1	56	0.009	1.63	BDL	0.04	N.T.	1.5
	4/18/96	5.7	276	8.8	6	200	0.9	11	0.14	2.27	BDL	0.04	0	6.3

3.1 Site Selection

Site selection for this study was based on the goal stated above, which was to quantify the pollutant loads that were entering and exiting the lake. There was a total of five storm sewers and two natural inlets that discharged water to the lake. These were sampled to quantify the external loads entering the lake. There is only one outlet of the lake which was sampled to quantify the pollutant loads exiting the lake. Figure 1 shows the locations that were sampled. ● = **Sampling Locations**

Figure 1. CAMERON LAKE SAMPLING LOCATIONS



Scale - 4.5 inches equals 1 mile.

3.2 Flow Monitoring

A continuous flow recorder was installed on the main inlet channel on July 13th, 1995. The continuous monitoring information was also supplemented by manually stream gauging as many times as possible to obtain an accurate hydrograph. This information was then used to calculate the flows for the other sampling locations. A more detailed description of the flow quantification is included in section 5.2.

3.3 Water Quality Monitoring

The first set of samples were collected on June 26th, 1995 after a rain event of over one inch. Four more sets of samples were taken in 1995 concluding with a set taken on September 29th. An April 18th 1996 set was taken to represent a spring runoff event. Direct runoff to the lake was considered to be negligible. The following figure shows all of the sampling events and the corresponding rain events.

The RLWD used its' local observer within the city limits of Erskine to relay rainfall totals so we knew when a sampling trip was warranted. As you can see by figure 2, sampling after every rain event did not occur. Other project priorities or no confirmation about the event from our contact person account for this.

Figure 2. Precipitation and Sampling Date Comparison

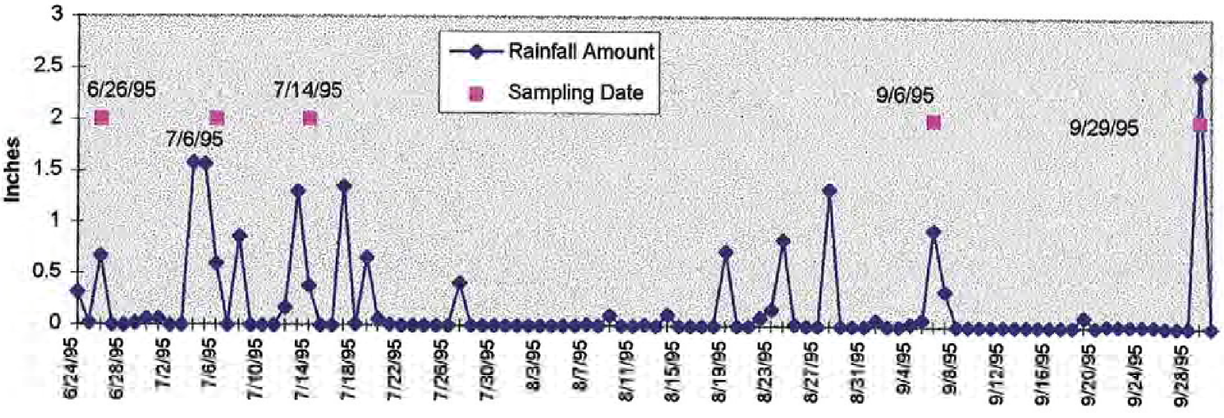


Fig. 2. Comparison of rainfall amounts and sampling dates for the Cameron Lake monitoring period.

The following chemical, biological and physical analyses were performed on the 5 storm sewer inlets, the two natural inlets, the lake and the outlet. These parameters were analyzed at the University of Minnesota Crookston's certified environmental testing laboratory. For explanations of the parameters, see annex A.

- Total Phosphorus
- Orthophosphorus
- Nitrate + Nitrite
- Total Kjeldahl Nitrogen
- Chemical Oxygen Demand
- Turbidity
- pH
- Specific Conductance
- Total Suspended Solids
- Fecal Coliforms
- Dissolved Oxygen
- Temperature

Field measurements performed at the time of the sample collection as well as other observations include:

- Name of Collector
- Date
- Time
- Unusual characteristics observed at the site at the time of sample collection
- Air Temperature
- Water Temperature
- Field pH
- Field Specific Conductance
- Dissolved Oxygen
- Estimated Stream Flow

Samples were collected using a Kemmerer bottle where appropriate, or they were dipped using a beaker that was rinsed a minimum of three times with distilled water between sites and at least once with the water that was collected. The samples are then labeled, placed in a sterile water bag, transferred to a cooler and put on ice (kept at 4°C, 39.2°F) for transport to the laboratory. The samples were analyzed or prepared for analysis within the maximum regulated storage time allowed for each specific parameter. Quality Control and Assessment guidelines for the laboratory were strictly followed during the sample analysis.

