LPL-485 + LPL-486

1997-98 WISCONSIN DNR LAKE MANAGEMENT PLANNING GRANT FINAL REPORT FOR LAKES AMNICON AND DOWLING IN DOUGLAS COUNTY

SUBMITTED TO THE AMNICON AND DOWLING LAKES MANAGEMENT AND SANITARY DISTRICT

FROM
C.J. OWEN AND ASSOCIATES
MARCH 1998

Introduction and Grant Criteria

The following project summary is presented by C.J. Owen and Associates to the Amnicon and Dowling Lakes Management and Sanitary District. The project was funded by a 1997-1998 Wisconsin DNR Lake Management Planning Grant. The planning grants are intended to provide funding for the lake management ***planning*** process. Up to $10,000 per project and a maximum of $50,000 is available at a 75% state cost share. The intent of the grant program is to help ***develop*** comprehensive management plans depending on the condition and needs of the lake (which the planning process will help determine). The plan will specify activities related to minimizing the impacts of future development, managing user conflicts, and improving fishing and water quality.

The current project focuses on developing long term, resident staffed, management activities to help monitor and maintain the health of the lake. In an effort to address this focus, analysis of water quality parameters have considered the whole lake as a potentially impacted resource, influenced by the entire community within the lake(s) watershed. Results from the lake studies of 1994, 1995, 1996 and this report should be characterized as an overall community concern. It should not be interpreted as indicating individual(s) responsibilities for a source of impact from a given geographical area. Resources are not available to assess each individual on quantifiable impacts to the water quality of the lakes, rather the data suggests possible avenues by which the whole community may be impacting the water resource.

The intent of this project is to develop a holistic approach to watershed management and should not focus on one perceived problem area. This is the case for the current and previous planning grant projects in that, although of concern to the district members, the focus should not be placed solely on septic issues. Rather all watershed pollution issues should be considered in the context of the continuation of the long term monitoring of water quality in Lakes Amnicon and Dowling.

When using the data generated by these studies it should be recognized that the focus of the sampling design is on protection of the health of the lake (i.e. the processes that effect how rapidly the lake ages (eutrophication) and the "usability" of the water resource by humans). Some of the data gathered may also be taken into consideration when analyzing possible impacts to the health and well being of the people utilizing the lakes.

Monitoring-Field

All in-lake monitoring for this project was carried out between July 19, 1997 and October 17, 1997 and will continue at ice out in the spring of 1998. Monitoring and sampling was conducted by residents of the Lake Management District under the training and supervision of C.J. Owen and Associates.

Study Lakes

Lake Amnicon is located in west central Douglas County, Wisconsin. Amnicon is a 172.4 hectare, relatively shallow (maximum depth 9.5 meters; mean depth 3 meter) drainage lake of glacial origin. Shoreline distance (not including two state owned islands) is 8.22 kilometers. Lake volume is approximately 5,200,000 cubic meters. The trophic status of Lake Amnicon is eutrophic (*1993, 1994, 1995 and 1996 final reports by C.J. Owen and Associates*). The shoreline of Amnicon is characterized as heavily developed, containing 2 and 3 tier development. One hundred and forty-eight shoreline lots were observed in 1994, resulting in a ratio of twenty-nine lots per shoreline mile. There are three (3) public boat launches and one campground on the lake.

Dowling Lake is adjacent to Amnicon Lake in west central Douglas County, Wisconsin. Dowling is a 62.24 hectare, shallow (maximum depth of 3.96 meters; mean depth 2.13 meters), drainage lake. Dowling is the major inflow to Amnicon Lake. Shoreline distance (not including islands) is 3.14 kilometers. The lake volume is approximately 1,400,000 cubic meters. The trophic status of Lake Dowling is eutrophic (*1993 ,1994,1995 and 1996 reports by C.J. Owen and Associates*). The shoreline of Dowling is characterized as heavily developed, containing 2 and 3 tier development.

Eighty-two shoreline lots were observed in 1994 resulting in 41 lots per shoreline mile. There is one (1) public boat launch and no campgrounds on Dowling. (Appendix 1: Map 1 and 2).

Sampling Methodology

Water temperature, dissolved oxygen concentration and specific conductivity at each sampling site were measured at one meter intervals. Secchi disk transparency was also recorded at each site. Samples of the epilimnion (shallow sample), collected for chemical and biological analysis, were sampled 0.2 meter below the surface. In addition to surface samples, maximum depth samples were also collected using a Van Dorn sampler. The deep samples were collected 1 meter off the bottom (the bottom of the hypolimnion).

Field Methods-Chemical Samples

Field measurement and sample collection were carried out using routine limnological practices (Kallar et al. 1981; Lind 1985; EPA 1989). Temperature, dissolved oxygen, and conductivity were measured with a YSI 85 probe. All probes were calibrated prior to each sampling. In the field, probes were lowered to the designated depth and allowed to equilibrate before measurements were recorded. Profiles were taken monthly from July 19, 1997 until October 17, 1997 and will continue at ice out in the spring of 1998. Water transparency for the lake was measured using a standard 20 cm diameter Secchi disk.

