IPS ENVIRONMENTAL AND ANALYTICAL SERVICES
Appleton, Wisconsin

PHASE I
LAKE MANAGEMENT PLAN
LITTLE CHAIN O' LAKES
WAUPACA COUNTY, WISCONSIN

REPORT TO:
CHAIN O' LAKES PROPERTY OWNERS ASSOCIATION

August, 1993

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIXES

SUMMARY

The Chain O' Lakes (Chain) is a recreationally popular group of lakes located in Waupaca County, Wisconsin. Generally, the lakes are spring fed, relatively deep and clear. For plan development, the Chain was divided into Upper, Middle, Lower, East and Little Chain subgroups. Specific Phase I objectives were to establish a water quality monitoring strategy to assess current status and track trends, to improve public awareness and participation, and to initiate assessment of recreational use opinions and options.

The Little Chain ([redacted]) comprises about only seven percent of the total Chain lake surface area, but 38 percent of the watershed area. Little Chain lakes are listed as **spring**[1] or **drainage lakes** and receive the most substantial spring inflow of all Chain O' Lakes project subgroups.

Little Chain lake **morphometry** is similar and water quality is good to excellent and indicative of **oligotrophic** to **mesotrophic** status. While nutrient levels were below those typical of Wisconsin lakes overall and of lakes in the Chain O' Lakes' ecoregion, higher levels in the more downstream Little Chain lakes suggested at least some effect of inputs from the Hartman/Allen Creek basin. Generally, water quality of the Little Chain was similar to that of other Chain lakes with similar physical characteristics.

Water quality monitoring, recreational use management, aesthetics protection/enhancement and prevention of exotic plant/animal introductions are recommended to protect the excellent quality of this resource.

Water quality trend monitoring should be continued on a similar schedule to supplement the small amount of historic data available; event samples should be taken as appropriate in areas of concern and in the Hartman/Allen Creek basin. Volunteers should be solicited to take **Secchi depth** readings on each lake.

Riparian land owner education and diligence with respect to runoff control, and yard waste and fertilizer management, should be encouraged to maximize aesthetics and minimize sediment and nutrient input to the lakes.

Recreational use survey results (presently being tabulated) should be analyzed, with appropriate correlations, to assess perceptions and attitudes and develop practical options for future management and minimization of use conflicts.

Measures to prevent or reduce the potential for invasion of exotic species (e.g., Eurasian milfoil and purple loosestrife which are present and spreading in Waupaca County) should be identified and implemented.

[1] Text terms in **bold** print defined in glossary (pp. vi-vii)

INTRODUCTION

The Chain O' Lakes (Chain) is a group of 22 interconnected lakes located in the southwest corner of Waupaca County near the City of Waupaca and the Villages of Rural and King. The lakes are mostly deep, clear, spring lakes; the Chain and associated wetlands, and undeveloped shoreline areas have been designated as environmentally sensitive areas (4).

The Chain O' Lakes Property Owners Association (CLPOA) was formed in the 1960's to provide leadership and coordination of lake preservation and educational activities pertinent to the Chain. Currently, the CLPOA has about 13 elected officers on the Executive Committee and about 600 members.

The CLPOA, in 1990, decided to pursue the development of a long range management plan for the Chain under the Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grant Program. The CLPOA officers selected IPS Environmental & Analytical Services (IPS) of Appleton, Wisconsin as its consultant to develop the plans. Grant applications, one each for five project groups of the Chain (Table 1), were prepared and submitted in January, 1991. The Little Chain application incorporated required or recommended program components including:

- assessment of current water quality in the Little Chain and implementation of a strategy to track trends,
- increase the awareness of the lake property owners of lake problems and establishment of a base of support for lake management efforts.

The Little Chain grant application was approved in April, 1991.

Table 1. Lake Management Planning Project Groups, Chain O' Lakes, Waupaca County, WI.

Upper Chain	Middle Chain	Lower Chain
Otter Lake	Nessling Lake	Columbia Lake
Taylor Lake	McCrossen Lake	Ottman Lake
George Lake	Round Lake	Youngs Lake
Sunset Lake	Limekiln Lake	Bass Lake
Rainbow Lake		Beasley Lake
		Long Lake

East Chain	Little Chain
Dake Lake	Marl Lake
Miner Lake	Pope Lake
	Manomin Lake
	Knight Lake
	Orlando Lake

DESCRIPTION OF AREA

The Chain O' Lakes is a group of "kettle" lakes located in the southwest corner of Waupaca County, WI (Figure 1). Kettle lakes are typically formed when large ice blocks are pushed into the soil by a retreating glacier; the depression subsequently fills with water when the ice blocks melt. The five Little Chain lakes, in the western-most portion of the Chain, have similar morphology and are classified either spring or drainage lakes.

The general topography of Waupaca County is related to glacial activity; the Chain is located in moranic hills left after the retreat of the Cary Glacier (5). Topography adjacent to the lakes is moderately to steeply sloping. Major soil types near the Little Chain are well drained Rosholt sandy loam on 2 - 20 percent slopes and Seelyeville muck on 0 - 2 percent slopes (6). Erosion potential is moderate (Rosholt) to slight (Seelyeville).

Predominant substrates are sand and **marl**; scattered reaches of rubble and muck are present (Personal communication WDNR). **Macrophytes** (aquatic plants) are present but are not considered a problem in the Little Chain where small, predominantly sandy **littoral** zones are not conducive to abundant or extensive plant growth. Two exotic nuisance plant species, Eurasian milfoil (Myriophyllum spicatum) and purple loosestrife (Lythrum

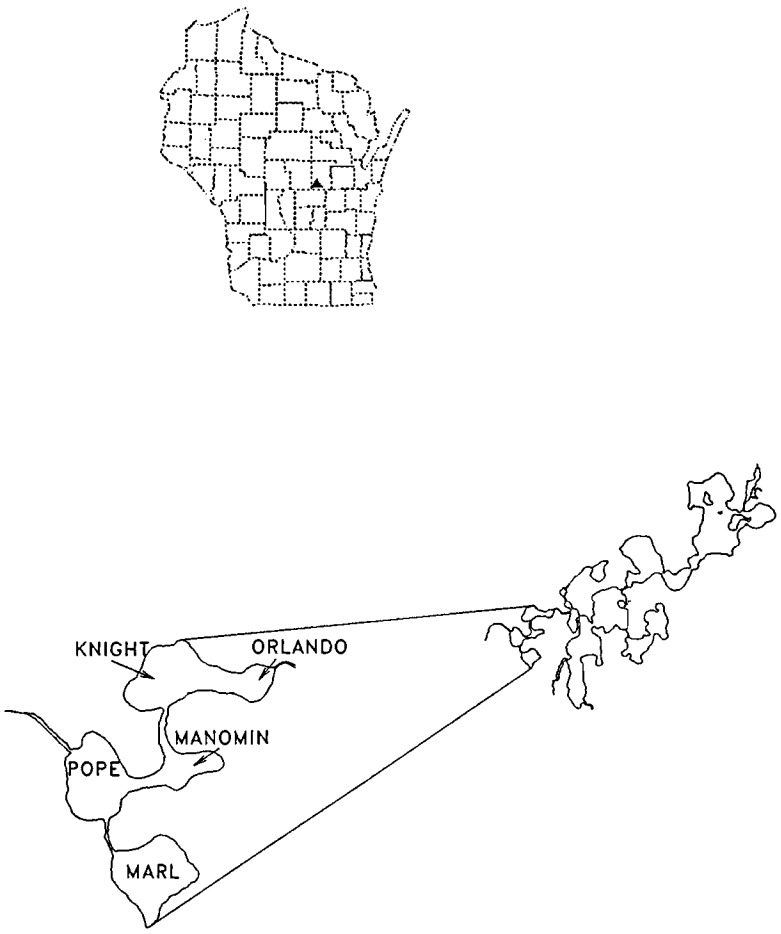

Figure 1. Location Map, Chain O' Lakes, Waupaca County, WI.

salicaria), are established in Waupaca County and are capable of spreading to the Chain O' Lakes system.

The Chain O' Lakes watershed, about 20,000 acres overall, is predominantly forested with open/agricultural areas. Native trees include maple, ash, oak and pine and dairy farming is the chief agricultural activity in the watershed (Pers. comm. WDNR).

Little Chain lake area ranges from 6 acres (Manomin) to 14 acres (Pope, Table 2). Lake volume ranges from 63 (Manomin) to 298 acre-feet (Marl) (Pers. comm. WDNR). Relatively small lake surface area (maximum **fetch** 0.25 miles, Knight Lake), depth (30 - 59 feet), and topography combine to inhibit mixing of the Little Chain lakes; thermal **stratification** develops during summer and restricts mixing to spring and fall overturns.

Table 2. Physical Characteristics of the Little Chain Lakes, Waupaca County, WI.

Lake Name	MARL	POPE	MANOMIN	KNIGHT	ORLANDO
Location					
Township	21N	21N	21N	21,22N	21N
Range	11E	11E	11E	11E	11E
Section(s)	05	05	05	32,05	05
Lake Type	Spring	Drainage	Drainage	Drainage	Drainage
Area (acres)	13	14	6	9	9
Max. Depth (ft)	59	40	30	42	39
Av. Depth (ft)	29	19	11	18	13
Volume (acre-feet)	298	262	63	158	117
Shoreline (miles)	0.70	0.90	0.50	0.60	0.60
Fetch (miles)	0.20	0.21	0.19	0.25	0.09
Fetch Orientation	N-S	NW-SE	SW-NE	W-E	N-S
Width (miles)	0.19	0.13	0.09	0.14	0.07
Lake Shore Soils					
Major Type	Rosholt[1]	Seelyeville[2]	Seelyeville[2]	Rosholt[1]	Rosholt[1]
% Slope	12-20	0-2	0-2	2-6	12-20

[1] = Rosholt sandy loam; [2] = Seelyeville muck.

The Chain supports warmwater and coldwater fisheries (Table 3). Some trout from the Chain are known to migrate into Emmon's Creek

to spawn; splake and rainbow trout were stocked in the past by the WDNR to supplement the cold water fishery. Hybrid muskellunge were stocked in the Chain from 1979 to 1986. No stocking presently occurs in the Chain (Pers. comm. WDNR). A WDNR consumption advisory (for mercury) currently exists for largemouth bass taken from Columbia Lake. Fish from Rainbow Lake have also been tested for mercury but no advisory was issued (7).

Public boat ramps are available at 10 locations on the Chain. Most connecting channels are navigable for powerboats and all but one (Ottman - Youngs) are navigable with a canoe. The channel which connects the Little Chain to the Chain (Beasley to Orlando Lake channel) is only navigable with a canoe and thus limits boat traffic to the Little Chain. The Little Chain has direct access boat ramps on Marl Lake and the Manomin - Knight Lake channel.

Because of intensive recreational use during summer, the Towns of Dayton and Farmington and the CLPOA adopted ordinances to regulate boat traffic on the Chain. Except for the largest lakes (Columbia, Long, Rainbow and Round), all lakes on the Chain have a "no wake" speed limit (Pers. comm. CLPOA). Water skiing on these lakes is limited to 10:00 a.m. - 2:30 p.m. on weekends and Holidays, 10:00 a.m. - 4:00 p.m. on Monday and Friday, and 10:00 a.m. - 7:00 p.m. on Tuesday through Thursday.

Table 3. Chain O' Lakes Fish Species.

COMMON NAME	SCIENTIFIC NAME
Warmwater Game Fish	
Muskellunge	*Esox masquinongy*
Hybrid muskellunge (muskellunge X northern pike)	
Northern pike	*Esox lucius*
Walleye	*Stizostedion vitreum*
Largemouth bass	*Micropterus salmoides*
Smallmouth bass	*Micropterus dolomieui*
Lake sturgeon	*Acipenser fulvescens*
Coldwater Game Fish	
Brown trout	*Salmo trutta*
Rainbow trout	*Salmo gairdneri*
Hybrid splake (lake trout X brook trout)	
Cisco	*Coregonus artedii*
Warmwater Panfish	
Bluegill	*Lepomis macrochirus*
Black crappie	*Pomoxis nigromaculatus*
Green sunfish	*Lepomis cyanellus*
Pumpkinseed	*Lepomis gibbosus*
Rock bass	*Ambloplites rupestris*
Warmouth	*Lepomis gulosus*
Yellow perch	*Perca flavescens*
Black bullhead	*Ictalurus melas*
Brown bullhead	*Ictalurus nebulosus*
Yellow bullhead	*Ictalurus natalis*
Rough Fish	
Bowfin	*Amia calva*
White sucker	*Catostomus commersoni*
Hog sucker	*Hypentelium nigricans*
Bigmouth buffalo	*Ictiobus cyprinellus*
Shorthead redhorse	*Moxostoma macrolepidotum*
Burbot	*Lota lota*
Forage Fish	
Brook silverside	*Labidesthes sicculus*
Western mudminnow	*Umbra limi*
Golden shiner	*Notemigonus crysoleucas*
Bluntnose minnow	*Pimephales notatus*
Central stoneroller	*Campostoma anomalum*
Northern common shiner	*Notropis cornutus*
Northern creek chub	*Semotilus atromaculatus*
Blackside darter	*Percina maculata*
Slimy muddler	*Cottus cognatus*
Central johnny darter	*Etheostoma nigrum*

METHODS

FIELD PROGRAM

Water sampling was conducted June 5, August 7 and September 5, 1991 and February 4 and May 5, 1992 at the deepest point of each lake in the Little Chain (Table 4, Figure 2). All sites were sampled three feet below the surface (designated "S") and three feet above bottom (designated "B").

