Corbett Lake Management Plan

Phase 1 and 2 Report

Ladysmith, Wisconsin

SEH No. LADYS9706.01/02

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Corbett Lake Management Plan

Ladysmith, Wisconsin

1.0 Introduction

Corbett Lake is a 33-acre basin located on the southwest side of the City of Ladysmith (see Figures 1 and 2). Contributing watershed areas to the lake have been significantly reduced by human activity. Formerly several square miles of rural land drained to Corbett Lake. However, due to human intervention early this century much of the watershed draining to Corbett Lake was diverted away from the City of Ladysmith. Today the 0.3 square mile (192-acres) Corbett Lake watershed lies entirely within the City limits and includes both portions of the downtown area (primarily commercial and light industrial land uses) and residential areas adjacent to the lake. The lake drains via a bee hive inlet and buried pipe to the Flambeau River.

Since Corbett Lake lies within the City of Ladysmith it is very accessible by City residents including both adult and children walkers and bikers. A City park (Falge Park) extends across much of the north shore of the lake. The park includes a short trail, playground equipment, picnic areas and a boat launch. Blue-gill and largemouth bass were stocked in the lake approximately 6 years ago. Residents enjoy fishing along the shores of the lake for pan fish and bass although the fish have become stunted in recent years. A new City of Ladysmith/Rusk County library is located adjacent to Falge Park on a hillside overlooking a bay of Corbett Lake. The library is expected to increase the recreational use of Corbett Lake.

Corbett Lake has a maximum depth of 12 feet and an average depth of 4 feet (see Figure 3). The northern portion of the lake adjacent to the library is the relatively deep area while the remainder of the lake is generally 6 feet deep or less. In August open water is found almost exclusively in the northern bay of the lake adjacent to the library. Elsewhere macrophytes dominate the lake with just an occasional small patch of open water being present. The Upper Chippewa River Basin Water Quality Management Plan (Wisconsin Department of Natural Resources, 1996) indicates that Corbett Lake has limited fishery potential. However, based on the ability to catch pan fish and bass in the past, the City of Ladysmith believes the lake to have significant potential for producing fish which residents will enjoy catching.

Corbett Lake does have a summer, fall, and winter dissolved oxygen problem primarily due to its generally shallow morphometry. In response to this problem, the City of Ladysmith operates a cascade aeration system located at the northeast side of the island in Falge Park.

1.1 History of the Corbett Lake Watershed

A forest and wetland dominated rural watershed formerly drained into Corbett Lake. The natural watershed of Corbett Lake extended upstream northwesterly to Tulea Lake, known locally as Dump lake. About 1916, the majority of the Corbett Lake surface water drainage was diverted away from the approximately 66-acre lake as it existed at that time (Terrill, undated). A ditch was constructed to drain water in wetlands west and north of Ladysmith. The ditch began at Bruno Lake and flowed into Dump Lake. The drainage ditch then ran southeast from Dump Lake towards Ladysmith. Near the western limit of the City, the ditch was turned south with runoff waters entering the Flambeau River near the present Mt. Scenario College. The remaining portion of the natural inlet channel to Corbett Lake between the ditch and the lake was diverted west into the drainage ditch. Shortly thereafter, the outlet to Corbett Lake was also modified and normal water levels in the lake were further reduced. Since that time the extent of the Corbett Lake watershed has remained approximately the same, though the City of Ladysmith has grown considerably around the lake such that all runoff entering the lake is of urban origin.

1.2 Project Overview

Issues and problems which need to be addressed during development of the Corbett Lake Management Plan include the following:

- Improve lake water quality;
- Manage pollutants in urban runoff entering the lake;
- Reestablish the lake's natural watershed;
- Control macrophytes;
- Protect and improve fisheries habitat;
- Increase recreational opportunities; and
- Protect and improve wildlife habitat.

The overall goal of the project is to improve Corbett Lake's water quality. Phases 1 and 2 of the project involved a basic data collection program to build the water quality and physical characteristic database needed to support water quality management decisions for Corbett Lake. The results of Phase 1 and 2 are presented in this report.

The quality of Corbett Lake has been degraded by the loss of a major portion of the contributing watershed area. The effectiveness and feasibility of reestablishing some of the Corbett Lake watershed as a means of improving water quality has been initially reviewed as part of Phase 1. Collecting water level data needed to analyze the feasibility of reestablishing some watershed areas is one focus of work in progress.

Macrophytes are present in many areas of the lake and one goal of the City is to control macrophyte growth, particularly in areas adjacent to the eastern deeper area of Corbett Lake. This may involve dredging some areas on the eastern side to deepen the lake further or a program of harvesting the macrophytes. An analysis of the benefits and feasibility of dredging will be included in the project.

The City of Ladysmith believes a descent fishery can be reestablished in the lake. Over the last several years, pan fish have become stunted which may relate to water quality degradation. The City desires to take steps to reverse this trend.

Improving recreational opportunities at Corbett Lake is another important goal. With improved water quality and fishery, the City would reestablish a fishing pier at Falge Park. Another potential recreation improvement would be to construct a boardwalk over wetland areas found at the west end of the park.

Another project opportunity would be to enhance wildlife habitat. For instance, it may be possible to use sediments removed during dredging to build small islands at the western end of the lake.

1.3 History of the Project

Phase 1 work at Corbett Lake completed for this report is supported by Lake Management Planning Grants number LPL-460 and LPL-491. The first phase focused on collecting basic data for Corbett Lake which addresses the first three project overview issues. The two main data collection tasks supported by the Lake Management Planning grant LPL-460 are as follows:

1. Obtain basic water quality data from two locations within the lake. Lake samples were collected once per month for the months of May, June, July, August, and September 1997. Qualitative observations on macrophyte, algae, and zooplankton populations were noted when the samples were collected.

2. Corbett Lake subwatershed boundaries were delineated in the field along with inflow points, drainage areas, and land use.

The second grant, LPL-491, allowed a topographic profile to be obtained between Corbett Lake and the drainage diversion ditch west of Ladysmith conveying runoff from former watershed areas. A series of staff gages were set between the lake and the diversion ditch. Water surface elevation readings were collected at least twice a month. The profile and water surface elevation data are now available to provide an initial interpretation of the feasibility of reestablishing some the lake's natural watershed.

Phase 2 of the project is also underway now, with support from Lake Management Planning Grant LPL-512. Work tasks to be completed include development of a preliminary annual water budget, creation of a bathymetric map and sounding of soft sediment depth.

2.0 Data Collection Results

A variety of environmental data has been collected during the first two phases of the Corbett Lake project including water quality, water level, bathymetry and soft sediment thickness. The results of these data collection efforts are presented in this section of the report.