Discrete samples were collected with a one-liter PVC Van Dorn water sampler. Samples were placed in pre-labeled polyethylene bottles containing the sampling date, lake name, site number and depth (provided by the State Laboratory of Hygiene). Samples were preserved according to instructions provided by the State Laboratory of Hygiene and placed into coolers, kept dark and iced during transport to the laboratory by overnight express UPS.

Project Description

In May of 1997 the commissioners of the Amnicon/Dowling Lake Management and Sanitary District contracted with the local water quality consulting firm of C.J. Owen and Associates to assist them with the following 1997-1998 Wisconsin DNR Lake Management Planning Grant project. To foster greater lake stewardship, the district agreed to take responsibility for the monthly physical and chemical monitoring of the two lakes, with C.J. Owen and Associates providing sample collection and processing training and data review. This recognized need for citizen input to the program was prompted by the districts continuing public education to the community and the public's awareness of the many issues that may be impacting the current and future water quality of the lakes. It was recognized that the greatest threat to the current lake water quality monitoring program was the loss of "momentum". The historical review of the lake data identified several past efforts by the district to obtain information on the water quality of the lakes, only to result in large gaps in data as enthusiasm in the lake monitoring programs of the 1970s and early 1980s decreased. The district feels that a large cause of this gap in data was a result of the increased reliance on consultants to perform standard water quality sampling and as a result prompted a loss in lakeshore property owner's "connection" to the program. This loss in momentum (and resulting gaps in data) was a critical missing piece in the discussion process related to current water quality issues being discussed by the district. As such a project with the following goals and objectives was undertaken to obtain the tools and instruction to take lake district ownership of the lake monitoring program.

Objectives

Objective 1: Obtain funding to equip district members with the basic analysis and collection equipment to allow for continued gathering of physical/chemical/biological samples and for obtaining dissolved oxygen, temperature and conductivity profiles of the study lakes.

Objective 2: Train 6-12 individuals (3-6 per lake) on the correct sample collection and processing techniques and the use of field analytical tools for sampling resources related to in-lake water quality. Training should emphasize physical and chemical water sampling, obtaining bacteriological, phytoplankton and well water samples and determining the identity of beneficial and unwanted macrophyte species.

Objective 3: Continue to provide onsite training to property owners in "groundtruthing" of the 1994 Aerial Lakeshore Analysis. Continue to instruct individuals on how to recognize areas that can be improved by implementation of lakeshore "Best Management Practices" (BMPs) as a resource to other property owners.

Objective 4: Continue the chemical, biological and physical characterization of Lakes Amnicon and Dowling, thereby maintaining a coherent lakes data set that can be used by the district in future lake management discussions. This can be accomplished by obtaining monthly oxygen, conductivity and temperature profiles and evaluating transparency changes by monitoring secchi depth readings. Chemical analysis of the two lakes will consist of Chlorophyll-a, NO_3, NH_4, TP and Ortho-P from surface and bottom samples at the deep hole locations taken on a monthly basis.

Results

Objective 1: The district has been supplied with the following analytical equipment to provide accurate and consistent limnological data acquisition.

* One YSI Model 85 Handheld oxygen, conductivity, salinity, and temperature meter. (See Appendix 2 for description and operations manual).

* One 20 cm Secchi Disk with metered line.

* One VanDorn water sampling device with metered line and trigger messenger.

* One 200 mm diameter plankton tow net.

* One rigid plastic carrying case for above equipment.

* One Gelman 4.5 cm magnetic filter tower with sidearm flask, pressure pump, one 1 liter graduated cylinder and misc. GFC and .45 m filters.

This equipment is available to interested district members at the discretion of the district commissioners and only after the completion of adequate training in its care and use.

Objective 2: Five (5) one half day training sessions were provided to interested district members on the correct procedures for sample collection and the operation of the diagnostic equipment. These training sessions were conducted by C.J. Owen and Associates in accordance with Wisconsin DNR, Wisconsin State Laboratory of Hygiene, and U.S. EPA guidelines. Training consisted of three sessions involving in-field hands-on demonstrations of correct field sampling protocol and documentation, analytical equipment operation, and concepts and procedures that will help provide less human impact to the lake systems. These three training sessions were facilitated by a training manual that was provided to participants and the district as a permanent record of collection techniques (see Appendix 3).

A fourth training session was devoted to the in-field recognition and identification of various macrophyte species within the two lake systems. Cindy Hagley, a macrophyte specialist with Minnesota Sea Grant, provided training and identification information on the common plant species that were identified in the earlier (1995) macrophyte assay of the two lakes. Exotic species identification and control guidelines were also a part of this training session. A document entitled Aquatic Plants of Lakes Amnicon and Dowling, Wisconsin was compiled and provided to the district and participants of this session. A copy of this document is included in Appendix 4.