Physicochemical parameters measured in the field were Secchi depth, water temperature, pH, dissolved oxygen (DO), and conductivity. Field measurements were taken using a Secchi disk and a Hydrolab Surveyor II multiparameter meter; the Hydrolab unit was calibrated prior to and subsequent to daily use.

Samples were taken for laboratory analyses with a Kemmerer water bottle. Samples were labelled, preserved if necessary, and packed on ice in the field; samples were delivered by overnight carrier to the laboratory. All laboratory analyses were conducted at the State Laboratory of Hygiene (Madison, WI) using WDNR or APHA (8) methods. Spring parameters determined by the laboratory included laboratory pH, total alkalinity, total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus and dissolved phosphorus, total solids, and

Table 4. Sample Station Descriptions, Little Chain, 1991 - 1992.

		WATER QUALITY	
Lake	Site	Latitude (North) / Longitude (West)	Depth
Marl (Deepest Pt.)	1403	44° 19' 25" / 89° 11' 30"	59.0 ft.
Pope (Deepest Pt.)	1402	44° 19' 34" / 89° 11' 39"	40.0 ft.
Manomin (Deepest Pt.)	1401	44° 19' 38" / 89° 11' 24"	30.0 ft.
Knight (Deepest Pt.)	1404	44° 19' 48" / 89° 11' 30"	42.0 ft.
Orlando (Deepest Pt.)	1405	44° 19' 48" / 89° 11' 12"	39.0 ft.

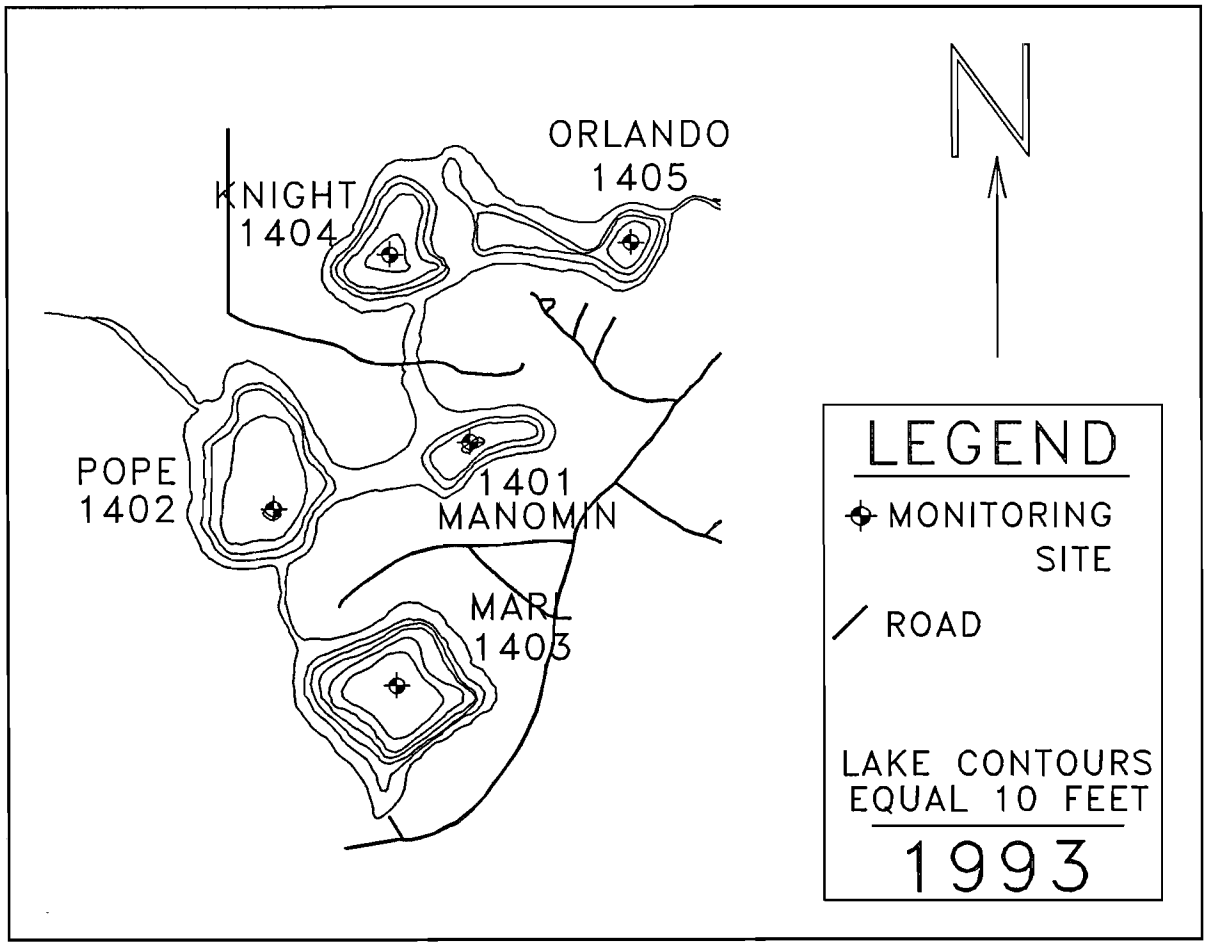

Figure 2. Sample Station Locations, Little Chain, Chain O' Lakes, Waupaca County, WI

chlorophyll a. Summer and late summer laboratory analyses included total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus, dissolved phosphorus, and chlorophyll a. Winter water quality parameters included total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus and dissolved phosphorus.

OTHER

Water Quality Information

Additional lake information was retrieved from the WDNR Surface Water Inventory (5) and the Wisconsin Lake Bulletin Board System.

Land Use Information

Details of zoning and specific land uses were obtained from the UW-Extension, Waupaca County zoning maps, United States Soil Conservation Service soil maps (6), aerial photographs, and United States Geological Survey quadrangle maps. This information, when considered questionable or out-dated, was confirmed by field reconnaissance.

Ordinance information was taken from Waupaca County Zoning Ordinance and Waupaca County Soil Erosion Control and Animal Wastewater Pollution Control Plans which were acquired from the Waupaca County Land Conservation Department.

Public Involvement Program

Public involvement activities coordinated with the lake management planning process are summarized in Appendix I.

Recreational Use Survey

A survey was distributed to CLPOA for subsequent distribution to members. The survey form was designed to assess current types and levels of use and opinions regarding them. The survey was furnished to CLPOA in June and returned August, 1992; tabulation and analysis are plan development Phase II activities.

FIELD DATA DISCUSSION

The Little Chain is comprised of five small, natural lakes. Flow through the Little Chain is from Marl to Pope Lake, and to Manomin, Knight and Orlando Lakes before draining to Bass Lake (Lower Chain). Inflow from the relatively undisturbed Hartman Creek basin enters Pope Lake but spring input to the Little Chain is considerable and greater than for other Chain project groups.

The Chain O' Lakes watershed consists of wooded/wooded residential, open/agricultural, open/residential and wetland areas; the Little Chain watershed, because of the Hartman and Allen Creek inflows to Pope Lake, is about 7,600 acres and the second largest of the Chain project groups. Land use adjacent to most Little Chain lakes is mostly wooded/wooded residential or otherwise undisturbed (Figure 3). Pope Lake borders Hartman Creek State Park and has no dwellings around it.

The Little Chain has a watershed to lake ratio of 149:1 which means that 149 times more land than lake surface area drains to the lakes. This value, much higher than the 88:1 ratio for drainage lakes and the 8:1 ratio for seepage lakes in Wisconsin (9), suggests a relatively high potential for nonpoint runoff should the watershed become more disturbed or erosion prone.

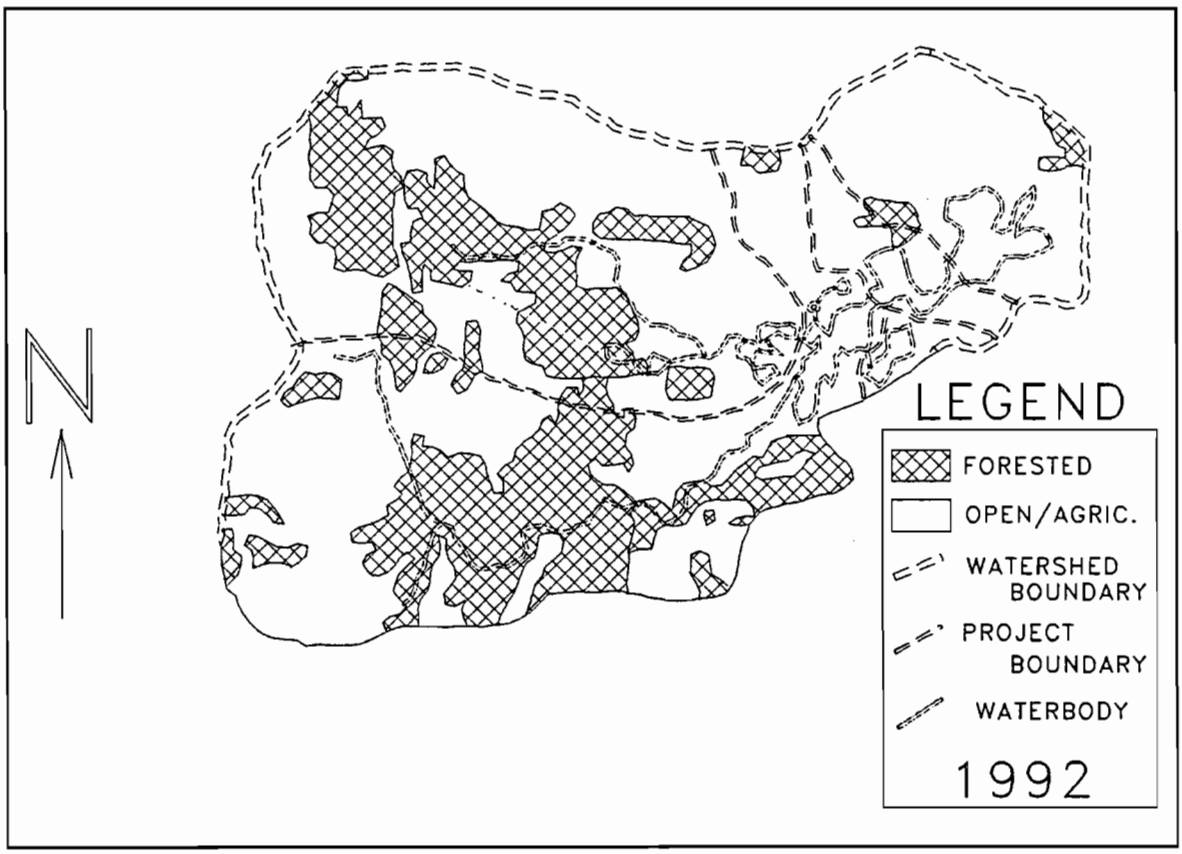

Figure 3. Land Uses in the Chain O' Lakes Watershed, Waupaca and Portage Counties, WI.

Monitoring in 1991-1992 (Tables 5-10), indicated good and generally similar water quality among the Little Chain lakes. Some differences in nutrient levels (nitrogen and phosphorus) were observed, however, between Marl and the downstream lakes.

Surface total nitrogen, which can be highly variable among lakes and is best considered on a trend or relative basis, ranged from 0.290 mg/l (milligrams per liter or parts per million) in Marl Lake to about 1.92 mg/l in Manomin Lake. Average surface total nitrogen was 1.07 mg/l overall and was lowest in Marl Lake (0.52 mg/l) and highest in Manomin Lake (1.39 mg/l). Lowest levels typically occurred during stratified conditions in Summer.