2.1 Lake Bathymetry and Soft Sediment Thickness

The bathymetric map (Figure 3) was prepared following a January 1998 lake survey. Overall, the lake is relatively shallow with the primary exception being the recently dredged bay adjacent to the Rusk County Library. The remainder of the lake is generally 6 feet or less in depth.

Soft sediments were also probed over the eastern half of the lake. The thickness of the soft sediments ranged from 1 or 2 feet near shore to 15 feet in the center of the lake. Over 100,000 cubic yards of soft sediment was found in the eastern half of the lake. Visual inspection of upper layers of the sediment indicate a primary source of the material is the macrophytes present in the lake.

2.2 Lake Water Quality

Lake water quality samples were collected at the two stations shown on Figure 2 on a monthly basis for the period from May 1997 to September 1997. Sample station 1 (CL-01) was at the deepest point of the lake and both surface and bottom samples were obtained. Only a surface sample was collected at station 2 (CL-02). Table A-1 in Appendix A presents the raw water quality data obtained. The laboratory report sheets for the data are found in Appendix B.

Qualitative observations were also made of macrophytes (rooted aquatic plants) and algae (microscopic plants) present in the lake. Appendix C contains the listing of macrophytes observed growing in Corbett Lake. A moderately diverse macrophyte community was found. In general, macrophytes dominate most of the relatively shallow lake. Qualitatively, algae were not observed to be a problem though algae could be observed growing within the macrophyte beds.

Table 1 below summarizes the water chemistry data. Phosphorus and chlorophyll "a" (chl a) concentrations are chemical measurements of biomass productivity and lake water quality state (trophic status). It is important to note the water column data for total phosphorus and chl a do not measure the amount of these materials found within the macrophytes.

Table 1
Corbett Lake Water Quality Data
Sample Site Summary

Parameter	Unit	CL-01 (Surface)		CL-01 (Bottom)		CL-02 Surface	
		Mean	Range	Mean	Range	Mean	Range
Chlorophyll a	µg/l	11.16	5.4-20.3	NA[1]	--	6.74	3.85-10.6
Ammonia-Nitrogen	mg/l	.005	nd(3)[2]-.015	.067	nd-.248	.007	nd(3)-.019
Nitrate-Nitrogen[3]	mg/l	.002	nd(4)-.01	.020	.01-.033	.002	nd(4)-.01
Total Kjeldahl Nitrogen	mg/l	.658	.6-.71	2.48	0.9-6.68	.73	.65-.8
Total Phosphorus	mg/l	.029	.012-.041	.102	.047-.161	.024	.02-.033
Dissolved Reactive Phosphorus	mg/l	.001	nd(3)-.004	.002	nd(3)-.007	.001	nd(3)-.002
Chloride	mg/l	86	80.7-90	104	81.5-140	86	83.2-89.1
pH	SU	7.2	6.04-8	6.4	5.8-6.7	7.2	6.0-7.6
Specific Conductance	µs/cm	302	268-329	378	346-455	296	267-327
Dissolved Oxygen	mg/l	7.6	4.94-9.4	0.30	.11-.62	3.6	0.6-10.1
Redox Potential	mV	292	278-303	134	94-222	345	301-386
Secchi Depth	ft	6.0	4.5-8.4	NA	--	4.2	3.6-4.6

1. Not applicable
2. Not detected, number of times not detected in parenthesis if more than once
3. Nitrate plus nitrite nitrogen

Lakes are often classified qualitatively by trophic status, which is a measure of water quality and productivity. Pristine clear lakes with low productivity are called oligotrophic. Lakes with high productivity and/or degraded water quality are called eutrophic lakes. Lakes with an intermediate quality or level of productivity are called mesotrophic.

Secchi depth is a measurement of the transparency which is often used in combination with total phosphorus and chl a concentrations to determine lake trophic status. In Corbett Lake, secchi depth at Station CL-02 was measured outside of the macrophyte beds. Here 4 out of 5 measurements represent the secchi disk lying on the bottom. In the densest parts of the macrophyte beds the secchi depth measurement would be much smaller. Secchi depth measured at Station Cl-01 represents the lake transparency that could be expected in the absence of the macrophytes (4.5 to 8.4 feet). The mean secchi disk transparency of 6 feet at Station Cl-01 was slightly below the average for 282 lakes sampled in northwestern Wisconsin by the Wisconsin Department of Natural Resources (Lillie and Mason, 1983).

With regard to limiting nutrient levels, phosphorus concentrations are seen to be relatively low though the amount of phosphorus found within the macrophytes is unknown and may in fact be high. Chlorophyll "a" concentrations indicate moderate biomass productivity in the water column. Total phosphorus and chl a concentrations in Corbett Lake are typical of the means (0.026 mg/l and 12.4 $\mu g/l$, respectively) for the lakes monitored by Lillie and Mason (1983). From a more descriptive perspective, Corbett Lake's quality would be considered fair to good.

Total phosphorous, chl a and secchi depth measurements taken together indicate Corbett Lake may be classified as mildly eutrophic, since it lies just within the range for eutrophic lakes as defined by Carlson Trophic State Index (Carlson, 1977). As strictly defined, the Carlson Trophic State Index does not apply to macrophyte dominated lakes. However, the eutrophic classification fits with the nature of the lake, which is shallow over much of the basin and dominated by macrophytes.

Nutrient enrichment typically does not cause nuisance macrophyte or "weed" growth. High macrophyte biomass is typical, however, for lake basins like Corbett Lake where the lake is generally shallower than the secchi depth, where calm relatively clear water predominate with nutrient rich moderately organic soils. High nutrient concentrations in the water column usually trigger algae blooms, a phenomenon not observed at Corbett Lake. Algae are a minor component of the productivity of Corbett Lake.

The presence of the macrophytes leads to the most important water quality constraint associated with Corbett Lake: low dissolved oxygen levels. Dissolved oxygen depletion was found in all months samples were taken (May to September 1997). In May, only the deeper water of the bay (Station CL-01) near the library was experiencing dissolved oxygen depletion (Figure 4). By June, however, the dissolved oxygen level measured at Sample Point CL-02 indicates that dissolved oxygen was becoming depleted throughout most of the lake (Figure 4 and Table A-1). On average, the dissolved oxygen concentration at Station CL-02 was 3.6 mg/l, which indicates a substantial oxygen deficit occurs much of the time throughout the lake since, for the average water temperature of this station, the water potentially could hold 9 mg/l of dissolved oxygen.