The fifth training session consisted of 1997 summer data review, reporting, and basic limnological analysis. It has been determined by the district that continued limnological sampling and trend analysis of the two lakes will be provided through a partnership with the University of Wisconsin - Superior. This final session involved an explanation of the data compiled over the previous year's studies (1993-1996) and recommendations for future analysis.

Objective 3: As part of the 1997 planning grant, A.W. Research Laboratories sent a professional groundtruthing specialist to continue work with the interested district members. A final report on the results of the project is provided in Appendix 5.

Objective 4: Adequately trained members of the district were responsible for the collection, processing and shipment of the various lake samples to the Wisconsin State Laboratory of Hygiene. The type and number of chemical analytes measured are outlined in Table 1 with year to date results noted in Tables 2 & 3. It was determined that sample collection would be suspended in the fall of 1997 and resumed in the spring of 1998 for best utilization of the district's resources. Water temperature, dissolved oxygen concentration and specific conductivity at each sampling site were measured at one meter intervals. Secchi disk transparency was also recorded at each site. This data is recorded in Tables 4 thru 9.

Analytes	July	Aug	Sept	April	May	June	July	Total
Chlorophyll-a*	1	1	1	1	1	1	1	7
Nitrate+Nitrite	2	2	2	2	2	2	2	14
Ammonia-N	2	2	2	2	2	2	2	14
Total-P	2	2	2	2	2	2	2	14
Ortho-P	2	2	2	2	2	2	2	14
Chloride	2			2		2		6
Color	1			1		1		3
Calcium	2			2		2		6
Iron	2			2		2		6
Magnesium	2			2		2		6
Manganese	2			2		2		6
Potassium	2			2		2		6
Sodium	2			2		2		6

Table 1. Amnicon/Dowling-Epilimnetic and Hypolimnetic Per Lake Chemical Sampling Schedule at Historic Deep Hole Sites (*Chlorophyll-a is sampled from surface only).

Sample Date	Chl-a (ug/l)	NO_3 (mg/l)	NH_3 (mg/l)	TP (mg/l)	OP (mg/l)	Chlo (mg/l)	Color	Ca (mg/l)	Fe (mg/l)	Mg (mg/l)	Mn (ug/l)	K (mg/l)	Na (mg/l)
Amnicon Epilimnion													
7/19/1997	5.68	ND	ND	.019	.002			6.2	0.10	2.3	0.4	0.6	2.4
8/09/1997	3.47	ND	.009	.017	.001								
9/08/1997	11.0	.01	.013	.024	.002								
Amnicon Hypolimnion													
7/19/1997		ND	ND	.032	.003	2.4	50	7.0	0.18	2.5	380	0.6	2.5
8/09/1997		ND	.60	.032	.009								
9/08/1997		.015	.053	.027	.002								

Table 2. Amnicon Epilimnetic and Hypolimnetic Per Lake Chemical Sampling Results at Historic Deep Hole Sites (*Chlorophyll-a is sampled from surface only).

Sample Date	Chl-a (ug/l)	NO_3 (mg/l)	NH_3 (mg/l)	TP (mg/l)	OP (mg/l)	Chlo (mg/l)	Color	Ca (mg/l)	Fe (mg/l)	Mg (mg/l)	Mn (ug/l)	K (mg/l)	Na (mg/l)
Dowling Epilimnion													
7/20/1997	8.62	ND	ND	.035	.005	4.4	70	5.4	0.66	2.1	28	0.6	1.5
8/09/1997	10.3	ND	.002	.033	.001								
9/08/1997	12.7	.01	.013	.040	.002								
Dowling Hypolimnion													
7/20/1997		.010	.019	.055	.014	1.4		6.0	0.92	2.2	390	0.7	2.0
8/09/1997		ND	.01	.036	.002								
9/08/1997		.020	.056	.022	.002								

Table 3. Dowling Epilimnetic and Hypolimnetic Per Lake Chemical Sampling Results at Historic Deep Hole Sites (*Chlorophyll-a is sampled from surface only).

AMNICON
CONDUCTIVITY & SECCHI

Date	7/19/1997	8/09/1997	9/06/1997	10/17/1997
Secchi	2.10	2.0	1.8	2.5
Surface	61.5	59.0	57.4	45.6
1 meter	61.5	60.9	57.4	45.8
2 meter	60.8	60.8	57.4	45.5
3 meter	61.0	60.7	57.3	45.6
4 meter	58.0	60.7	57.1	45.6
5 meter	57.2	60.7	57.4	45.5
6 meter		83.6	57.6	45.5
7 meter		96.6		45.6
Bottom	71.0	104.7	64.1	45.6

Table 4. Amnicon 1997 Conductivity and Secchi Measurements at Historic Deep Hole Sites. Secchi is measured in meters and conductivity in umhos.