Phosphorus is often the limiting nutrient to plant and algal production in lakes. Surface total phosphorus ranged from 0.004 in Manomin and Marl Lakes to 0.018 mg/l in Orlando Lake (Tables 5-10). (Note: A sample from Manomin Lake that registered 0.115 mg/l appeared to have been contaminated and was ignored.) Average surface total phosphorus was 0.009 mg/l overall and was lowest in Marl Lake (0.005 mg/l) and highest in Orlando Lake (0.011 mg/l). Phosphorus levels for the Little Chain were still lower than those typical for stratified lakes (0.023 mg/l) and for lakes in the central region of Wisconsin (0.020 mg.l) (9); levels were also below those typical for the ecoregion in which the Chain is located (0.010 - 0.014 mg/l) (10) (Figure 4).

Table 5. Water Quality Parameters, Station 1403, Marl Lake, Waupaca County, WI.

PARAMETER	SAMPLE[1]	06/05/91	08/07/91	09/05/91	02/04/92	05/05/92
Secchi (feet)		21.0	13.0	14.0	NR[2]	12.0
Cloud Cover (%)		10	50	10	100	0
Temperature (°C)	S	20.84	22.14	21.25	3.73	12.20
	B	7.28	8.31	9.05	4.20	6.47
pH (S.U.)	S	8.30	8.55	8.53	8.25	8.41
	B	7.52	6.97	7.46	7.76	7.68
D.O. (mg/l)	S	9.37	10.36	10.85	7.30	11.14
	B	1.86	0.12	0.32	3.45	4.74
Conductivity (µmhos/cm)	S	333	290	274	327	298
	B	407	379	354	334	324
Laboratory pH (S.U.)	S	8.4	NR	NR	NR	8.45
	B	7.8	NR	NR	NR	8.09
Total Alkalinity (mg/l)	S	160	NR	NR	NR	174
	B	198	NR	NR	NR	193
Total Solids (mg/l)	S	194	NR	NR	NR	NR
	B	242	NR	NR	NR	NR
Total Kjeldahl N (mg/l)	S	0.3	0.2	0.2	0.5	0.3
	B	0.6	1.0	0.2	0.5	0.5
Ammonia Nitrogen (mg/l)	S	0.043	0.016	0.022	0.293	0.033
	B	0.169	0.746	0.020	0.337	0.166
NO_3 + NO_2 Nitrogen(mg/l)	S	0.227	0.126	0.090	0.334	0.345
	B	0.409	ND[3]	0.093	0.276	0.400
Total Nitrogen (mg/l)	S	0.527	0.326	0.290	0.834	0.645
	B	1.009	<1.000	0.293	0.776	0.9
Total Phosphorus (mg/l)	S	0.005	0.005	0.004	0.008	0.004
	B	0.019	0.029	0.005	0.011	0.017
Diss. Phosphorus (mg/l)	S	ND	0.002	ND	0.002	ND
	B	0.036[4]	ND	0.002	0.002	0.002
N/P Ratio	S	105.4	65.2	72.5	104.2	161.2
	B	53.1	<34.7	58.6	70.5	52.9
Chlorophyll a (µg/l)	S	1	2	2	NR	3

[1] S = Near Surface; B = Near Bottom; [2] NR = No Reading; [3] ND = Not Detectable; [4] = Apparent contamination; Diss P = Total P.

Table 6. Water Quality Parameters, Station 1402, Pope Lake, Waupaca County, WI.

PARAMETER	SAMPLE[1]	06/05/91	08/07/91	09/05/91	02/04/92	05/05/92
Secchi (feet)		13.0	15.0	14.0	NR[2]	13.1
Cloud Cover (%)		5	100	10	100	0
Temperature (°C)	S	19.59	20.13	18.89	3.57	11.84
	B	7.92	9.15	9.92	3.99	6.90
pH (S.U.)	S	8.13	8.30	8.34	9.80	8.30
	B	7.44	6.98	7.19	8.54	7.24
D.O. (mg/l)	S	8.88	9.63	9.85	11.20	11.08
	B	0.84	0.16	0.27	6.72	2.66
Conductivity (µmhos/cm)	S	340	313	304	348	302
	B	404	366	351	361	320
Laboratory pH (S.U.)	S	8.3	NR	NR	NR	8.43
	B	7.6	NR	NR	NR	7.74
Total Alkalinity (mg/l)	S	160	NR	NR	NR	171
	B	193	NR	NR	NR	186
Total Solids (mg/l)	S	212	NR	NR	NR	NR
	B	246	NR	NR	NR	NR
Total Kjeldahl N (mg/l)	S	0.4	0.2	0.3	0.2	0.2
	B	0.6	1.4	1.5	0.3	0.6
Ammonia Nitrogen (mg/l)	S	0.050	0.033	0.019	0.075	0.015
	B	0.340	0.848	1.06	0.203	0.256
NO_3 + NO_2 Nitrogen(mg/l)	S	0.663	0.772	0.821	1.54	1.05
	B	0.307	0.023	0.009	1.54	0.832
Total Nitrogen (mg/l)	S	1.063	0.972	1.121	1.74	1.25
	B	0.907	1.423	1.509	1.84	1.432
Total Phosphorus (mg/l)	S	0.011	0.009	0.007	0.013	0.009
	B	0.034	0.150	0.199	0.010	0.026
Diss. Phosphorus (mg/l)	S	ND[3]	ND	ND	0.002	0.003
	B	ND	0.005	0.013	0.005	0.002
N/P Ratio	S	96.6	108.0	160.1	133.8	138.9
	B	26.7	9.5	7.6	184.0	55.1
Chlorophyll a (µg/l)	S	3	3	4	NR	5

[1] S = Near Surface; B = Near Bottom; [2] NR = No Reading; [3] ND = Not Detectable

Table 7. Water Quality Parameters, Station 1401, Manomin Lake, Waupaca County, WI.

PARAMETER	SAMPLE[1]	06/05/91	08/07/91	09/05/91	02/04/92	05/05/92
Secchi (feet)		11.0	18.0	15.0	NR[2]	14.8
Cloud Cover (%)		NR	80	10	100	0
Temperature (°C)	S	20.60	21.42	20.30	3.00	12.65
	B	7.15	8.24	9.12	3.53	6.50
pH (S.U.)	S	8.09	8.46	8.33	9.21	8.14
	B	7.40	6.85	6.80	8.20	7.00
D.O. (mg/l)	S	9.45	10.88	9.31	10.43	10.90
	B	0.78	0.21	0.16	2.78	0.34
Conductivity (µmhos/cm)	S	335	308	298	344	300
	B	416	430	440	358	344
Laboratory pH (S.U.)	S	8.3	NR	NR	NR	8.43
	B	7.5	NR	NR	NR	7.63
Total Alkalinity (mg/l)	S	159	NR	NR	NR	171
	B	209	NR	NR	NR	204
Total Solids (mg/l)	S	210	NR	NR	NR	NR
	B	266	NR	NR	NR	NR
Total Kjeldahl N (mg/l)	S	1.9	0.2	0.4	0.2	0.3
	B	0.4	4.2	1.7	0.4	1.5
Ammonia Nitrogen (mg/l)	S	0.988	0.033	0.042	0.086	0.030
	B	0.097	2.72	0.829	0.239	0.799
NO_3 + NO_2 Nitrogen(mg/l)	S	<0.015	0.659	0.650	1.65	0.980
	B	0.593	0.057	0.018	1.37	ND[3]
Total Nitrogen (mg/l)	S	<1.915	0.859	1.05	1.85	1.28
	B	0.993	4.257	1.718	1.77	1.5
Total Phosphorus (mg/l)	S	0.115[4]	0.008	0.008	0.004	0.008
	B	0.014	0.30	0.071	0.009	0.087
Diss. Phosphorus (mg/l)	S	ND	0.004	ND	0.002	0.002
	B	0.002	0.018	ND	0.006	0.002
N/P Ratio	S	<16.6	107.4	131.2	462.5	160.0
	B	70.9	14.2	24.2	196.7	17.2
Chlorophyll a (µg/l)	S	9	2	3	NR	3

[1] S = Near Surface; B = Near Bottom; [2] NR = No Reading; [3] ND = Not Detectable; [4] Apparent contamination

Table 8. Water Quality Parameters, Station 1404, Knight Lake, Waupaca County, WI.

PARAMETER	SAMPLE[1]	06/05/91	08/07/91	09/05/91	02/04/92	05/05/92
Secchi (feet)		18.0	17.0	16.0	NR[2]	17.0
Cloud Cover (%)		10	50	10	100	0
Temperature (°C)	S	21.89	21.56	20.66	2.89	12.30
	B	7.40	8.17	8.70	4.74	7.00
pH (S.U.)	S	8.15	8.40	8.29	8.36	8.23
	B	7.35	6.87	7.13	7.60	7.16
D.O. (mg/l)	S	9.00	9.62	10.21	9.48	10.79
	B	0.76	0.17	0.33	0.98	0.28
Conductivity (µmhos/cm)	S	334	310	303	348	305
	B	466	418	402	377	367
Laboratory pH (S.U.)	S	8.3	NR	NR	NR	8.43
	B	7.6	NR	NR	NR	7.99
Total Alkalinity (mg/l)	S	158	NR	NR	NR	173
	B	222	NR	NR	NR	211
Total Solids (mg/l)	S	202	NR	NR	NR	NR
	B	276	NR	NR	NR	NR
Total Kjeldahl N (mg/l)	S	0.4	0.4	0.3	0.4	0.2
	B	0.6	1.2	1.5	0.4	<0.2
Ammonia Nitrogen (mg/l)	S	0.057	0.048	0.034	0.136	0.054
	B	0.230	0.713	1.01	0.247	0.043
NO_3 + NO_2 Nitrogen(mg/l)	S	0.570	0.508	0.486	1.38	0.931
	B	0.243	0.009	ND[3]	0.852	0.795
Total Nitrogen (mg/l)	S	0.97	0.908	0.786	1.78	1.131
	B	0.843	1.209	<1.500	1.252	<0.995
Total Phosphorus (mg/l)	S	0.012	0.012	0.008	0.010	0.006
	B	0.058	0.146	0.185	0.025	0.022
Diss. Phosphorus (mg/l)	S	0.003	0.005	0.002	0.002	0.002
	B	0.005	0.016	0.017	0.020	0.002
N/P Ratio	S	80.8	75.7	98.2	178.0	188.5
	B	14.5	8.3	<8.1	50.1	<45.2
Chlorophyll a (µg/l)	S	3	1	3	NR	2

[1] S = Near Surface; B = Near Bottom; [2] NR = No Reading; [3] ND = Not Detectable

Table 9. Water Quality Parameters, Station 1405, Orlando Lake, Waupaca County, WI.

PARAMETER	SAMPLE[1]	06/05/91	08/07/91	09/05/91	02/04/92	05/05/92
Secchi (feet)		12.0	16.0	16.0	NR[2]	26.1
Cloud Cover (%)		30	50	10	100	10
Temperature (°C)	S	21.32	21.42	21.23	2.91	12.93
	B	6.00	6.57	7.73	4.11	5.65
pH (S.U.)	S	8.12	8.42	8.39	8.71	8.14
	B	7.29	6.50	6.93	7.79	7.09
D.O. (mg/l)	S	8.85	9.81	9.20	8.89	10.03
	B	0.90	0.09	0.26	0.22	0.35
Conductivity (µmhos/cm)	S	335	307	295	347	304
	B	450	453	406	376	364
Laboratory pH (S.U.)	S	8.3	NR	NR	NR	8.34
	B	7.5	NR	NR	NR	7.65
Total Alkalinity (mg/l)	S	159	NR	NR	NR	172
	B	219	NR	NR	NR	213
Total Solids (mg/l)	S	218	NR	NR	NR	NR
	B	280	NR	NR	NR	NR
Total Kjeldahl N (mg/l)	S	0.4	0.3	0.2	0.3	0.4
	B	2.5	3.9	3.0	1.2	2.0
Ammonia Nitrogen (mg/l)	S	0.057	0.043	0.062	0.136	0.077
	B	1.42	2.75	1.97	0.803	1.42
NO_3 + NO_2 Nitrogen(mg/l)	S	0.576	0.455	0.454	1.52	0.921
	B	0.017	0.023	0.011	0.573	ND[3]
Total Nitrogen (mg/l)	S	0.976	0.755	0.654	1.82	1.321
	B	2.517	3.923	3.011	1.773	<2.000
Total Phosphorus (mg/l)	S	0.010	0.010	0.007	0.012	0.018
	B	0.108	0.28	0.232	0.069	0.144
Diss. Phosphorus (mg/l)	S	0.002	0.002	ND	0.004	0.003
	B	0.002	0.133	0.126	0.051	0.057
N/P Ratio	S	97.6	75.5	93.4	151.7	73.4
	B	23.3	14.0	13.0	25.7	<13.9
Chlorophyll a (µg/l)	S	3	2	3	NR	1