The dissolved oxygen profiles depicted on Figure 4 indicate the cascading aerating is providing some relief from the oxygen depletion which occurs in Corbett Lake. The aerator's effect is on the upper meter of the lake water with little aeration of deeper water occurring.

Nitrogen, another important nutrient, was found to be primarily in the organic form (total kjeldahl nitrogen), which is consistent with the macrophyte dominated nature of the lake. Nitrogen was not found at concentrations which would be considered excessive. An elevated chloride level was found in the bottom sample at Sample Point CL-01 for the May 1997 sample. Finding an elevated chloride concentration at depth is an indication that urban runoff is influencing the quality of the lake water. Furthermore, the average chloride level of 86 mg/l observed in Corbett Lake is extremely high. Of the 282 lakes monitored by Lillie and Mason (1973), the average chloride concentration was 2 mg/l. From a statewide perspective this same study of 660 lakes indicated an average concentration of 4 mg/l with a 57 mg/l as an observed maximum. Also of note, turbid water from storm water discharges was observed entering Corbett Lake in March 1998.

2.3 Water Level Measurements

Water levels were measured at three locations to make an initial determination of the feasibility of diverting water back into Corbett Lake from the drainage ditch on the west side of Ladysmith. Measurements were made at Corbett Lake, in the wetland on the west side of Highway 27 that lies between Corbett Lake and the drainage ditch, and at the point where the drainage ditch turns south towards Mt. Scenario College (Figure 1). The water level data is found in Appendix D.

Figure 5 depicts the water levels at these locations for the May to November 1997 period. The most important result of the water level measurements is the water level in the ditch is always significantly lower than the Corbett Lake water level. On average, the water level in the ditch was 1.9 feet below the Corbett Lake water level. For the most part, the water level at the intermediate wetland was higher than that of Corbett Lake. This indicates that intermediate wetland lies on the drainage divide between the ditch and Corbett Lake and it would take a pump station to divert water from the ditch into Corbett Lake.

There is a wood duck nesting box mounted on a steel pole at the point where the drainage ditch turns south towards Mt. Scenario College. An obvious high water mark could be seen on the steel pole, and an elevation of 1121 feet was measured for the high water mark. One explanation for the high watermark is as follows: during spring break up the ditch, as it turns south towards Mt. Scenario College, may be partially plugged with ice and allowing water to pond near this point. During these limited times water potentially could flow east into Corbett Lake.

A 30 inch diameter culvert crossing exists under Highway 27 where the old inflow channel to Corbett Lake previously existed. The west invert of this culvert is the highest, having an invert elevation of 1119.66 feet. Since visually, other than State Highway 27, there are no other barriers to water flow east towards Corbett Lake from the drainage ditch, it is quite possible that a limited amount of water occasionally flows into Corbett Lake from the drainage ditch during periods of flood. The amount of water that may enter Corbett Lake from the drainage ditch is not likely to be significant to the long term quality of the lake.

2.4 Water Budget

A monthly water budget has been prepared for Corbett Lake and is presented in Table 2. The hydrology of the lake is limited by the 0.3 square mile watershed. For instance, evaporation exceeds surface inflows throughout the summer. Significant inflows to the lake occur only during the spring snow melt period and fall. The net runoff to the lake is estimated to be only 6 inches over the watershed, which is only 18 percent of the total estimated rainfall for the watershed. The water level data indicate groundwater inflows or outflows are not significant to the water budget of Corbett Lake. For instance, during dry periods the water level of the lake drops to the invert elevation of the outlet, but does not drop below this elevation as would occur if groundwater outflow rates were significant.

Table 2
Corbett Lake Water Budget

Month	Average Precipitation[1] (in)	Surface Water Runoff[2] (in)	Groundwater Inflow (in)	Average Lake Evaporation[3] (in)	Net Inflow (in)	Groundwater Outflow (in)	Surface Water Outflow (in)
January	1.06	0.79	0	0	0.79	0	0
February	0.78	0.58	0	0	0.58	0	0
March	1.71	0.69	0	0	0.69	0	3.06
April	2.71	1.49	0	4.18	0	0	0
May	3.65	2.32	0	4.52	0	0	0
June	4.46	3.06	0	4.89	0	0	0
July	3.72	2.38	0	4.31	0	0	0
August	4.48	3.08	0	3.05	0	0	0
September	4.44	3.04	0	2.21	0.83	0	0.83
October	2.52	1.33	0	0	1.33	0	1.33
November	1.80	0.75	0	0	0.75	0	0.75
December	1.22	1.01	0	0	1.01	0	0
Annual Total	32.49	20.52	0.00	23.16	5.98	0.00	5.97

1. From NOAA Climatological Data Report for 1996, Holcombe Wisconsin gage.
2. Calculated using SCS runoff volume computation methods.
3. From NOAA Technical Report NWS 34, December 1982.

3.0 Discussion

The following discussion addressed potential measures for improving the quality of Corbett Lake.

3.1 Improving Water Quality

3.1.1 Increasing the Watershed Size

Reestablishing the natural watershed by diverting water from the unnamed drainage ditch west of Ladysmith back into Corbett Lake is not practical because the lake water surface is 1.5 to 2 feet higher than typical water levels in the unnamed ditch. A pump station could be installed to pump the water from the unnamed drainage ditch under State Highway 27 to Corbett Lake. However, given that macrophytes and low dissolved oxygen are the main water quality problems, there are better approaches to improving lake water quality.

3.1.2 Aeration

Adding more aerators to the lake should be considered as a high priority for water quality improvement. The cascading aerator in place is providing some relief to the upper part of the lake near the aerator, but much of the lake continues to suffer from low dissolved oxygen concentrations. Fisheries habitat in Corbett Lake is very limited by the low dissolved oxygen. Additional aeration will increase the area of the lake habitable by fish and help prevent algae from becoming a nuisance.

Aeration the oxygen poor bottom waters would be the best approach to improving concentrations in the lake. This approach creates an artificial circulation in the lake by bringing bottom waters to the surface allowing oxygen introduced from the atmosphere to be distributed throughout the water column. This technique will result in uniform temperatures from top to bottom, which can be expected to occur much of the time naturally given the shallow nature of Corbett Lake. A uniform vertical temperature distribution in the lake would not affect the ability of the lake to produce pan fish or large mouth bass.

There are a wide variety of bottom aerators available. A standard test, named the standard aeration efficiency (SAE) test, has been developed for measuring the efficiency of an aerator. SAE numbers are a fair comparison when comparing similar equipment. The test is a measure of the amount of oxygen transferred into the water per the amount of energy used. The correct aeration system for a particular application is chosen according to type, SAE, capital cost and anticipated maintenance cost. The likely range of capital cost for additional aeration for Corbett Lake is $2,500 to $5,000.