AMNICON
DISSOLVED OXYGEN

Date	7/19/1997	8/09/1997	9/06/1997	10/17/1997
Surface	6.81	7.7	8.59	9.7
1 meter	6.58	7.50	8.54	10.1
2 meter	6.86	7.59	8.47	9.8
3 meter	6.10	7.50	8.36	9.8
4 meter	3.32	7.62	7.90	9.9
5 meter	0.70	7.60	6.44	9.6
6 meter		0.03	5.85	9.7
7 meter		0		4.8
Bottom	0.0	0	0.07	3.4

Table 5. Amnicon 1997 Dissolved Oxygen Measurements at Historic Deep Hole Sites. D.O. is measured in mg/l.

AMNICON
TEMPERATURE

Date	7/19/1997	8/09/1997	9/06/1997	10/17/1997
Surface	24.3	23.1	20.2	11.5
1 meter	24.4	23.1	20.1	11.4
2 meter	24.4	23.1	20.0	11.3
3 meter	24.3	23.0	20.0	11.2
4 meter	21.0	23.0	19.7	11.2
5 meter	18.4	23.0	19.2	11.2
6 meter		16.9	19.0	11.2
7 meter		14.1		11.2
Bottom	15.9	12.9	17.1	11.2

Table 6. Amnicon 1997 Temperature Measurements at Historic Deep Hole Sites. Measured in degrees centigrade.

DOWLING
CONDUCTIVITY & SECCHI

Date	7/20/1997	8/09/1997	9/06/1997	10/17/1997
Secchi	1.5	1.62	1.5	1.5
Surface	48.5	50.1	46.6	
1 meter	48.2	50.1	46.5	
2 meter	47.8		46.5	
3 meter	48.3		46.5	
Bottom	56.9	49.9	46.5	

Table 7. Dowling 1997 Conductivity and Secchi Measurements at Historic Deep Hole Sites. Secchi is measured in meters and conductivity in umhos.

DOWLING
DISSOLVED OXYGEN

Date	7/20/1997	8/09/1997	9/06/1997	10/17/1997
Surface	5.25	7.8	8.14	9.8
1 meter	4.4	7.8	8.08	9.7
2 meter	4.7		7.99	9.7
3 meter	.73			9.6
Bottom	0	7.7	7.56	9.2

Table 8. Dowling 1997 Dissolved Oxygen Measurements at Historic Deep Hole Sites. D.O. is measured in mg/l.

DOWLING
TEMPERATURE

Date	7/20/1997	8/09/1997	9/06/1997	10/17/1997
Surface	23.7	23.0	19.9	11.1
1 meter	23.7	22.9	19.8	10.9
2 meter	23.4		19.8	10.8
3 meter	21.0			10.7
Bottom	18.7	22.9	19.6	10.6