3.4 Modeling Methods

The computer program **FLUX** was used to calculate tributary loads. **FLUX** is an interactive menu driven program, which consists of 5 unique methods for load estimation (Walker, 1986). The program uses daily stream volume and chemistry data, and is supported by the Army Corps of Engineers, Vicksburg, Mississippi.

The goal of the load estimation procedure is to minimize the error associated with the load estimate. This is accomplished by first estimating the load for each of the techniques and noting the variance associated with each estimate. The method with the lowest variance was chosen and estimates for each inlet and the outlet were determined. This method tended to be "Method 4, Regression First Order" (see page II-7, Walker 1986). This method assumes loading is proportional to some power of flow, the power determined by a regression relationship between concentration and flow.

The computer water quality program **BATHTUB** (Version 4.4) was used for predicting present and future in-lake concentrations, given actual and theoretical total phosphorus loads. The model predictions that are illustrated in the Trophic Status figures represent average concentrations during the ice-free season.

4.0 Limnological Concepts

Limnology is the study of lakes, and is the central idea of lake management. A basic understanding of limnological concepts is needed to understand why certain lake management measures are effective in improving water quality, and why other measures fail. This portion of the report presents some of the important limnological concepts and ideas, for the lay person.

4.1 The Limiting Nutrient Concept

The idea of nutrient limitation is basic to dry-land and aquatic biology. All plants using light as an energy source need nutrients and a source of carbon (often carbon dioxide) to grow. When a nutrient is present in quantities small enough to prevent or reduce plant growth it is considered the limiting nutrient. By limiting the amount of nutrients entering Cameron Lake, the quantity of plant biomass like algae, can in theory be reduced. The analogy is the use of fertilizers by farmers to increase crop yields. Phosphorus and nitrogen are the two substances that generally limit plant growth in lakes, although light level may also limit plant growth. Therefore it is important to know the amount of nutrients per volume of water for various forms of phosphorus and nitrogen. The ratio of nitrogen to phosphorus is also important. Generally, lakes with inorganic nitrogen to inorganic phosphorus ratios exceeding approximately 7-10 are considered phosphorus limited (Walker, 1986). Lakes with a ratio less than 7 are considered nitrogen limited. The ratio for Cameron lake based on inflow and outflow concentrations was about 10 which would make it phosphorus limited. In reality, it is difficult to control the amount of nitrogen entering a lake. Nitrogen gas is a major component in the atmosphere and many blue-green algae can directly use or "fix" atmospheric nitrogen. For this reason, most lake management strategies concentrate on controlling the amount of phosphorus entering a lake.

4.2 Lake Morphometry

Lake morphometry describes the physical characteristics of a lake basin; the maximum depth, the average depth, the volume, the surface area and the length of shoreline. Physical characteristics are important because lake morphometry influences water quality and physical characteristics are used for input into the water quality model. Lakes that flush rapidly, or have large amounts of water entering compared to lake volume, generally have lower algae concentrations. Figure 3 shows a "bathymetric map" for Cameron Lake, while Table 2 shows the lake's morphometry data.