3.1.3 Nutrients and Solids

Nitrogen and phosphorus, key nutrients to lake productivity and nuisance algae, are not found in the lake at excessive concentrations. The focus of water quality improvements other than improving dissolved oxygen levels should be on reducing solids being discharged to the lake from urban areas.

There are several opportunities for construction of simple biofiltration treatment systems to remove suspended solids from storm water prior to its' entry into Corbett Lake. The best opportunity is on the east side of the lake where a storm sewer enters the lake from the area of Corbett's Third Addition near the corner of Second Street South and First Street South. It may be possible to enhance the ditch between the storm sewer and the lake at this location to provide a biofiltration system for storm water treatment.

On the north side of Corbett Lake where a storm sewer discharges from Fourth Street South towards the lake is another point where biofiltration of storm water may be feasible. The primary constraint of this location is the relatively steep lake side slope which would need to be accommodated by the system.

Snow removal stockpile areas should be reviewed to make sure these stockpiles do not drain to Corbett Lake. Pollutants in snow removed from roads can be a source of water quality problems. The elevated chloride levels reflect this problem. To protect Corbett Lake it would be best to stockpile snow at locations that do not drain to the lake. For instance, use of the snow removal stockpile area on the east side of Corbett Lake should be discontinued.

3.2 Lake Restoration

Macrophytes dominate much of the Corbett Lake Basin because of the shallow nature of the lake. To improve water quality, reduce sediment accumulation, provide macrophyte control and improve fishery habitat, the potential for deepening the eastern basin of the lake through dredging should be investigated. Deepening a portion of the east basin to a depth of 12 to 14 feet would provide another macrophyte free area in the lake. The dredging can be accomplished with an irregular shape to create more drop offs and edge area that would be used by fish. The best result would be obtained by placing a bottom aerator in the newly dredged area.

Dredging should be further investigated as an option for Corbett Lake. Preliminary cost should be developed for dredging, which would require preliminary layout of a proposed dredge cut and identification of a site to dispose of the sediment. There is no State grant program which would support dredging at Corbett Lake. However, dredging would provide the greatest improvement of the lake by reducing the area of macrophyte growth.

3.3 Macrophyte Harvesting

Another option for controlling macrophytes is mechanical harvesting. This control method is generally viewed as a cosmetic measure to control nuisance plants interfering with uses such as boating or fishing. Harvesting can effect the ecology of a lake but has not been shown to reduce the overall population size of fish.

Harvesting is employed during the growing season when submersed vegetation has grown to or near the water surface. Cutting needs to include the collection of plant fragments, a process that the more expensive mechanical harvesters provide.

Mechanical harvesters can be expensive, are technically specialized, and require specialized training and maintenance. Cost for mechanical harvesters start around $10,000 and ranges to over $100,000, not including accessories such as trailers. The Recreational Boating Grant Program administrated by the Wisconsin Department of Natural Resources (WDNR) will support 50 percent of the capital cost for a mechanical harvester. WDNR requires investigation of two mechanical harvesting approaches for the program including 1) contracting the work and 2) purchase and operation of the equipment by the City.

4.0 Recommendations

It is recommended the following additional steps, given in order of priority, be taken to complete the lake management plan and begin implementation of lake restoration measures:

1. Obtain one more lake management planning grant to support final project planning.
2. Develop comparative technical and cost data for several lake bottom aeration systems.
3. Develop a preliminary cost estimate for lake dredging.
4. Develop cost estimate for storm water biofiltration systems for storm sewer outfalls entering the east side of Corbett Lake. Review potential measures for controlling suspended solids in storm water being discharged to Corbett Lake and make recommendations.
5. Investigate a well system that could be intermittently operated to provide dilution for flushing water to the lake.