[1] S = Near Surface; B = Near Bottom; [2] NR = No Reading; [3] ND = Not Detectable

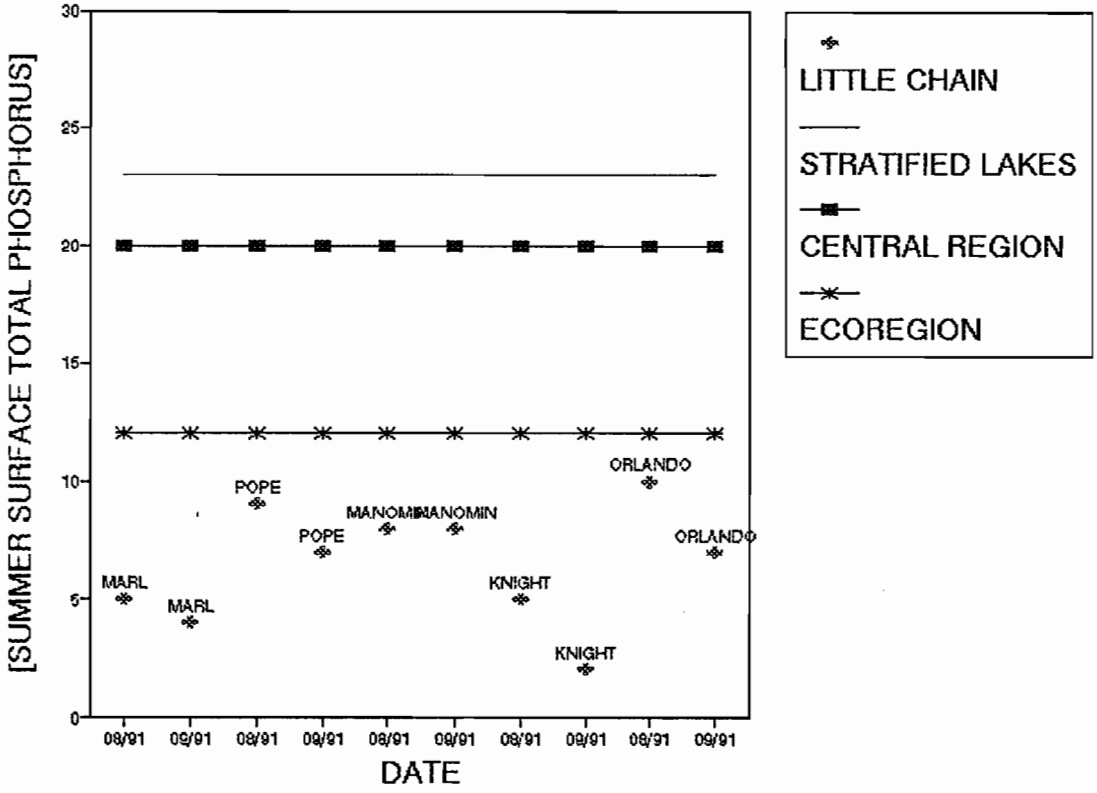

Figure 4. Comparison of Total Phosphorus Levels, Little Chain, Chain O' Lakes, 1991.

Substantially higher values for total phosphorous and other nutrient parameters were often observed near bottom and suggested nutrient release from sediments under **anoxic** or near-anoxic conditions in the **hypolimnion** which occurred during summer stratification and during winter at these relatively deep points. Nitrogen to phosphorus ratios (**N/P ratio**) for surface samples were greater than 15 and indicated all Little Chain lakes to be phosphorus limited during the 1991 - 1992 monitoring period.

All Little Chain lakes were thermally stratified during summer (Figure 5, Appendix II). Depth to the thermocline was variable among lakes [minimum 9 feet (Pope Lake), maximum 18 feet (Manomin Lake)]. Hypolimnetic oxygen levels were below those generally considered necessary to sustain most aquatic life. Winter water column readings indicated typical unstratified conditions with dissolved oxygen levels decreasing with increasing lake depth (Figure 6).

Numerous summarative indices have been developed to indicate lake **eutrophication** status based on water quality parameters. The Trophic State Index (TSI) developed by Carlson (11) utilizes Secchi transparency, chlorophyll a, and total phosphorus. As with most indices, application is generally most appropriate on a relative and trend monitoring basis. This particular index does not account for natural, regional variability in total phosphorus

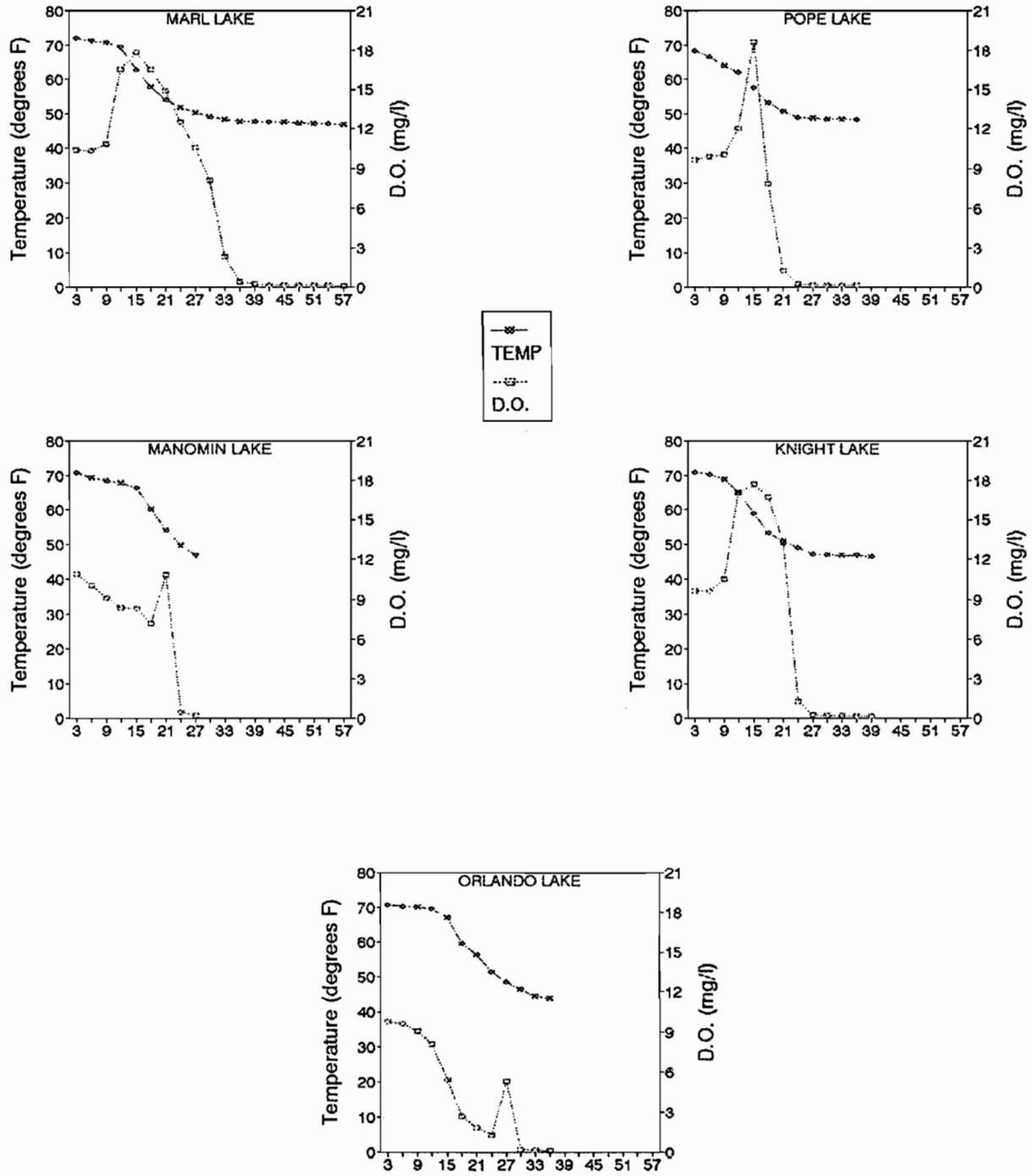

Figure 5. Temperature/DO Profiles, Little Chain, Chain O' Lakes, Summer, 1991.

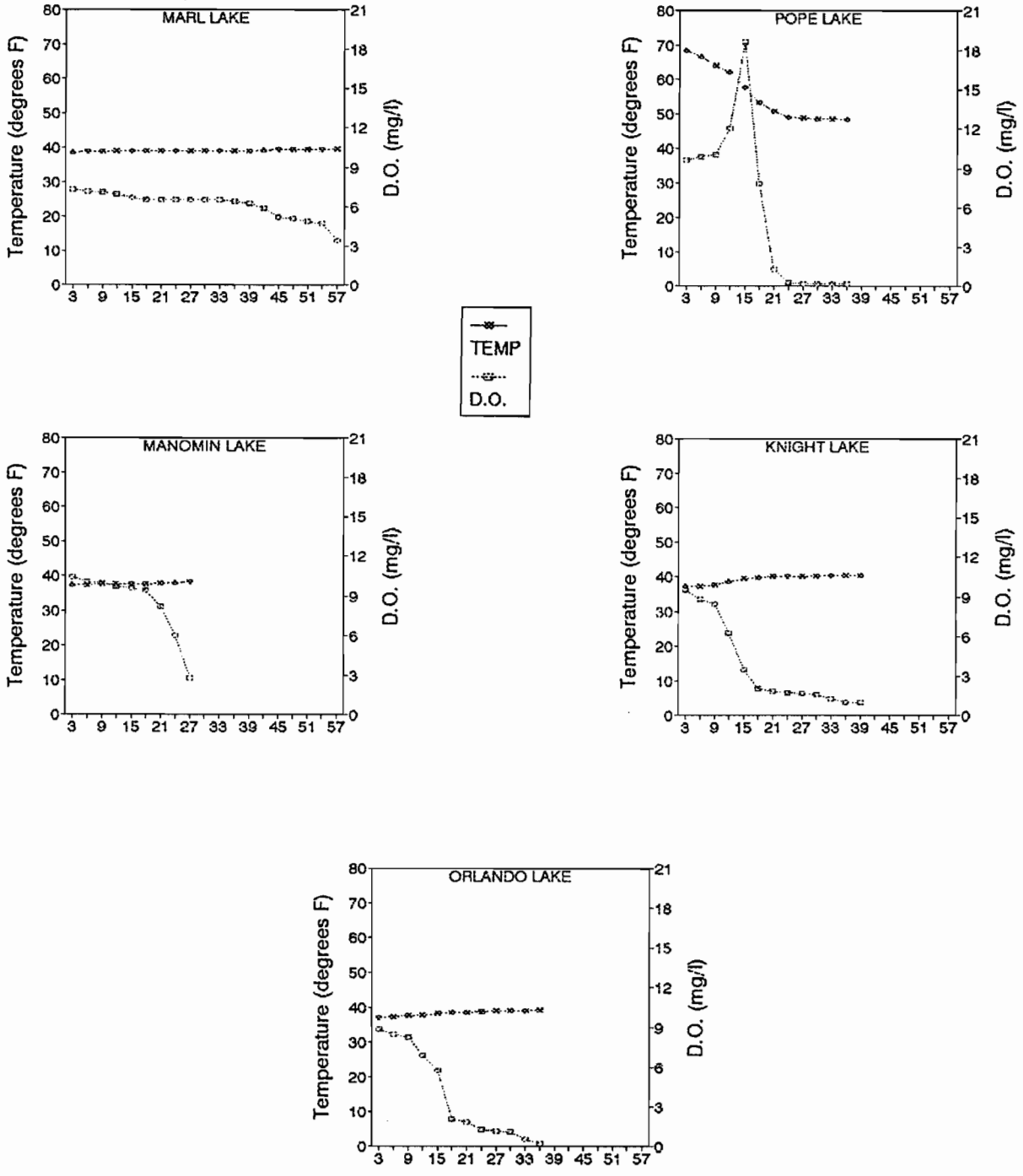

Figure 6. Temperature/DO Profiles, Little Chain, Chain O' Lakes, Winter, 1992.

levels nor in Secchi transparency reduction unrelated to algal growth (e.g. that associated with color). TSI numbers for the Little Chain sampling sites, generally, indicated oligotrophic to mesotrophic conditions (Figure 7). No readily discernable trend was evident from the limited amount of historic data available (Appendix III).