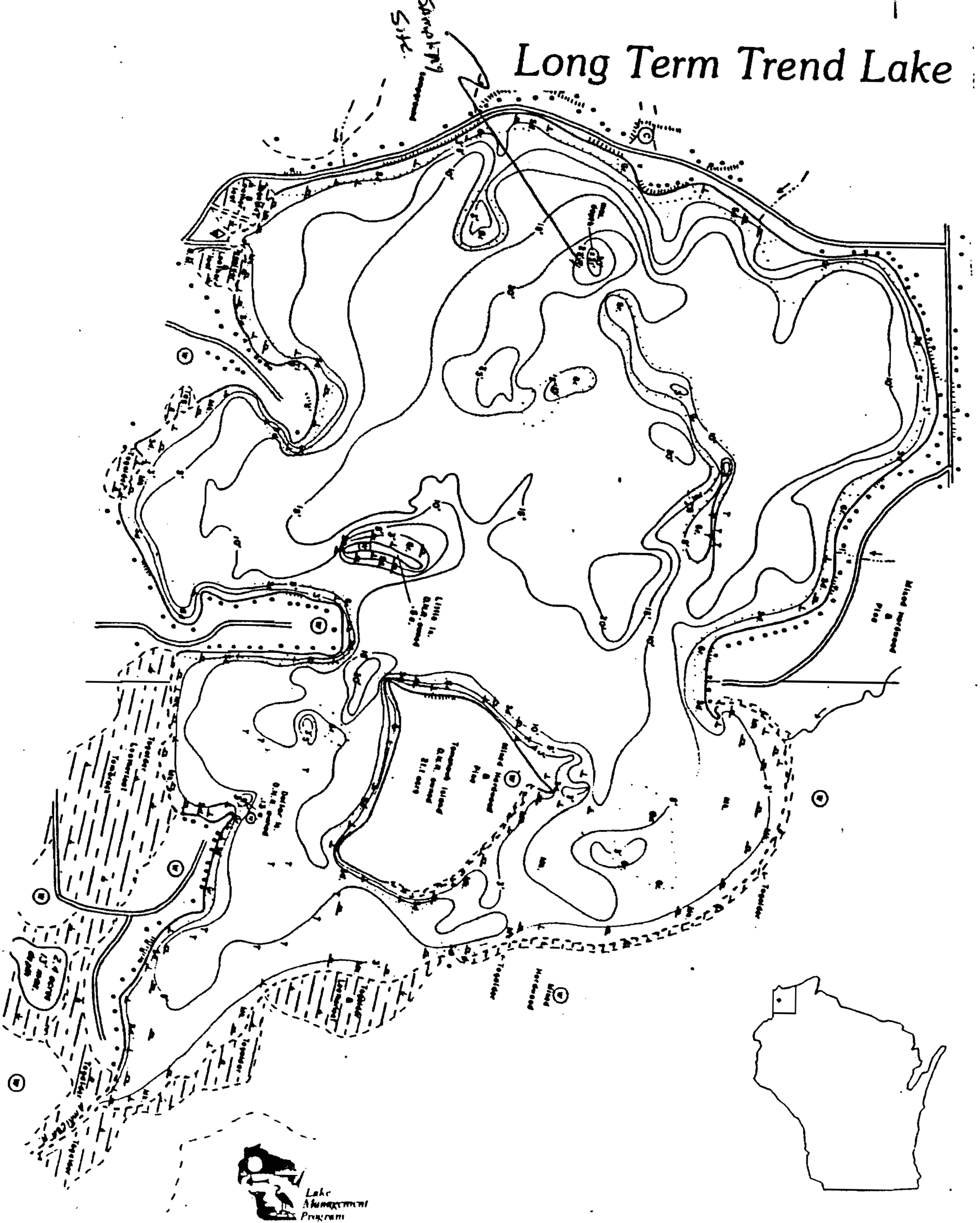
Table 9. Dowling 1997 Temperature Measurements at Historic Deep Hole Sites. Temperature is measured in degrees centigrade.

Appendix 1

AMNICON LAKE

Douglas County

Long Term Trend Lake



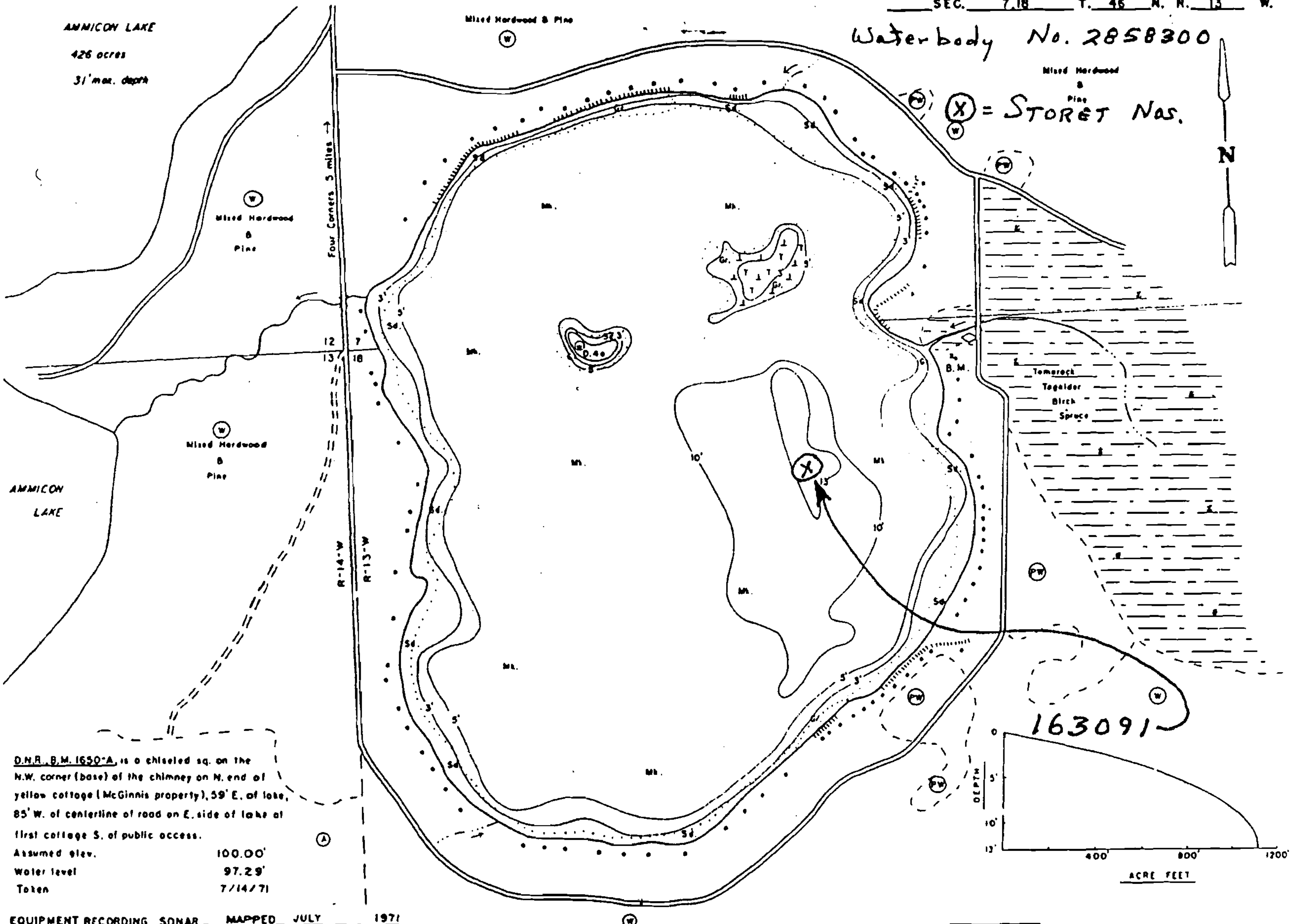
STATE OF WISCONSIN
DEPARTMENT OF NATURAL RESOURCES