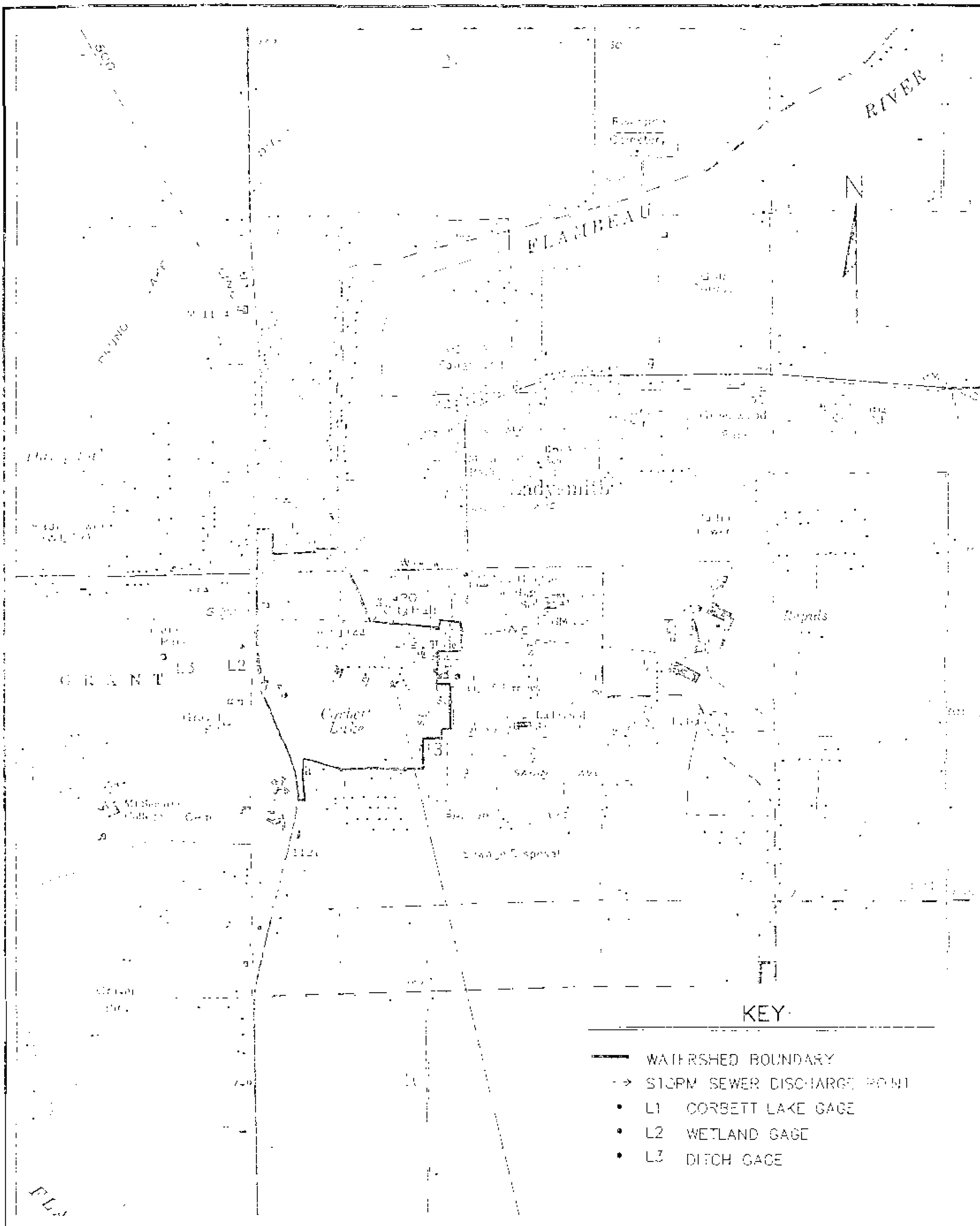
5.0 References

Cooke, Welch, Peterson and Newroth. 1993. *Restoration and Management of Lakes and Reservoirs*. Lewis.

Lille, Richard A. and John W. Mason. 1983. *Limnological Characteristics of Wisconsin Lakes*. Technical Bulletin No. 138, Wisconsin Department of Natural Resources.

Terrill, John, unknown date, *Tails, Trails and Tails* Article on Corbett Lake in Ladysmith News.

Figures



GENERAL LOCATION MAP

FILE NO	FIGURE
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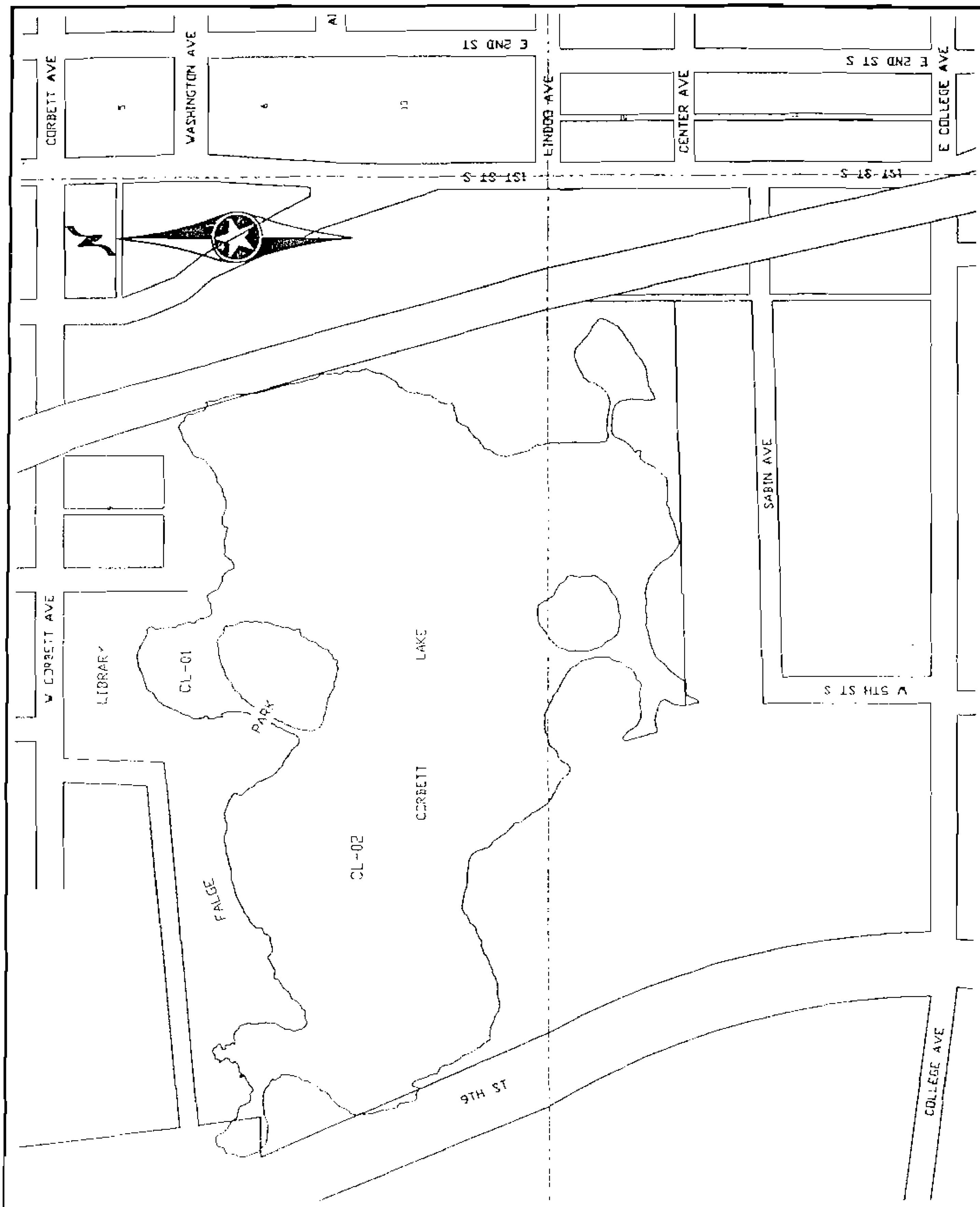
DATE 04/03/98	