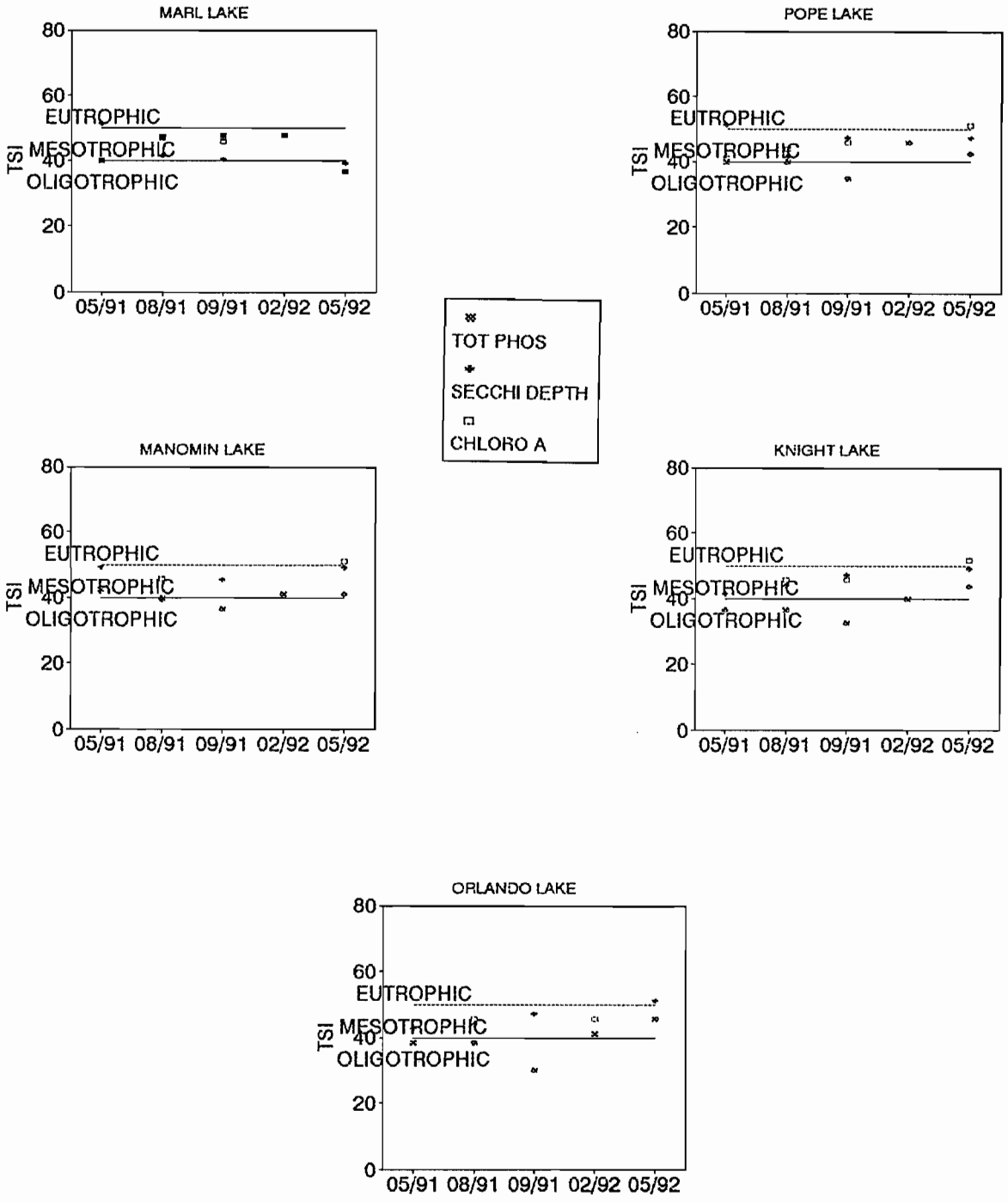

Figure 7. Trophic State Index for Secchi Depth, Total Phosphorus and Chlorophyll a, Little Chain, Chain O' Lakes.

BASELINE CONCLUSIONS

The Little Chain is a group of five lakes that accounts for only seven percent of the total lake surface area, but 38 percent of the watershed of the Chain O' Lakes. Inflow to the Little Chain is primarily groundwater, either directly to the lakes, or via Hartman Creek which drains to Pope Lake.

Overall, water quality is good to excellent for all parameters measured and generally indicated an oligotrophic to mesotrophic classification. Some nutrient elevation, relative to Marl Lake, was noted in the more downstream of the Little Chain lakes, but even these levels were below levels for similar lake types and regional locations. No trends were evident from the limited amount of historical data available. Excellent water quality is attributable to low overland inflow to the system, a relatively undisturbed, forested watershed, flushing from groundwater flow and phosphorus binding from marl precipitation.

Recreational use during summer months is excessive for other Chain project groups and the towns and lake association have taken steps to regulate boat traffic. Access and location appear to further restrict traffic on the Little Chain. A recreational use survey was distributed during Phase I of this project to identify, characterize or quantify the uses.

MANAGEMENT RECOMMENDATIONS

Management recommendations for the Little Chain are targeted at maintenance of existing good to excellent water quality through continued monitoring, reduction of nutrient inflow to the system (where possible and practical), and protection of the aesthetic value/assessment of the need for further regulation on the Little Chain to maximize enjoyment of the resource by all.

Relatively little is known about historic water quality on the Little Chain; efforts should be made to continue regular water quality testing. Testing should also include event testing of Hartman Creek and Allen Creek; land use assessment in these basins to identify and protect sensitive areas may, even at present, be warranted. Regular monitoring should be conducted in a similar schedule; event testing should be conducted after major rain or snowmelt runoff events. Self-Help secchi disk monitoring should be conducted by volunteers on each lake.

Riparian landowners have been involved from the onset of these projects and can lend additional help by implementing lake lot management practices to protect/improve aesthetics and prevent nutrient and sediment runoff to the lakes. Many of these practices are common sense approaches. Fertilizer and compost management, buffer stripping and runoff control are inexpensive

ways to help reduce these inputs and slow lake aging processes. Fertilizers should be used sparingly, if at all. If used, the land owner should use phosphate-free fertilizers and apply small amounts more often instead of large amounts at one or two times. Composting lawn clippings and leaves away from the lake can reduce nutrient inputs to the lake. If leaves are burned, it should be done in an area where the ash cannot wash directly into the lake, or indirectly to the lake via roadside ditches.

Creation of a buffer strip with diverse plants at least 20 feet wide immediately adjacent to the lake can control wave erosion, trap soil eroded from the land above and increase infiltration (to filter nutrients and soil particles). Buffer strips can also shade areas of the lake to reduce macrophyte growth (especially on south shores) and provide fish cover. Placement of a low berm in this area can enhance effectiveness of the buffer strip by further retarding runoff during rainfalls. A buffer zone protects lake water quality, creates habitat for wildlife, and provides privacy.

Sources of local assistance for landowners who would like more information on these or other methods of land management are outlined in Appendix IV. Pertinent ordinances and plans are presented in Appendix V.

Recreational use survey data, when compiled and analyzed should indicate the attitudes and preferences of landowners adjacent to the Chain. These data may help to focus recreation management efforts or identify options (e.g., further regulation) to maximize enjoyment of the Chain O' Lakes resource.

The CLPOA, in cooperation with local townships, Waupaca County and the State of Wisconsin, should take an active role in protection of the Chain resource from invasion by exotic, potentially harmful species. The spread of purple loosestrife or introduction of Eurasian milfoil and other exotic species may be slowed or prevented by posting signs at boat landings, providing brochures or other materials to educate the public about harmful species and their prevention. Efforts must also be made to control known populations of purple loosestrife and Eurasian milfoil.

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APPENDIX I
SUMMARY OF PUBLIC INVOLVEMENT ACTIVITIES
Chain O' Lakes Management Plans

The Chain O' Lakes Property Owners Association (CLPOA) initiated steps to develop comprehensive lake management plans under the Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grant Program in the fall of 1990. The grants were received on April 1, 1991. A public involvement program was immediately initiated as part of the planning process. The following is a summary of major public involvement efforts.

Planning Advisory Committee

An advisory committee comprised of representatives from WDNR, CLPOA, IPS, and Waupaca County UW-Extension was established at the start of the program. The committee provided direction during the planning program and served as main reviewer of the draft plan documents.

Brochures

A brochure entitled "Chain O' Lakes Management Planning" was also produced. Over 1000 copies were made available for CLPOA use and distribution. The brochure described the main features of plan development and pertinent information specific to the Chain O' Lakes management plan.

Meetings

The CLPOA conducted meetings for its board, its members and interested parties. IPS presented progress reports, provided information about the resource and interpretations of these results at board meetings and at the 1991 and 1992 CLPOA annual meetings.

Print Media

An IPS newsletter entitled "Lake Management News" was developed and distributed to the CLPOA for the Board's use and distribution among the membership. A special "Chain O' Lakes Edition" was also developed to notify the CLPOA of any late developments in the planning program.

APPENDIX II
LITTLE CHAIN TEMPERATURE/DO PROFILES, 1991 - 1992
(Thermocline denoted in Bold Type)

MARL LAKE

	08/07/91			02/04/92	
Depth(ft)	Temp. °C	DO(mg/l)	Depth(ft)	Temp. °C	DO(mg/l)
3	22.14	10.36	3	3.73	7.30
6	21.63	10.30	6	3.79	7.15
9	21.47	10.82	9	3.81	7.09
12	20.71	16.50	12	3.85	6.95
15	17.18	17.80	15	3.95	6.67
18	**14.31**	**16.50**	18	3.98	6.55
21	**12.37**	**14.86**	21	3.98	6.49
24	**11.00**	**12.50**	24	3.98	6.49
27	10.21	10.58	27	3.96	6.50
30	9.59	8.10	30	3.95	6.50
33	9.16	2.29	33	3.95	6.50
36	8.86	0.41	36	3.95	6.44
39	8.77	0.25	39	3.96	6.27
42	8.68	0.20	42	4.01	5.90
45	8.61	0.16	45	4.08	5.24
48	8.55	0.16	48	4.12	5.13
51	8.48	0.17	51	4.13	4.89
54	8.45	0.17	54	4.16	4.77
57	8.31	0.12	57	4.20	3.45

POPE LAKE

	08/07/91			02/04/92	
Depth(ft)	Temp. °C	DO(mg/l)	Depth(ft)	Temp. °C	DO(mg/l)
3	20.13	9.62	3	3.57	11.20
6	19.23	9.86	6	3.65	10.85
9	**17.84**	**10.04**	9	3.66	10.22
12	**16.76**	**12.00**	12	3.64	9.51
15	**14.23**	**18.60**	15	3.64	9.09
18	**11.84**	**7.80**	18	3.84	8.31
21	**10.47**	**1.25**	21	3.92	7.72
24	**9.47**	**0.27**	24	3.95	7.41
27	9.33	0.20	27	4.04	6.92
30	9.22	0.20	30	4.02	6.76
33	9.20	0.16	33	4.02	6.70
36	9.15	0.16	36	3.99	6.72

MANOMIN LAKE

	08/07/91			02/04/92	
Depth(ft)	Temp. °C	DO(mg/l)	Depth(ft)	Temp. °C	DO(mg/l)
3	21.42	10.88	3	3.00	10.43
6	20.66	10.08	6	3.05	10.08
9	20.21	9.10	9	3.10	9.93
12	19.98	8.38	12	3.10	9.74
15	19.03	8.27	15	3.12	9.55
18	**15.71**	**7.20**	18	3.17	9.40
21	**12.32**	**10.83**	21	3.23	8.21
24	**9.93**	**0.46**	24	3.29	5.99
27	**8.24**	**0.21**	27	3.53	2.78

APPENDIX II
(Continued)
(Thermocline denoted in Bold Type)

KNIGHT LAKE

08/07/91			02/04/92		
Depth(ft)	Temp. °C	DO(mg/l)	Depth(ft)	Temp. °C	DO(mg/l)
3	21.56	9.62	3	2.89	9.48
6	21.21	9.58	6	2.94	8.81
9	20.45	10.50	9	3.07	8.48
12	**18.35**	**17.05**	12	3.70	6.28
15	**15.03**	**17.70**	15	4.10	3.47
18	**11.84**	**16.72**	18	4.37	2.07
21	**10.62**	**13.30**	21	4.43	1.83
24	**9.39**	**1.25**	24	4.47	1.72
27	8.50	0.29	27	4.52	1.66
30	8.33	0.21	30	4.58	1.60
33	8.26	0.21	33	4.68	1.25
36	8.22	0.17	36	4.76	1.03
39	8.17	0.17	39	4.74	0.98