LAKE SURVEY MAP

DOWLING LAKE — DOUGLAS COUNTY

SEC. 7, 18 T. 46 N. R. 13 W.

Waterbody No. 2858300



EQUIPMENT RECORDING SONAR MAPPED JULY (MONTH) 1971 (YEAR)

TOPOGRAPHIC SYMBOLS		LAKE BOTTOM SYMBOLS	
(B) Brush	Steep slope	P. Peat	Boulders
(PW) Partially wooded	Indefinite shoreline	Mk. Muck	Stumps & Snags
(W) Wooded	Marsh	C. Clay	Rock danger to navigation
(C) Cleared	Spring	M. Marl	T Submergent vegetation
(P) Pastured	Intermittent stream	Sd. Sand	Emergent vegetation
(A) Agricultural	Permanent inlet	St. Silt	Floating vegetation
B.M. Bench Mark	Permanent outlet	Gr. Gravel	Brush shelters
Dwelling	Dam	R. Rubble	
Resort	D.N.R. State owned land	Bc. Bedrock	
Camp			

SCALE: 300' 0 300' 600' 900' 1200'

Access — Access with Parking — Boat Livery

Drawn by: T. Ginder

Field work by: C. Busch, G. Lund, & L. Sather

SPECIES OF FISH	Abundant	Common	Present
Muskie		X	
N. Pike			
Walleye		X	
L.M. Bass			X
S.M. Bass			
Panfish		X	
Trout			

WATER AREA 153.8 ACRES
UNDER 3 FT. 8 %
OVER 20 FT. 0 %
MAX. DEPTH 13 FEET.
TOTAL ALK. 22 P.P.M.
VOLUME 1113.3 ACRE FT.
SHORELINE 1.95 MILES
WITH ISLAND 2.06 MILES

1997 AMNICON/DOWLING LAKE MANAGEMENT & LIMNOLOGICAL PRIMER

Solutions for a Better Environment

C.J. Owen & Associates
Progressive Systems International Inc.

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INTRODUCTION

It is commonly recognized that "bad" data is worse than no data at all. Not only are your time and money wasted, but environmental management decisions may be made which create or worsen a problem simply because those decisions were based on worthless information. For data to be useful, the quality must be adequate and known.

Knowing the quality of data is as important as the data itself. This document will present quality control guidelines for the development of a monitoring program capable of providing accurate lake management data. Each monitoring group should develop their own quality assurance plan for each project before monitoring begins. This will enable anyone in the future, unfamiliar with the project, to repeat exactly the procedures associated with the data collected for that project. With this consistency, comparisons over long periods of time, perhaps decades, can be made. Documented methods of how, when and where samples were taken erases any doubt as to their validity. Word of mouth and memory are not sufficient. **DETAILED DOCUMENTATION** will allow future evaluation of data quality. If the procedures used in the past can be reproduced, proper interpretations of historic data can be made.

Before monitoring begins, decide what your program is trying to accomplish and what your budget will allow. Many monitoring programs are designed to characterize long term trends in water quality as well as determination of current trophic status with the calculation a trophic state index (TSI).

TROPHIC STATUS

Since the early part of the 20th century, lakes have been classified according to their *trophic state.* "Trophic" means nutrition or growth. A *eutrophic ("well* nourished") lake has high nutrients and high plant growth. An *oligotrophic lake* has low nutrient concentrations and thus low plant growth. In between, are *mesotrophic* lakes. The trophic status of a lake is affected by the age and shape of the lake, geology of the watershed, ratio of watershed area to lake area, flushing rate of water through the lake, human impact, and many other factors. Consequently, while lakes may be lumped into a few trophic classes, each lake has a unique constellation of attributes that contribute to its trophic status.