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CORBETT LAKE BASIN

FILE NO.	FIGURE
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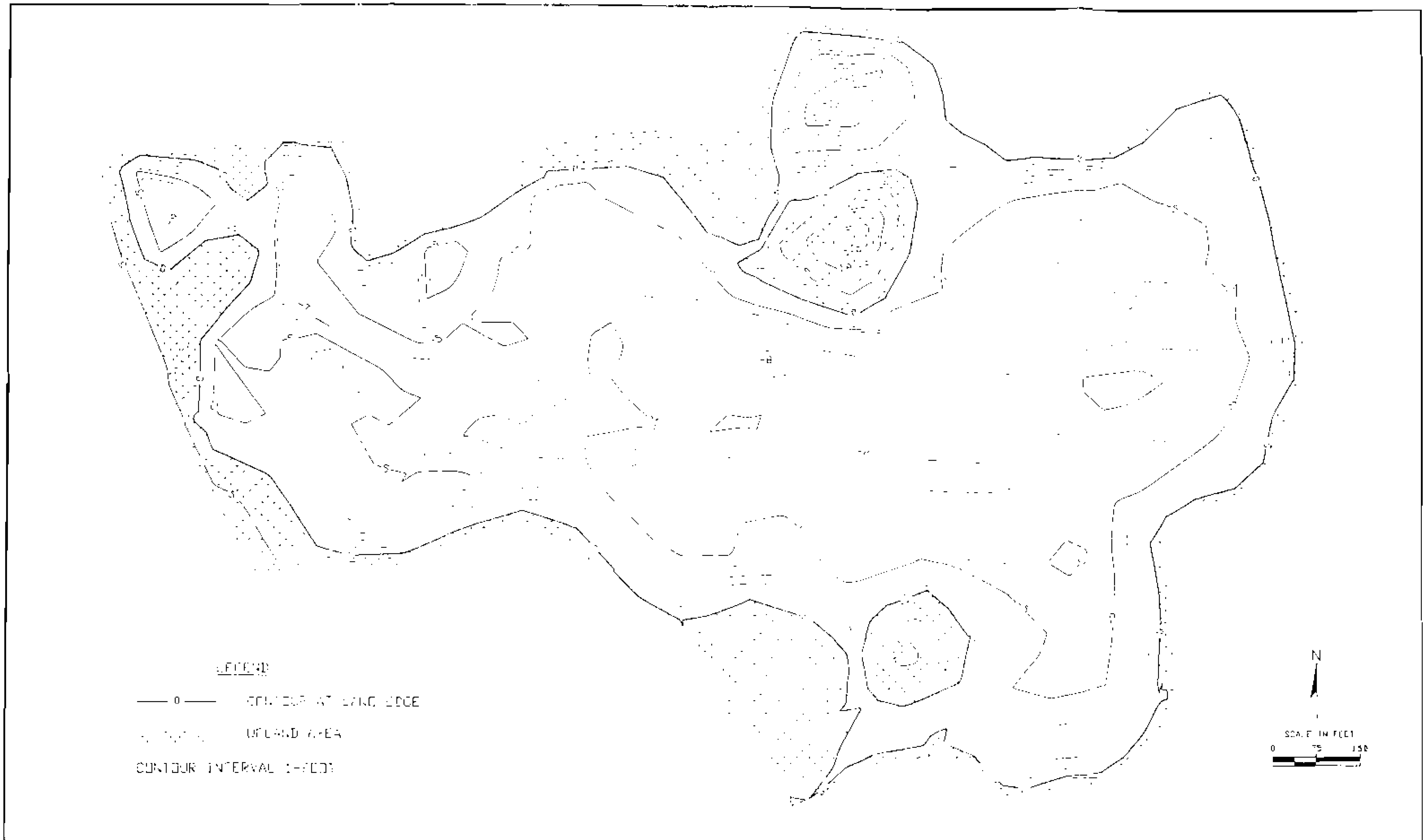
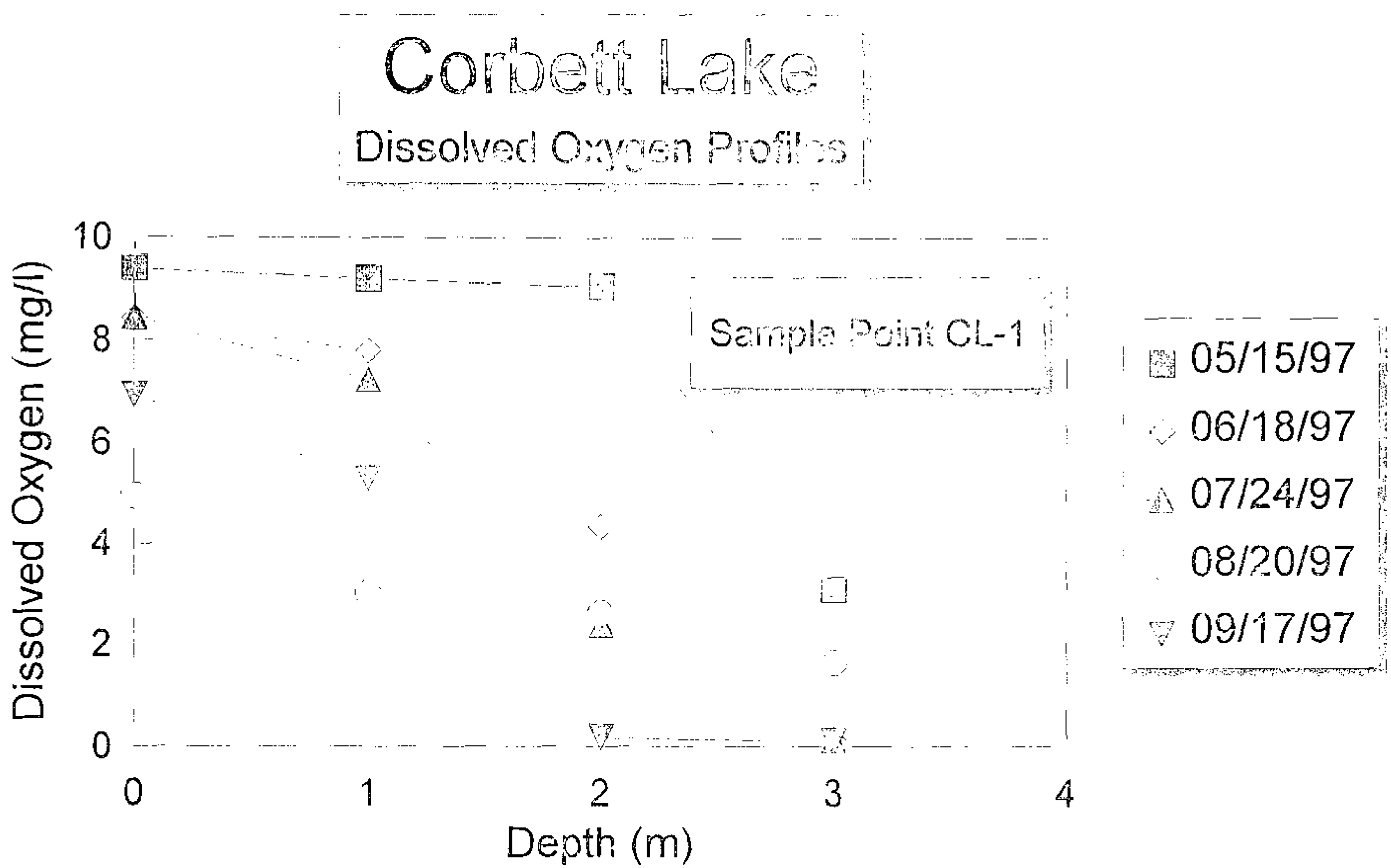