ORLANDO LAKE

08/07/91			02/04/92		
Depth(ft)	Temp. °C	DO(mg/l)	Depth(ft)	Temp. °C	DO(mg/l)
3	21.42	9.81	3	2.91	8.89
6	21.32	9.61	6	3.01	8.46
9	21.18	9.08	9	3.07	8.24
12	20.80	8.11	12	3.26	6.87
15	**19.43**	**5.38**	15	3.47	5.72
18	**15.38**	**2.67**	18	3.70	2.05
21	**13.56**	**1.85**	21	3.72	1.86
24	**10.75**	**1.30**	24	3.82	1.27
27	**9.29**	**5.31**	27	3.85	1.15
30	**8.01**	**0.22**	30	3.87	1.09
33	**6.89**	**0.18**	33	3.96	0.57
36	6.57	0.09	36	4.11	0.22

APPENDIX III
HISTORIC WATER QUALITY DATA
Marl Lake, Waupaca County, WI
Water Chemistry: 06/87; Deepest Site
Source: UW-Stevens Point Environ. Task Force

PARAMETER	Sample Date 06/23/87
Depth (feet)	0
Secchi (meters)	5.0
pH (S.U.)	8.55
Conductivity (μmhos/cm)	258
Total Alkalinity (mg/l $CaCO_3$)	143
Calcium (mg/l $CaCO_3$)	86.0
Magnesium (mg/l Ca CO_3)	66.0
Hardness (mg/l $CaCO_3$)	152.0
Sodium (mg/l)	2.0
Potassium (mg/l)	0.8
Chloride (mg/l)	1.0
Turbidity (NTU's)	0.4
Color (S.U.)	3.0
Total Kjeldahl N (mg/l)	0.32
Ammonia Nitrogen (mg/l)	0.06
NO_2 + NO_3 Nitrogen (mg/l)	0.16
Total Nitrogen (mg/l)	0.48
Total Phosphorus (mg/l)	0.005
Phosphate Phos. (mg/l)	<0.002
N/P Ratio	96.0

APPENDIX III
HISTORIC WATER QUALITY DATA
Pope Lake, Waupaca County, WI
Water Chemistry: 06/87; Deepest Site
Source: UW-Stevens Point Environ. Task Force

PARAMETER	Sample Date 06/23/87
Depth (feet)	0
Secchi (meters)	2.7
pH (S.U.)	8.03
Conductivity (μmhos/cm)	241
Total Alkalinity (mg/l $CaCO_3$)	131
Calcium (mg/l $CaCO_3$)	78.0
Magnesium (mg/l Ca CO_3)	68.0
Hardness (mg/l $CaCO_3$)	146.0
Sodium (mg/l)	1.9
Potassium (mg/l)	0.7
Chloride (mg/l)	1.0
Turbidity (NTU's)	0.4
Color (S.U.)	28.0
Total Kjeldahl N (mg/l)	0.54
Ammonia Nitrogen (mg/l)	0.10
NO_2 + NO_3 Nitrogen (mg/l)	0.38
Total Nitrogen (mg/l)	0.92
Total Phosphorus (mg/l)	0.012
Phosphate Phos. (mg/l)	<0.002
N/P Ratio	76.7

APPENDIX III
HISTORIC WATER QUALITY DATA
Manomin Lake, Waupaca County, WI
Water Chemistry: 06/87; Deepest Site
Source: UW-Stevens Point Environ. Task Force

PARAMETER	Sample Date 06/23/87
Depth (feet)	0
Secchi (meters)	2.7
pH (S.U.)	8.06
Conductivity (μmhos/cm)	252
Total Alkalinity (mg/l $CaCO_3$)	136
Calcium (mg/l $CaCO_3$)	84.0
Magnesium (mg/l Ca CO_3)	65.0
Hardness (mg/l $CaCO_3$)	149.0
Sodium (mg/l)	1.7
Potassium (mg/l)	0.7
Chloride (mg/l)	2.0
Turbidity (NTU's)	0.5
Color (S.U.)	24.0
Total Kjeldahl N (mg/l)	0.52
Ammonia Nitrogen (mg/l)	0.13
NO_2 + NO_3 Nitrogen (mg/l)	0.47
Total Nitrogen (mg/l)	0.99
Total Phosphorus (mg/l)	0.010
Phosphate Phos. (mg/l)	<0.002
N/P Ratio	99.0

APPENDIX III
HISTORIC WATER QUALITY DATA
Orlando Lake, Waupaca County, WI
Water Chemistry: 11/84 - 05/85; Deepest Site
Source: UW-Stevens Point Environ. Task Force

PARAMETER	Sample Date 11/28/84	05/27/85
Depth (feet)	0	0
pH (S.U.)	7.90	8.06
Conductivity (μmhos/cm)	328	303
Total Alkalinity (mg/l $CaCO_3$)	174	156
Calcium (mg/l $CaCO_3$)	77.3	84.3
Magnesium (mg/l Ca CO_3)	115.2	79.8
Hardness (mg/l $CaCO_3$)	192.5	164.1
Sodium (mg/l)	1.6	1.5
Sulfate (mg/l)	7.5	7.5
Potassium (mg/l)	1.1	8.1
Chloride (mg/l)	1.4	2.0
Turbidity (NTU's)	0.9	0.4
Color (S.U.)	8.0	15.0
Total Kjeldahl N (mg/l)	0.48	0.27
Ammonia Nitrogen (mg/l)	0.32	0.09
NO_2 + NO_3 Nitrogen (mg/l)	0.72	0.36
Total Nitrogen (mg/l)	1.20	0.63
Total Phosphorus (mg/l)	0.004	0.010
Phosphate Phos. (mg/l)	0.004	<0.002
N/P Ratio	300.0	63.0

IPS ENVIRONMENTAL AND ANALYTICAL SERVICES
Appleton, Wisconsin

PHASE II
LITTLE CHAIN O' LAKES MANAGEMENT PLAN
WAUPACA COUNTY, WISCONSIN

REPORT TO:
CHAIN O' LAKES PROPERTY OWNERS ASSOCIATION

December, 1995

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIXES

Little Chain O' Lakes **Phase II**

SUMMARY

The Little Chain project group consists of Marl, Pope, Manomin, Knight and Orlando Lakes of the Chain O 'Lakes, a group of 22 mostly interconnected relatively small lakes in Waupaca County, Wisconsin. Water quality is good to very good and related to substantial groundwater inflow. Water quality, along with the Chain's proximity to population centers, contribute to highly developed shoreline areas (many permanent residential) and periodic high to excessive non-resident recreational use. An initial resource assessment was made in 1992 (Phase I Chain O 'Lakes Management Plan); this document supplements the 1992 report with Phase II efforts toward development of a comprehensive lake management plan.

The Chain O 'Lakes watershed, primarily agricultural but with significant forested and wetland areas, is a subwatershed of the Tomorrow/Waupaca River basin which has recently been granted Priority Watershed Project Status. Variable, but generally low groundwater nitrate levels were observed in the Chain subwatershed during the appraisal phase of the Priority Watershed Project. Overland flow nutrient and sediment inputs were estimated to be lower than expected, but field estimates for nutrients were substantially higher. Lake modeling for some Chain lakes indicated a natural process of phosphorus removal by marl precipitation.

Little Chain water quality monitoring during Phases I and II indicated in-lake nutrient levels below those typical of Wisconsin lakes overall and of lakes in the Chain O 'Lakes 'ecoregion. Hartman's Creek inflow, however, appeared to slightly elevate nutrient levels in the more downstream Little Chain lakes.

The Little Chain is less developed than the other Chain O 'Lakes project groups and recreational use survey results suggested that the opinion of the Little Chain user group differ from those of Chain O 'Lakes overall and various resident group users. Results indicated periodic excessive use during summer weekends or holidays with perceived safety problems and diminished recreational enjoyment of the resource related primarily to non-resident or commercial watercraft. Residents fully agreed there is adequate public boater access, disagreed with the establishment of a public park or restrooms, and were nearly evenly divided on establishment of a public swimming beach. A majority of Little Chain residents agreed additional water use regulations need to be enacted and enforced and also agreed there should be limits set on the number of watercraft on the Chain.

Purple loosestrife, an exotic potentially nuisance plant, was not present in the Little Chain, but is established in nearby Chain O 'Lakes project groups.

Water quality protection and water use conflict minimization are priority management objectives for the Little Chain and all Chain O 'Lakes residents. Specific recommendations for the Little Chain include private well testing for nitrates and/or pesticides, more event sampling (coordinated with flow and rainfall monitoring) and purple loosestrife surveillance.

Other recommendations are applicable to the Little and other Chain project groups and emphasize continued focus and expanded involvement (designated Chain O 'Lakes Property Owners Association individuals or committees) in watershed-wide surface water and groundwater quality issues, use management, and exotic species control. These recommendations, which include trend monitoring for water quality, are designed to identify potential problem areas or conflicts before they become widespread or severe.

INTRODUCTION

The Chain O' Lakes is a group of 22 mostly interconnected lakes in the Towns of Dayton and Farmington, Waupaca County, Wisconsin. The lakes are, in general, relatively small, highly developed, groundwater fed and located in a sandy, mostly level watershed. The lakes are a major tourist attraction for Waupaca County and occasionally receive excessive recreational use.

The Chain O' Lakes Property Owners Association (CLPOA), which serves as the main steward for the resource, was formed in the 1960's and currently has about 800 voting members (1). The CLPOA received its first Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grant in April, 1991. IPS Environmental & Analytical Services (IPS) of Appleton, Wisconsin was selected as their consultant for management plan development.

The Chain O' Lakes was delineated into five Project Groups (Table 1) for management planning purposes. Phase I efforts included baseline assessment activities (for water quality and aquatic plants) and a public involvement program. Specific physical properties, preliminary methods, and other introductory and technical information for the Chain O' Lakes and the respective Project Groups were presented in the Phase I reports (printed 1993).

Table 1. Lake Management Planning Project Groups, Chain O' Lakes, Waupaca County, Wisconsin.

Upper Chain	Middle Chain	Lower Chain
Otter Lake	Nessling Lake	Ottman Lake
Taylor Lake	McCrossen Lake	Bass Lake
George Lake	Round Lake	Youngs Lake
Sunset Lake	Limekiln Lake	Beasley Lake
Rainbow Lake		Long Lake
		Columbia Lake

East Chain	Little Chain
Dake Lake	Orlando Lake
Miner Lake	Knight Lake
	Manomin Lake
	Pope Lake
	Marl Lake

A Phase II grant was received in August, 1993; Phase II efforts included continuation of the water quality monitoring and public involvement programs, analysis of a recreational use questionnaire (circulated under Phase I) and more intensive assessment of areas of concern in the watershed. This report presents the results of these Phase II lake management planning efforts for the Little Chain O'Lakes.

DESCRIPTION OF AREA

The Chain O' Lakes is a group of "kettle" lakes in the southwest corner of Waupaca County, Wisconsin (Fig. 1). Kettle lakes were formed when ice was pushed into the soil by retreating glaciers; the depressions subsequently filled with water when the ice blocks melted. The Little Chain consists of Knight, Manomin, Marl, Orlando and Pope Lakes in the southwest portion of the Chain.

Compared to most other Chain O' Lakes project groups, the Little Chain has a relatively more extensive watershed and higher potential for effects associated with nonpoint runoff (2). Flow within the Little Chain is from Marl to Pope Lake (which receives inflow from Hartman's Creek), through Manomin, Knight and Orlando Lakes before draining to Bass Lake of the Lower Chain project group.

Generally, groundwater inflow to the Chain O' Lakes is from the northwest. Groundwater input was most visible and documented in Sunset Lake (south and west shores), Otter Lake (northwest shore) and George Lake (north shore) of the Upper Chain O'Lakes.