Trophic status is a useful means of classifying lakes and describing lake processes. Oligotrophic versus eutrophic were terms originally used to distinguish highland versus lowland lakes in Germany. Highlands and other areas with infertile soils release comparatively little nitrogen and phosphorus to lakes. In contrast, lowland areas with rich organic soils release larger amounts of nutrients into nearby waters.

In addition to describing geographic variation, the "trophic" terms are used to describe geologic as well as recent history of lakes. *Eutrophication,* the progress of a lake toward a eutrophic condition, is often discussed in terms of a lakes history. A typical lake is said to age from a young, oligotrophic lake to an older, eutrophic lake (Figure 1). Turbulent geological events, such as glaciation, created lakes in uneven land surfaces and depressions. The landscapes surrounding lakes were often infertile and thus many lakes were oligotrophic. Eventually some of the areas supported colonizing organisms that decomposed rough cover materials into reasonably fertile soils. Active biological communities developed and lake basins became shallower and more eutrophic as decaying plant and animal material accumulated on the bottom. There are undoubtedly exceptions to this typical historical development where geology, topography, and lake morphology caused eutrophic conditions from the start.

This concept of lake aging has unfortunately been interpreted by some as an irreversible process whereby a lake eventually dies. In the 1960s this was an issue exemplified by the hypereutrophic condition of Lake Erie. Although it was pronounced dead, it eventually returned to less eutrophic conditions when major point sources of phosphorus (i.e., wastewater treatment plants) were controlled in the early 1970s.

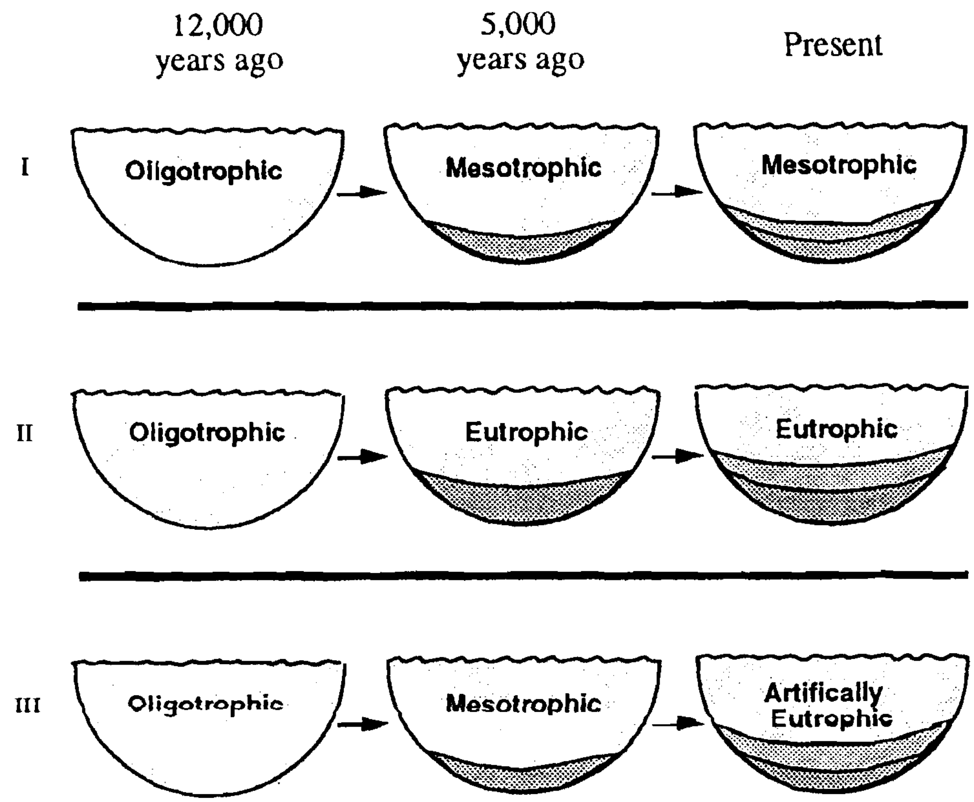

Figure 1.

Furthermore, research in paleolimnology has provided some evidence that contradicts the idealized version of a lake aging as continued eutrophication. Studies of sediment cores have suggested that the algal productivity of Wisconsin lakes actually may have fluctuated a great deal during the past 12 to 14 thousand years (the period since the last glaciation). Changes in climate and watershed vegetation seem to have both increased and decreased lake productivity over this period. It is probable that some lakes experienced high rates of photosynthesis fairly soon after glacial retreat and then became less productive until recent times. It is also possible that water sources for some lakes have changed over the past thousands of years through diversions of stream flow. In such cases water supplies to a lake (and therefore nutrient supplies) could have changed, and the lake's productivity may have changed also.