BATHYMETRIC MAP

CORBETT LAKE
LADYSMITH, WI

FILE NO. LADYS9706
DATE 3/25/98
FIGURE 3



SEH ENGINEERS ARCHITECTS PLANNERS

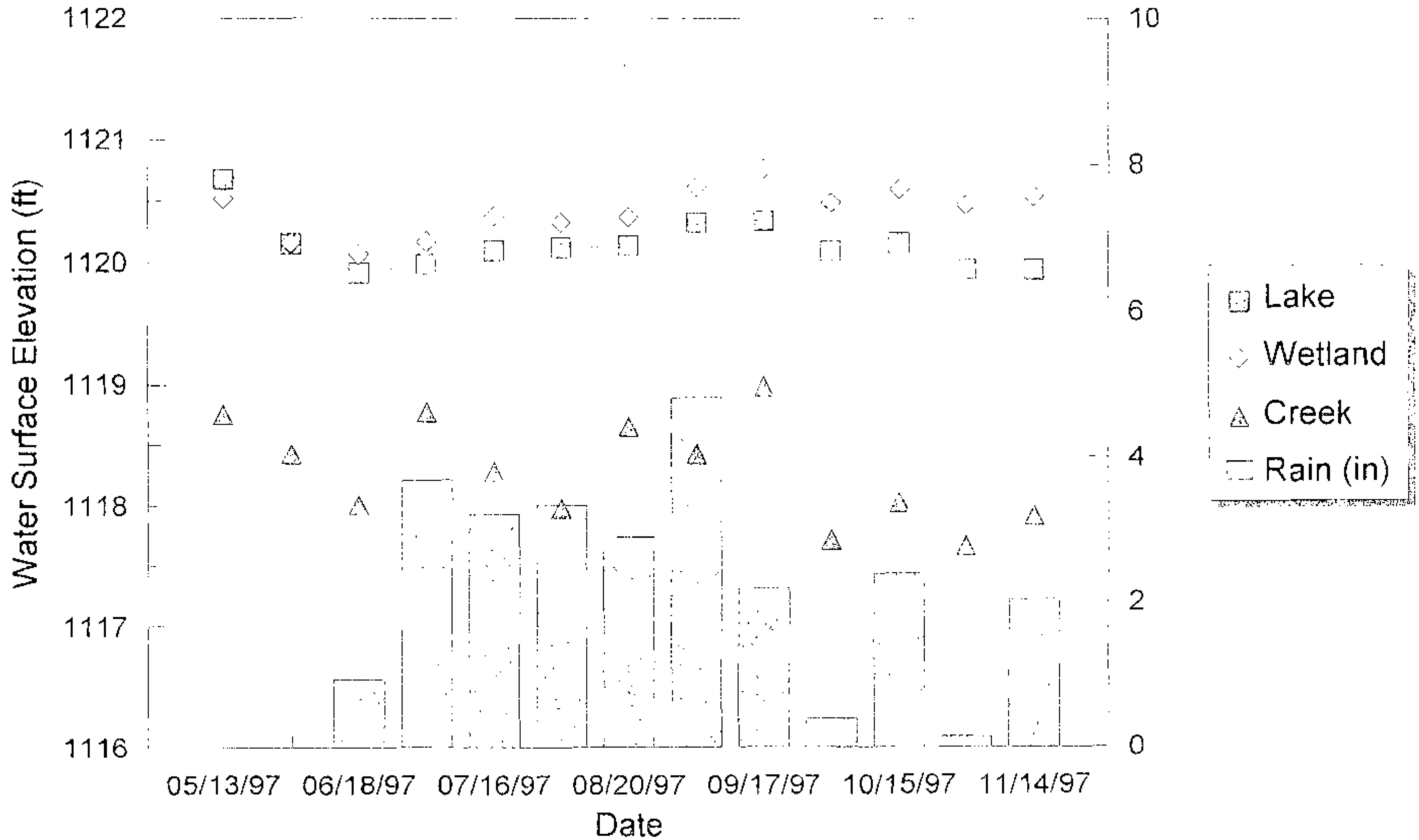
DISSOLVED OXYGEN PROFILES

FILE NO. ADYS9706
DATE 03/26/98

FIGURE 4

Corbett Lake Management Plan

Comparison of Water Levels



SEH ENGINEERS ■ ARCHITECTS ■ PLANNERS	COMPARISON OF WATER LEVELS	FILE NO. LADYS9706 DATE 03/26/98	FIGURE 5

Appendix A

Corbett Lake Water Quality Data

Corbett Lake Water Quality Data Summary — Table A-1

Sample Location: CL-01

Parameter	Units	Date 05/15/97	05/15/97 Notes	06/18/97	06/18/97 Notes	07/24/97	07/24/97 Notes	08/20/97	08/20/97 Notes	09/17/97	09/17/97 Notes	Mean
chlorophyll a	ug/l	13.1	1	6 32	2	5.37		20 3	6	10 7		11 158
ammonia	mg/l	nd		nd		0 01	less than	0 015	6	nd		0.005
nitrate+nitrite nitrogen	mg/l	nd		nd		0 01	less than	nd	6	nd		0 002
total kjeldahl nitrogen	mg/l	0 7		0 68	3	0 6		0 71	6	0.6		0 653
total phosphorus	mg/l	0 041		0 025	4	0 012		0 040	6	0 027		0 029
dissolved reactive phosphorus	mg/l	nd		0 004		nd		0.002	6	nd		0 001
Chloride	mg/l	85 2		90				80 7				85 633
Temperature	C	11.43		21 1		22.43		18 25		19 71		18.585
pH		7 56		6 74		7 84		8		6 04		7 236
pH - lab		7.44		7 43								
Alkalinity	mg/l	21		20								
Specific Conductance	uS/cm	317		329		304		290		268		301 600
Dissolved Oxygen	Percent Saturation	88 1										
Dissolved Oxygen	mg/l	9 4		9 43		8 46		4 94		6 33		7 632
TDS		0 203										
Redox	mV	295		299		278		284		303		291 800
Secchi Depth	ft	4 5		8 4		7 1		4 7		5 1		5 960