Figure 3. Cameron Lake Bathymetric Map

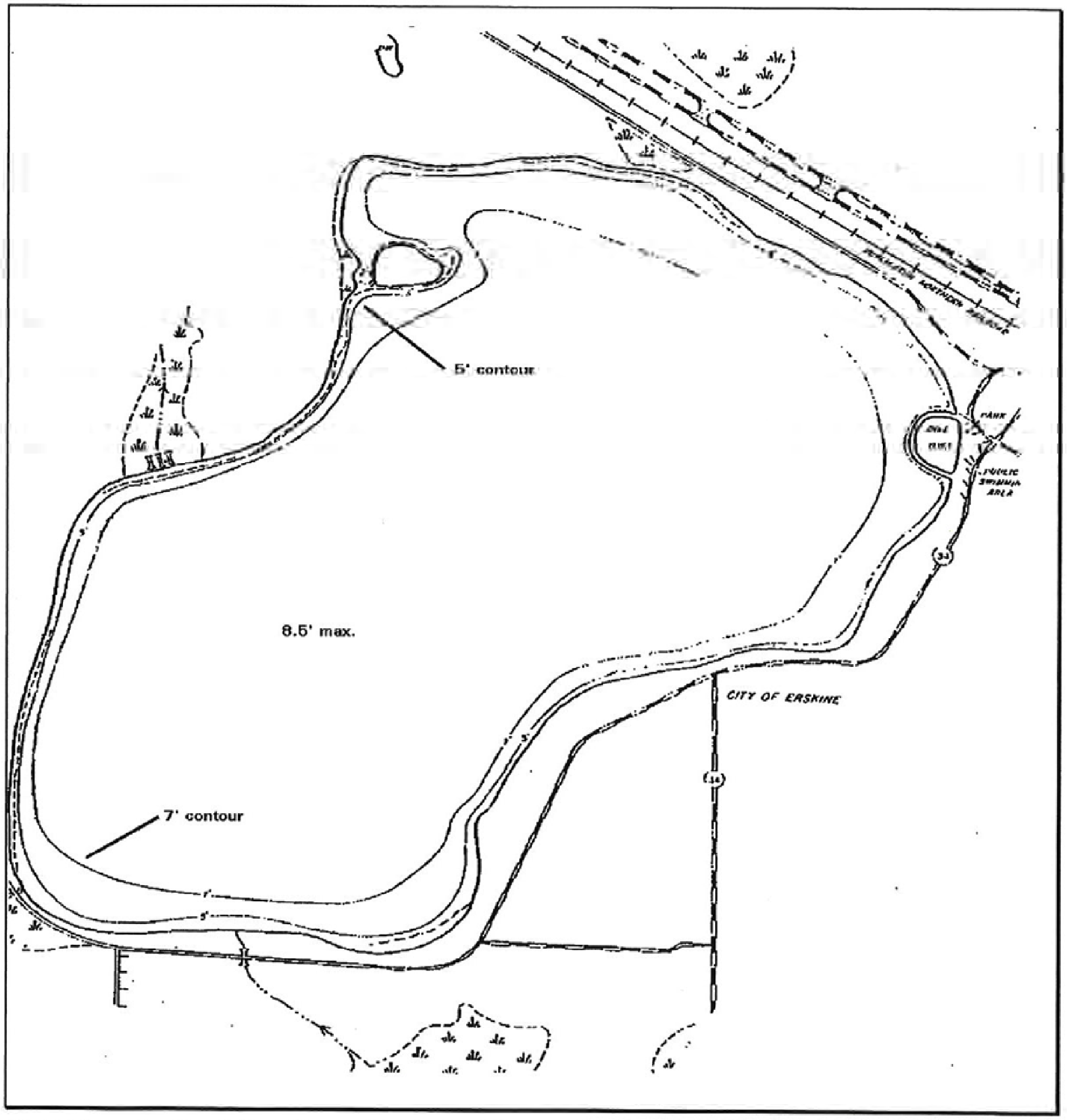


Fig. 3. The contour lines indicate the associated depths of Cameron Lake. Maximum depth is 8.5 feet.

Table 2. Cameron Lake Morphometric Data

Characteristic	Value
Lake Length (miles)	.92
Maximun Width (miles)	.62
Shoreline Length (miles)	2.74
Maximum Depth (feet)	8.5
Mean Depth (feet)	7.5
Surface Area (acres)	224
Drainage Area (acres)	1562
Volume (acre feet)	891.05
Hydraulic Residence Time (years)	2.09

4.3 Trophic Status

The trophic status of a lake is an index or measure of the potential for plant growth, amount of oxygen and a general estimate of nutrient availability (and hence plant growth) within a lake. It is an index of water quality. Lakes can be generally classified as, in order of increasing productivity (and presumably declining water quality):

- Oligotrophic - indicated by low plant productivity and high transparency, cold water fisheries
- Mesotrophic - appropriate for water based recreation but not cold water fisheries
- Eutrophic - indicated by high photosynthetic activity and low transparency, warm water fisheries
- Hypereutrophic - indicated by frequent algal blooms, extensive weed growth and fish kills due to low oxygen levels

Using historical data combined with the data collected from this study, Cameron lake can be classified as hypereutrophic. Figure 4 shows where Cameron Lake falls within Carlson's Trophic state index. This means Cameron Lake has the tendency for growing "large" amounts of plants and the water quality probably will not support a viable game fish population.