TROPHIC STATE INDICES

Trophic state indices (TSIs) are an endeavor to provide a single quantitative index for the purpose of classifying and ranking lakes, most often from the standpoint of evaluating water quality. In recent years, the Carlson (1977) Index appears to have attained general acceptance in the limnological community as a rational approach to this classification problem. A number of modifications and regional "customizations" of his approach have occurred, but for this evaluation Carlson's index will be used because of its historical use by the Wisconsin-DNR in past evaluations.

Carlson's index results in values ranging from 0 to 100 with increasing values indicating more eutrophic conditions (Table 1). The trophic states for the index are defined by using each doubling of Secchi transparency as the criterion for the division between each state, i.e. each time the transparency doubles from some base value, a decrease in TSI-S (trophic state indices for Secchi depth) occurs. The relation of Secchi depth to total phosphorus is a simple inverse function, so a doubling of total phosphorus causes the TSI-P (trophic state indices for phosphorus) to increase by 10 units. Both TSI-P and TSI-S are related to chlorophyll-a concentration. The resulting relationship results in the third TSI, TSI-C (trophic state indices for chlorophyll). The indices are based on the following three expressions:

$$\text{TSI-P} = 4.15 + (14.42 * \ln \text{TP}), \text{ in } \mu\text{g/L}.$$

$$\text{TSI-C} = 30.6 + (9.81 * \ln \text{Chlorophyll-a}), \text{ in } \mu\text{g/L}.$$

$$\text{TSI-S} = 60.0 - (14.41 * \ln \text{Secchi Depth}), \text{ in meters.}$$

Carlson's Tropbic State Index

TSI <30	**Classical oligotrophy: Clear water, oxygen throughout the year in hypolimnion, salmonid fisheries in deep lakes.**
TSI 30-40	**Deeper lakes still exhibiting classical oligotrophy, but some shallower lakes will become anoxic in the hypolimnion during the summer.**
TSI 40-50	**Water moderately clear, but increasing probability of anoxia in hypolimnion during summer.**
TSI 50-60	**Lower boundary of classical eutrophy: Decreased transparency, anoxic hypolinmia during summer.**
TSI 60-70	**Dominance of blue-green algae, algal scums probable, extensive macrophyte problems.**
TSI 70-80	**Heavy algal blooms possible throughout the summer, dense macrophyte beds, but extent limited by light penetration. Often would be classified as hypereutrophic.**
TSI >80	**Algal scums, summer fish kills, few macrophytes, an over abundance of rough fish.**

Table 1.

The following "rules" should be applied when using TSIs:

1) If one index value is based on numerous measurements, while the other is based on a single measurement, then the former is used as a better indicator.

2) If there is only a single measure for each or an equal number of measures, the TSI-P value should be favored.

3) TSI-S and TSI-C based on a single measure are to be viewed with caution.

STANDARD FIELD OPERATING PROCEDURES.

Monitoring regimes range from simple and inexpensive (obtaining Secchi disk transparency readings every other week from May to September) to intensive and expensive (biweekly transparencies, temperature/ dissolved oxygen profiles, total phosphorus, chlorophyll, and other chemical data may be obtained) . Usually, the monitoring regime which best suits the budget and goals of the monitoring program falls somewhere between these two extremes. It is best to consult with a Wisconsin DNR lakes biologist for advice on the design of your program.

This manual is intended for use by volunteer monitors but also documents the common methods used by lake biologists. Nothing in this manual replaces the guidance offered by equipment manufacturers concerning care and calibration of their products.

The Standard Field Operating Procedures that follow, outline steps used to collect and record lake data. If samples are not taken the same way each time, data will not be comparable, nor will the procedures used to collect data be repeatable in the future. It is absolutely necessary to locate the same sample locations and repeat the procedures used to collect water quality data in order to use the data in the future.

ESTABLISHING SAMPLE LOCATIONS FOR LAKES

1. Obtain a Bathymetric map of the lake to be sampled (Figures 2&3).

2. Look for the deepest recorded depth on the map. Circle the area with the deepest readings (from now on referred to as the "deep hole"). This area will be the primary sampling station (location) for the lake and should be called Station # 1. The deep hole is usually Station # 1. Most lakes only require one sampling location, however, if more than one station is desired, the area with the second deepest area is Station # 2 and so on. Sometimes a lake will have two deep holes at different places in the lake. In this case, the hole that appears to cover the largest area should be labeled Station # 1. Sample stations are not the same as lake basins and should not be used as such. If a different protocol is preferred for a project, document the change, otherwise the protocol described above will be assumed.

NOTE: It is best to check with the Wisconsin DNR prior to establishing a sampling location to obtain the lake's identification statistics and verify that the appropriate station number is assigned.

If a DNR map is not available (lake has never been surveyed by DNR), photocopy the lake from a map and mark the location to be sampled. It may take some actual field depth readings with a depth finder or weight