Little Chain lakes are small [range: 6 acres (Manomin) to 14 acres (Pope)] and are separated from the other Chain O' Lakes project groups by a shallow (wadable) creek. Little Chain lake

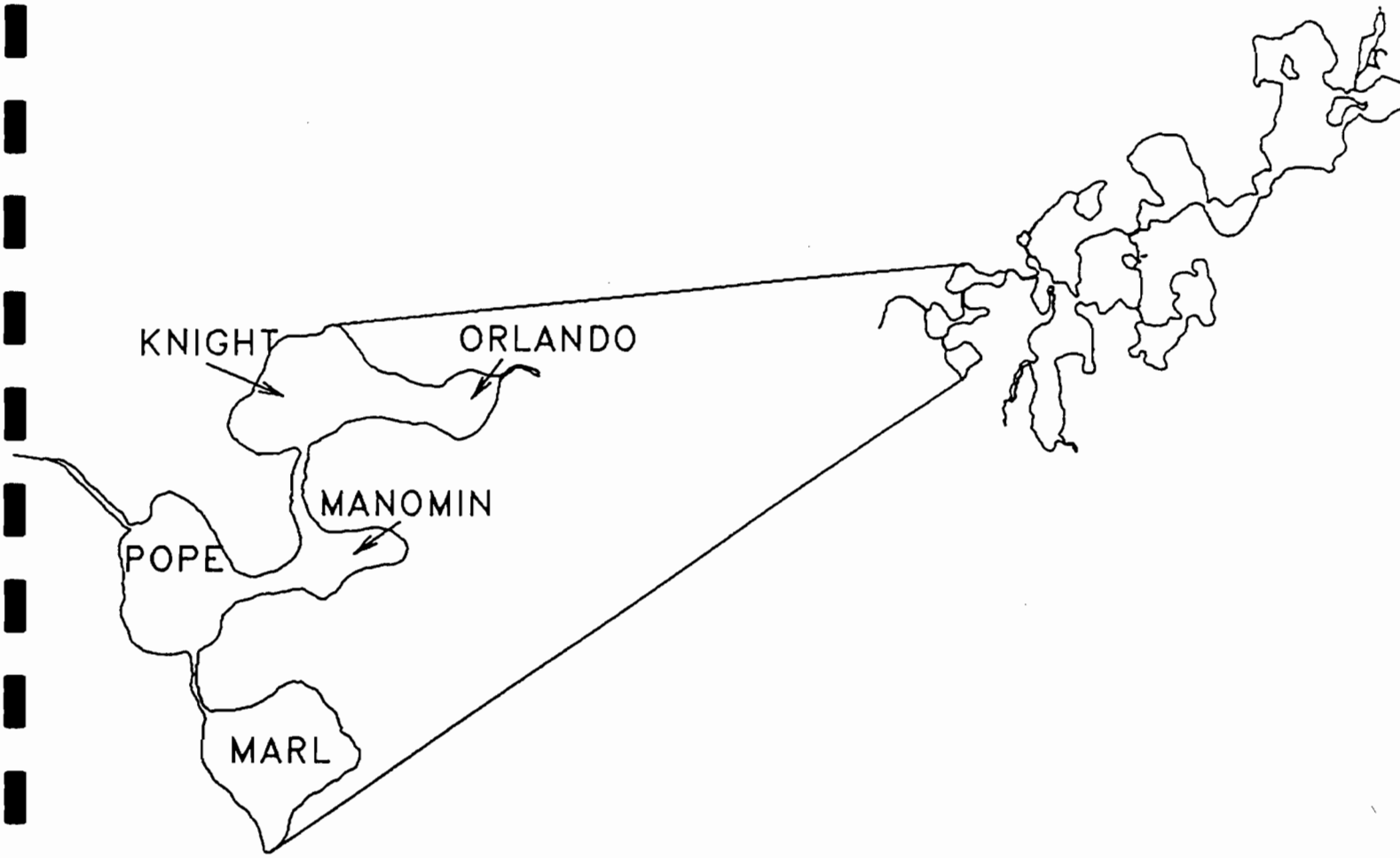

Figure 1. Location Map, Chain O' Lakes, Waupaca County, Wisconsin.

maximum depths range from 30 feet (Manomin) to 59 feet (Marl) (3).

Public boat ramps are available at about ten locations on the Chain. Most of the connecting channels on the Chain are navigable for powerboats and all but one (Ottman - Youngs) are navigable with a canoe. The Little Chain has direct access boat ramps on Marl Lake and the Manomin - Knight Lake Channel.

Because of intensive recreational use, the Towns of Dayton and Farmington and the CLPOA adopted ordinances to regulate boat speeds on the Chain. Except for the largest lakes (Columbia, Long, Rainbow and Round), all lakes on the Chain have a "no wake" speed limit. Water skiing on these lakes is limited to 10:00 a.m. - 2:30 p.m. on weekends and Holidays, 10:00 a.m. - 4:00 p.m. on Monday and Friday, and 10:00 a.m. - 7:00 p.m. on Tuesday through Thursday.

METHODS

Watershed Characteristics

Most watershed information was obtained during the appraisal process of the Tomorrow/Waupaca River Priority Watershed (TWRPW) Project. The appraisal began February, 1994 and was completed in 1995. Pertinent information from the appraisal as it relates to the Chain O' Lakes is included in the Field Data Discussion section of this report.

Water Quality Monitoring

Water quality samples were taken in July and September, 1992, February, May, August and October, 1993, and February, May, August and September, 1994. Samples were collected three feet below the surface and three feet above bottom for all lakes (Table 2, Fig. 2). Parameters measured in the field were Secchi depth, water temperature, pH, dissolved oxygen (DO), and conductivity (see the Phase I document for specific equipment and methods information). The Hartman's Creek site was sampled on October 6, 1993, and February 15, 1994. Event samples were collected on May 3, July 6, and August 1, 1994 (Table 2).

Recreational Use

A recreational use survey of the CLPOA membership was conducted to obtain property and lake use, water use opinions and

Table 2. Sample Station Descriptions, Little Chain, 1992 - 1994.

REGULAR MONITORING

Lake	Site Number	Depth
Manomin (Deepest Point)	1401	30 feet
Pope (Deepest Point)	1402	40 feet
Marl (Deepest Point)	1403	59 feet
Knight (Deepest Point)	1404	42 feet
Orlando (Deepest Point)	1405	39 feet

Event Site	Description
14E1	Hartman's Creek - Rural Road

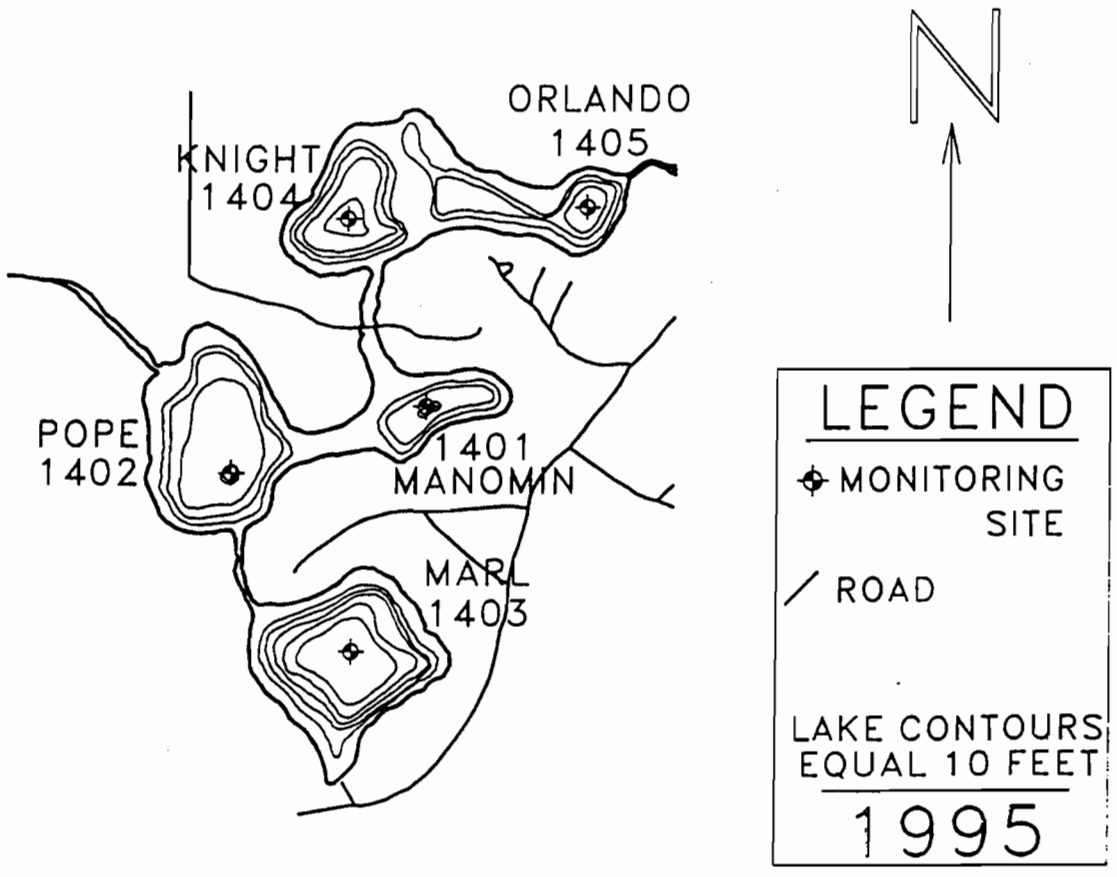

Figure 2. Sample Station Locations, Little Chain, 1992 - 1994.

demographics information. About 800 questionnaires were distributed (one per household) by CLPOA neighborhood volunteers to maximize the return rate. A sample survey questionnaire is included in Appendix I.

Exotic Species

Visual observations [including a full shoreline cruise and in-lake observations (raking and SCUBA)] were made throughout the 0Phase I and II grant periods to document the occurrence exotic species. Target species included Eurasian Water Milfoil (*Myriophyllum spicatum*), Purple Loosestrife (*Lythrum salicaria*) and Zebra Mussels (*Dreissena polymorpha*).

Public Involvement Program

Public involvement activities were coordinated to inform and educate the CLPOA about lake management in general and specifics regarding the Chain O' Lakes resource. Activities included news releases, IPS newsletters, article preparation for CLPOA newsletters, meeting attendance and presentations to the CLPOA and other interested parties. Public involvement activities are summarized in Appendix II.

FIELD DATA DISCUSSION

Watershed Characteristics

The Chain O' Lakes watershed is estimated to be 33,819 acres or 17% of the entire TWRPW (3). Land use for the Chain O' Lakes subwatershed was determined during the 1994 - 1995 inventory to be: non-irrigated agriculture, 16,931 acres (50%); irrigated agriculture, 2,205 acres (7%); forested, 10,921 acres (32%); wetland (including surface water), 1,673 acres (5%); and developed areas, 2,089 acres (6%) (Fig. 3).

There were 220 landowners who had livestock operations in the TWRPW, of which 168 (76%) had more than 20 animal units and 52 (24%) had 20 or fewer animal units. Sixty-two percent of the barnyards were surface drained; 38% were internally drained (4).

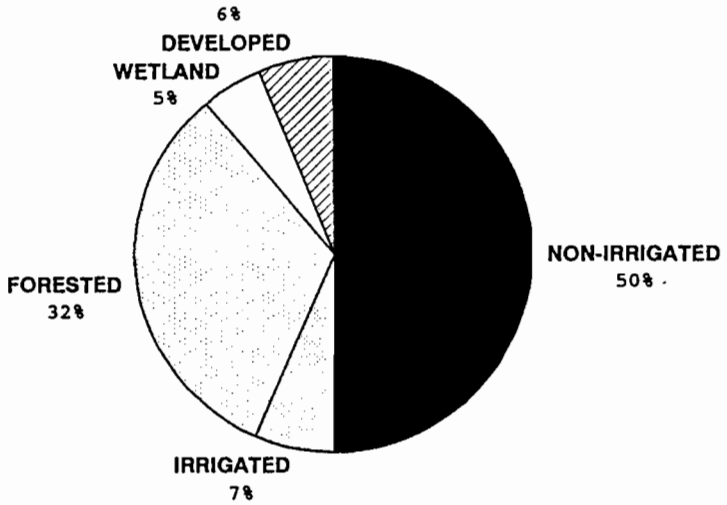

Figure 3. Land Uses in the Chain O' Lakes Subwatershed, 1994.

Groundwater

Nitrate was identified as a contaminant of concern in the Wolf River Basin Plan (5) and was targeted for analyses in the TWRPW Project groundwater appraisal. Relative to other subwatersheds in the TWRPW Project, residential well samples in the Chain O' Lakes subwatershed had the lowest average nitrate levels [2.59 milligrams per liter (mg/l)] (Table 3). Fifty-seven percent of the Chain O' Lakes subwatershed well samples were below 2 mg/l; nitrate levels over 2 mg/l are generally considered indicative of human impact on groundwater. Thirty-two well samples (8.2%) in the Chain O' Lakes subwatershed were over the health standard of 10 mg/l (4).

Table 3. Well Nitrate Data by Subwatershed for the Tomorrow/ Waupaca River Priority Watershed Project, 1995.

Subwatershed	No. of Samples	>2 mg/l	>10 mg/l	>20 mg/l	Average
Lower Tomorrow	258	168	66	20	6.82
Spring Creek	275	154	39	5	4.71
Chain O' Lakes	389	136	30	2	2.59
Crystal River	266	117	22	5	3.27
Waupaca/ Weyauwega	63	15	11	4	5.31
Total	1,251	590	168	36	4.54
Percent	100%	47%	13%	3%	

Surface water nitrate levels were also assessed during periods of highest groundwater contribution to the Tomorrow/Waupaca River system. Various creek samples taken March 1, 1994 or January 20, 1995 averaged 3.06 and 3.52 mg/l, respectively (Table 4). The highest nitrate levels were observed in Radley and Murray Creeks during January, 1995.