Figure 4. Carlson's Trophic State Index for Lake Cameron

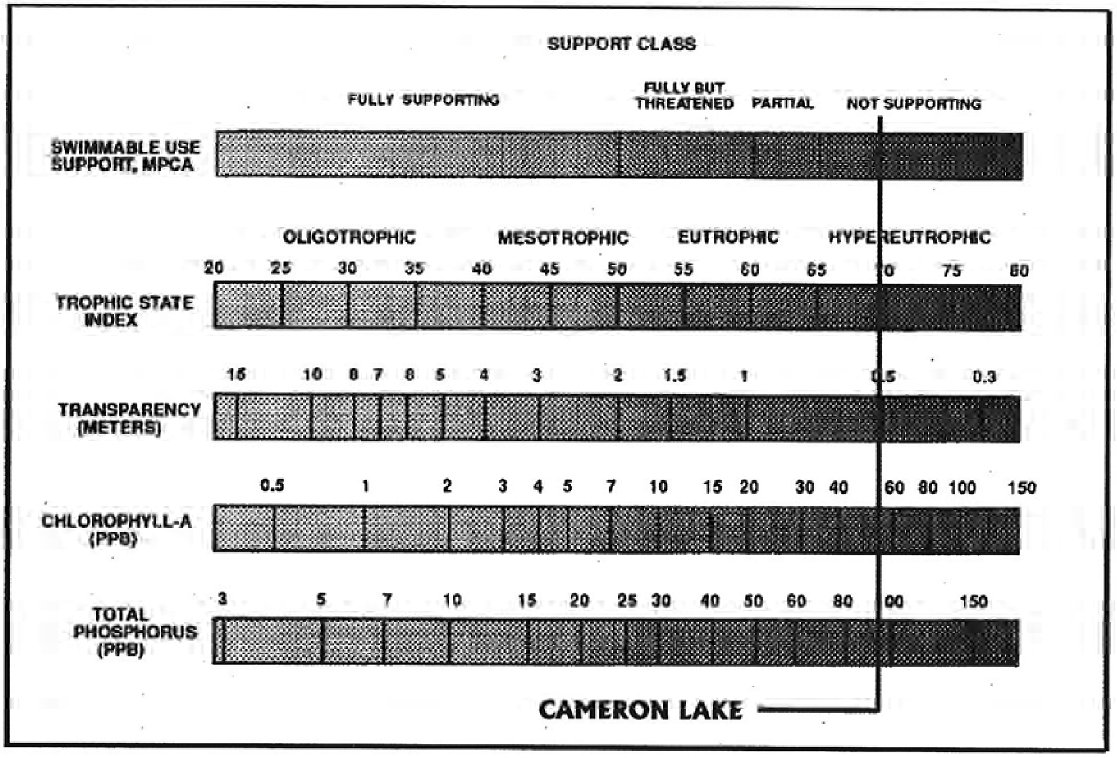
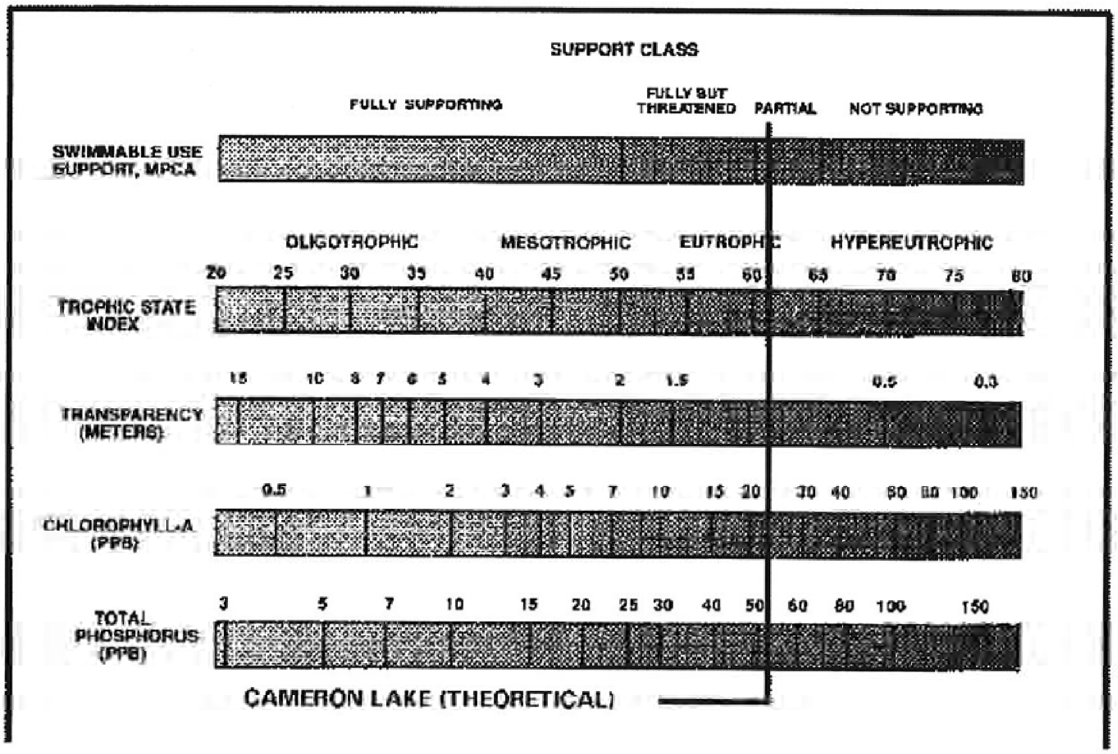