Sample Location: CL-01d

Parameter	Units	Date 05/15/97	05/15/97 Notes	06/18/97	06/18/97 Notes	07/24/97	07/24/97 Notes	08/20/97	08/20/97 Notes	09/17/97	09/17/97 Notes	Mean
chlorophyll a	ug/l											
ammonia	mg/l	nd		0 038		0 036		0 013	6	0 248		0 067
nitrate+nitrite nitrogen	mg/l	0 03		0 013		0 013		0 01	6	0 033		0 020
total kjeldahl nitrogen	mg/l	1.7		6 68	3	1 2		0 9	6	1 9		2 476
total phosphorus	mg/l	0 161		0 115	4	0 069		0 047	6	0 117		0 102
dissolved reactive phosphorus	mg/l	nd		0 007		nd		0 001	6	nd		0 002
Chloride	mg/l	140		89 1				31 5				103 533
Temperature	C	10 43		17 34		17 8		17.3		15.14		15 802
pH		6 42		c 4		0 08		6 67		5 3		6.394
pH - lab		6 51		7 2								
Alkalinity	mg/l	33		25								
Specific Conductance	uS/cm	455		342		375		346		372		378 000
Dissolved Oxygen	Percent Saturation	3 2										
Dissolved Oxygen	mg/l	0 2		0 14		0 11		0.62		0 11		0 236
TDS		0 315										
Redox	mV	94		222		101		135		115		133 600

Sample Location: CL-02 CL-02

Parameter	Units	Date 05/15/97	05/15/97 Notes	06/18/97	06/18/97 Notes	07/24/97	07/24/97 Notes	08/20/97	08/20/97 Notes	09/17/97	09/17/97 Notes	
chlorophyll a	ug/l	7 8	1	10 6	2	4 19	5	3 85	5,6	7.27		6 742
ammonia	mg/l	nd		0 019		nd	less than	0 015	6	nd		0 007
nitrate+nitrite nitrogen	mg/l	nd		nd		nd	less than	0 01	6	nd		0 002
total kjeldahl nitrogen	mg/l	0 8		0.7	3	0 8		0.65	6	0 7		0 730
total phosphorus	mg/l	0 033		0 02	4	0 02		0 023	6	0 025		0.024
dissolved reactive phosphorus	mg/l	nd		0 002		nd		0 001	6	nd		0 001
Chloride	mg/l	85 8		89.1		83.2						86 033
Temperature	C	11.2		20 25		21.25		16 74		17 46		17.380
pH		7 61		7 3		7 58		7 53		5 97		7 198
Specific Conductance	uS/cm	307		327		297		283		267		296 200
Dissolved Oxygen	Percent Saturation	94 8										
Dissolved Oxygen	mg/l	10 13		3 74		1 24		0 6		2 13		3.568
TDS		0 196										
Redox	mV	301		326		344		370		386		345 400
Secchi Depth	ft	4 2		4 6		4.2		3 6		4 3		4 150

Notes
1 Holding time exceeded by 17 days, result approx
2 Holding time exceeded by 15 days, result approx
3 Holding time exceeded by 5 days, result approx
4 Matrix Q C exceeded, spike recovery = 111.1%
5 Low absorbance, result approx
6 Ice melted, result approx

Appendix C

Macrophytes Observed at Corbett Lake, Summer 1997

SEH

SHORT ELLIOTT HENDRICKSON

RECEIVED AUG 19 1997

MEMORANDUM

■ ST. PAUL, MN ☐ MINNEAPOLIS, MN ☐ ST. CLOUD, MN ☐ CHIPPEWA FALLS, WI ☐ MADISON, WI ☐ LAKE COUNTY, IN

TO: Roger Clay

FROM: Wayne Jacobson

DATE: August 15, 1997

RE: Corbett Lake Vegetation Sampling
Performed on August 14, 1997
SEH No. A-LADYS9601.00

Below are the species of aquatic plants found along with their relative abundance and location in Corbett Lake:

Emergent Plants

Common Name	Scientific Name	Relative Abundance	Location
Arrowhead	Sagittaria latifolia	Present	Shore
Blue flag	Iris versicolor	Present	Shore
Bulrush, Soft-Stem	Scirpus validus	Common	Shore
Cattail, Broad-leaved	Typha latifolia	Common	Shore
Cattail, Narrow-leaved	Typha angustifolia	Occasional	Shore
Reed Canarygrass	Phalaris arundinacea	Common	Shore
Rice Cutgrass	Leersia Oryzoides	Occasional	Shore
Sedge, Bearded	Carex comosa	Common	Shore
Sedge, Hop	Carex lupulina	Occasional	Shore
Smartweed, Swamp	Polygonum Hydropiperoides	Present	Shore
Smartweed, Water	Polygonum amphibium	Occasional	Shore
Spikerush, Creeping	Eleocharis palustris	Common	Shore
Wapato, Stiff	Sagittaria rigida	Present	Shore
Woolgrass	Scirpus cyperinus	Occasional	Shore

Submergent Plants

Common Name	Scientific Name	Relative Abundance	Location
Coontail	Ceratophyllum demersum	Abundant	Open Water
Duckweed, Lesser	Lemna minor	Occasional	Shore
Pondweed, Narrow leaf	Potamogeton strictifolius	Occasional	Open Water
Pondweed, Variable	Potamogeton gramineus	Occasional	Open Water
Water-Lily, Little White	Nymphaea tetragona	Occasional	Open Water
Water-Lily, White	Nymphaea tuberosa	Abundant	Open Water
Water-Lily, Yellow	Nuphar variegatum	Present	Open Water
Water Shield	Brasenia schreberi	Occasional	Open Water

The open water area of the lake is choked with White Water Lily and Coontail. The only area of the lake which is somewhat weed-free and usable for recreation is the north bay directly south of the library which is also the deepest part of the lake. This north bay represents less than 10 percent of the lake's surface area.

sah
[illegible]

Appendix D

Water Level Data

Table D-1
Corbett Lake Water Level Measurements

Water Surface Elevation (ft)

	Lake Gage 1	Wetland Gage 2	Creek Gage 3	Difference G1 - G3	Average Difference
Elevation Top of Staff (ft)	1122.92	1122.55	1120.79		
Elevation Bot of Staff (ft)	1119.59	1119.22	1117.46	(ft)	(ft)
Date	Lake	Wetland	Creek		
05/13/97	1120.68	1120.52	1118.76	1.92	
06/04/97	1120.15	1120.16	1118.43	1.72	
06/18/97	1119.92	1120.07	1118.01	1.91	
07/02/97	1119.99	1120.17	1118.78	1.21	
07/16/97	1120.1	1120.37	1118.28	1.82	
08/06/97	1120.12	1120.32	1117.98	2.14	
08/20/97	1120.14	1120.37	1118.66	1.48	
09/03/97	1120.32	1120.62	1118.43	1.89	
09/17/97	1120.34	1120.77	1118.99	1.35	
10/02/97	1120.1	1120.49	1117.72	2.38	
10/15/97	1120.16	1120.6	1118.03	2.13	
10/29/97	1119.95	1120.47	1117.67	2.28	
11/14/97	1119.95	1120.54	1117.92	2.03	1.87
average	1120.15				

See Figure 1 for gage locations