Fig. 4. Illustration of the trophic state of Cameron Lake under the current water quality conditions. Cameron Lake is considered hypereutrophic and therefore, not supporting of swimmable use.

The model that was used to estimate Cameron Lake's current condition was also run to obtain a theoretical trophic state. Figure 5 shows the lake's trophic state based on "cleaner" water entering the lake from the 5 storm sewers and the 2 inlets.

Figure 5. Theoretical Trophic State for Cameron Lake



As you can see, if the external loads to Cameron Lake can be improved, theoretically, the lake's response will move towards a partially supporting trophic status. The information used as input from the theoretical model was taken from the Minnesota Pollution Control Agency's Red River Valley ecoregion data for minimally impacted streams

4.4 The Nutrient Budget

Like a hydrologic budget which is an accounting of water, a nutrient is an accounting of the amount of weight, or mass of nutrients entering and leaving Cameron Lake. Often the term load is used. A load is the mass of a substance passing a specific location during some period of time. Loads are expressed in units of mass per time (e.g. , lbs/year). Loads are estimated by considering the concentration of a substance in water and the amount of water; a load is the concentration times the flow. A high load may result from a high flow, but a low concentration. Or, a high load may result from a high concentration and a low flow. Concentration and flow are needed to calculate loads.

The concept of nutrient loading to a lake is key to understanding how a lake works. Generally, the lower the loading of nutrients like phosphorus and nitrogen, the less plant growth. The strategy of most lake management plans is to reduce nutrient loading. Management strategies for lakes generally concentrate on reducing the phosphorus load. This is because phosphorus is generally the limiting nutrient in lakes and is easier to control than nitrogen. As explained earlier in Section 4.1, the large atmospheric source of nitrogen and the ability of some algae to fix atmospheric nitrogen, makes control more difficult.

4.5 Water Quality Modeling

A water quality model is simply a mathematical representation of the processes occurring within a lake; a set of equations "packaged" together. Models may be simplistic or complex. Simple models generally treat a lake as a "box" and balance the nutrient load entering and leaving a lake. Algae "grow" in the box model, based on observations from other similar lakes or scientific theories. Complex models use equations to represent specific processes within a lake; like the growth and settling of algae. Often these equations are based on measurements made within the laboratory; biological, physical, chemical parametric determinations.

The power of water quality modeling is that it allows the prediction of water quality within Cameron Lake, under assumed conditions; ie., assumed nutrient loading if the incoming waters are improved. The theoretical trophic status, fig. 5, illustrates this point. Another example of this is, you would be able to evaluate the amount of phosphorus reduction needed from all or specific external inlets to attain a certain in-lake phosphorus concentration.

The water quality model **BATHTUB** (Version 4.4) was used to evaluate the information on trophic status for Cameron Lake. **BATHTUB** is a model distributed and supported by the U.S. Army Corps of Engineers, Waterways Experiment Station. The model was developed specifically for reservoir application, but is generally appropriate for use on Cameron Lake.