Table 4. Nitrate Levels (mg/l) for Surface Water in the Chain O' Lakes Subwatershed, 1994 - 1995.

	03/01/94	01/20/95
Radley Creek (South Road)	3.51	5.06
Radley Creek (1st Avenue)		7.1
Hartman Creek (Rural Road)	0.94	1.03
Emmon's Creek (Rural Road)	2.48	2.18
Emmon's Creek (3rd Avenue)		1.97
Murray Creek (South Road)	2.77	2.37
Murray Creek (10th Road)		6.0
Tomorrow/Waupaca Average	3.06	3.52

Lakes

A computer model applied by WDNR to the western portion of the Chain O' Lakes indicated that the Chain has a natural ability to

remove phosphorus from the water column via marl precipitation. Marl (calcium carbonate) binds with phosphorus and settles to the lake bottom.

Overall, the lakes modeled (Marl, Pope, Manomin, Orlando, Knight, Ottman, Youngs, Bass, Beasley and Long) showed a 36% reduction of (outflowing versus inflowing) phosphorus. Reduction ranged from 8% for Orlando Lake to 90% for Marl Lake (4). Phosphorus levels measured during Phase I and Phase II efforts for these lakes were near or below levels predicted by the model.

Sediment and Nutrient Delivery

Sediment delivery was estimated to be less than expected for the Chain O' Lakes subwatershed; the Chain subwatershed included 7.7% of the cropland draining to streams for the TWRPW but had only 6.0% of the sediment delivery (146 tons per year). With an estimated nine pounds of phosphorus per ton of sediment, phosphorus delivery is 1,313 pounds per year. Sediment was estimated to be entirely from upland sources, as none of the 21.8 miles of streambank were observed to be degraded (4).

Water Quality

Current data indicated generally similar water quality among the Little Chain lakes and trends similar to those observed during Phase I. Pope and Orlando Lakes exhibited somewhat higher nutrients than the other Little Chain lakes and all nutrient data

reflected seasonal influence of stratification/mixing and surface or groundwater inflows (Tables 5-9, Figs. 4 and 5).

Surface total nitrogen ranged from 0.339 mg/l (Marl) to 1.88 mg/l (Manomin) with an average of 1.07 mg/l for all Little Chain Lakes (Tables 5-9). Total nitrogen levels were relatively lower in Marl Lake than in the more downstream Lower Chain lakes. Lowest surface total nitrogen levels were observed during stratified conditions (Summer); highest levels were during periods of highest groundwater input (Winter) (Fig. 5).

Substantially higher values for total phosphorus and other nutrient parameters were observed near bottom at Manomin, Pope, and Orlando Lakes, and suggested nutrient release from sediments under anoxic or near-anoxic conditions during summer stratification at these relatively deep points.

Surface phosphorus levels for the Little Chain were lower than those typical for stratified lakes (0.023 mg/l) and for lakes in the central region in Wisconsin (0.020 mg/l) (6); levels were typically at or below those typical for the ecoregion in which the Chain is located (0.010 - 0.014 mg/l) (7). NOTE: Some samples exceeded the recommended maximum holding time before analysis. A study has shown, however, that the data remain accurate for samples analyzed well after the 28-day holding time (8).

Table 5. Water Quality Parameters, Station 1401, Manomin Lake, Chain O' Lakes, July 1992 - September 1994.

PARAMETER	SAMPLE[1]	DATE									
		07/14/92	09/23/92	02/03/93	05/18/93	08/17/93	10/06/93	02/15/94	05/02/94	08/02/94	09/21/94
Secchi (feet)		23.5	16.4	NR[2]	8.5	14.0	8.7	NR	9.4	19.0	9.5
Cloud Cover (percent)		100	0	10	100	100	0	0	10	10	100
Temperature (degrees Celcius)	S	19.26	15.06	2.47	14.16	22.05	12.48	2.09	9.91	21.69	19.92
	B	10.50	12.61	3.18	6.24	8.88	5.10	2.50	6.24	10.37	11.54
pH (surface units)	S	7.94	8.25	7.30	7.67	7.49	7.60	6.95	NR	7.79	8.90
	B	7.01	7.38	7.01	6.10	6.50	6.40	6.88	NR	6.58	7.20
D.O. (mg/l)	S	8.43	7.97	9.33	11.70	7.34	9.26	9.43	11.24	8.49	9.43
	B	0.15	0.50	4.00	0.19	0.65	0.67	8.44	0.61	0.34	0.99
Conductivity (umhos/cm)	S	294	303	341	305	299	326	344	300	306	292
	B	372	394	357	361	357	392	351	336	399	392
Laboratory pH (surface units)	S	NR	NR	NR	8.46	NR	NR	NR	8.24	NR	NR
	B	NR	NR	NR	8.04	NR	NR	NR	NR	NR	NR
Total Alkalinity (mg/l)	S	NR	NR	NR	162	NR	NR	NR	161	NR	NR
	B	NR	NR	NR	196	NR	NR	NR	NR	NR	NR
Total Solids (mg/l)	S	NR	NR	NR	200	NR	NR	NR	198	NR	NR
	B	NR	NR	NR	234	NR	NR	NR	NR	NR	NR
Tot. Kjeld. Nitrogen (mg/l)	S	0.3	0.4	0.3	0.4	0.4	0.5	0.5	0.4	0.46[4]	0.37[4]
	B	1.6	1.6	0.4	1.0	2.0	2.6	0.5	0.8	NR	1.34
Ammonia Nitrogen (mg/l)	S	0.051	0.078	0.150	0.021	0.042	0.109	0.194	0.024	0.43	0.027
	B	0.766	0.638	0.268	0.417	0.767	2.02	0.256	0.440	NR	0.434
NO_2 + NO_3 Nit. (mg/l)	S	0.811	0.699	1.54	0.675	0.739	0.457	1.38	0.926	0.629	0.714
	B	ND[3]	0.124	1.24	0.123	0.010	ND	1.30	0.509	NR	0.099
Total Nitrogen (mg/l)	S	1.111	1.099	1.84	1.075	1.139	0.957	1.88	1.326	1.089	1.084
	B	1.6	1.724	1.64	1.123	2.010	2.6	1.80	1.309	–	1.439
Total Phosphorus (mg/l)	S	0.010	0.009	0.004	<0.02	0.011	0.008	0.010	0.019	0.010	0.011
	B	0.153	0.125	0.008	0.05	0.23	0.048	0.012	0.038	NR	0.269
Dissolved Phos. (mg/l)	S	0.006	0.002	0.004	ND	ND	0.004	0.002	NR	ND	ND
	B	0.056	0.002	0.006	ND	0.026	0.013	0.007	NR	NR	0.187
Nit./Phos Ratio	S	111.1	122.1	460.0	–	103.5	119.6	188.0	69.8	108.9	98.5
	B	10.5	13.8	205.0	22.5	8.7	54.2	150.0	34.4	–	5.35
Chlorophyll a (ug/l)	S	2.0	3.11	NR	8.85	2.07	6.89	NR	11.6	1.67	1.65

[1] S = surface, B = bottom; [2] NR = no reading; [3] ND = not detectable; [4] holding time exceeded by SLOH

Table 6. Water Quality Parameters, Station 1402, Pope Lake, Chain O' Lakes, July 1992 - September 1994.

PARAMETER	SAMPLE[1]	DATE									
		07/14/92	09/23/92	02/03/93	05/18/93	08/17/93	10/06/93	02/15/94	05/02/94	08/02/94	09/21/94
Secchi (feet)		17.0	16.2	NR[2]	7.9	13.1	9.8	NR	10.0	14.5	12.0
Cloud Cover (percent)		100	0	10	100	100	0	0	0	10	100
Temperature (degrees Celcius)	S	17.67	14.34	3.28	13.24	19.95	12.28	0.27	9.69	19.54	18.89
	B	9.07	10.14	4.01	6.40	8.97	9.53	4.17	7.02	9.30	9.83
pH (surface units)	S	8.01	8.05	7.77	7.74	7.41	NR	7.05	NR	7.66	8.95
	B	6.89	7.28	7.27	6.34	6.21	NR	6.80	NR	6.34	7.49
D.O. (mg/l)	S	8.57	8.30	9.98	12.10	6.92	9.72	12.10	11.64	8.70	9.61
	B	0.08	0.58	5.44	2.61	0.16	0.39	5.52	0.63	0.36	0.53
Conductivity (umhos/cm)	S	293	307	348	309	304	330	342	298	316	293
	B	348	357	358	336	337	372	363	344	365	338
Laboratory pH (surface units)	S	NR	NR	NR	8.47	NR	NR	NR	8.29	NR	NR
	B	NR	NR	NR	8.05	NR	NR	NR	NR	NR	NR
Total Alkalinity (mg/l)	S	NR	NR	NR	164	NR	NR	NR	161	NR	NR
	B	NR	NR	NR	180	NR	NR	NR	NR	NR	NR
Total Solids (mg/l)	S	NR	NR	NR	202	NR	NR	NR	198	NR	NR
	B	NR	NR	NR	216	NR	NR	NR	NR	NR	NR
Tot. Kjeld. Nitrogen (mg/l)	S	0.3	0.4	0.3	0.4	0.4	0.3	0.4	0.3	0.35[4]	0.42[4]
	B	1.2	1.8	0.4	0.5	1.1	1.5	0.4	0.5	1.41[4]	NR
Ammonia Nitrogen (mg/l)	S	0.050	0.045	0.144	0.014	0.036	0.029	0.157	0.014	0.038	0.033
	B	0.762	1.19	0.266	0.256	0.767	1.10	0.192	0.295	0.901	NR
NO_2 + NO_3 Nit. (mg/l)	S	0.908	0.804	1.33	0.776	0.842	0.877	1.42	0.960	0.830	0.797
	B	ND[3]	0.011	1.39	0.820	ND	0.009	1.25	0.677	0.010	NR
Total Nitrogen (mg/l)	S	1.208	1.204	1.63	1.176	1.242	1.177	1.82	1.26	1.18	1.217
	B	1.2	1.811	1.79	1.320	1.1	1.509	1.65	1.18	1.42	--
Total Phosphorus (mg/l)	S	0.011	0.009	0.004	<0.02	0.011	0.011	0.009	0.011	0.011	0.009
	B	0.176	0.178	0.010	0.02	0.102	0.180	0.007	0.021	0.159	NR
Dissolved Phos. (mg/l)	S	0.004	0.003	0.004	0.002	ND	0.004	0.003	NR	ND	ND
	B	0.014	0.009	0.008	0.002	0.010	0.012	0.005	NR	0.004	NR
Nit./Phos Ratio	S	109.8	133.8	407.5	--	112.9	107.0	202.2	114.5	107.3	135.2
	B	6.8	10.2	179.0	66.0	10.8	13.97	235.7	56.0	8.93	--
Chlorophyll a (ug/l)	S	2	4.44	NR	8.45	1.70	4.09	NR	9.00	1.80	1.79

[1] S = surface, B = bottom; [2] NR = no reading; [3] ND = not detectable; [4] holding time exceeded by SLOH

Table 7. Water Quality Parameters, Station 1403, Marl Lake, Chain O' Lakes, July 1992 - September 1994.

PARAMETER	SAMPLE[1]	DATE									
		07/14/92	09/23/92	02/03/93	05/18/93	08/17/93	10/06/93	02/15/94	05/02/94	08/02/94	09/21/94
Secchi (feet)		11.5	13.7	NR[2]	13.9	6.0	14.0	NR	13.0	11.0	13.0
Cloud Cover (percent)		100	0	10	80	100	0	0	0	0	100
Temperature (degrees Celcius)	S	19.61	16.28	3.95	14.28	23.53	13.00	3.88	10.82	22.87	20.34
	B	8.27	9.34	4.06	6.60	8.65	8.99	4.14	6.90	8.64	9.33
pH (surface units)	S	8.36	8.37	7.27	7.77	8.15	NR	6.95	7.10	8.17	NR
	B	6.99	7.05	7.20	6.60	6.35	NR	6.87	6.48	6.43	NR
D.O. (mg/l)	S	10.80	11.15	6.40	11.50	9.98	10.56	6.84	12.20	9.89	9.46
	B	0.30	0.49	5.42	4.04	0.12	0.32	6.08	6.13	0.41	0.98
Conductivity (umhos/cm)	S	280	274	326	310	271	313	340	305	286	265
	B	348	371	328	349	347	390	341	337	368	341
Laboratory pH (surface units)	S	NR	NR	NR	8.51	NR	NR	NR	8.38	NR	NR
	B	NR	NR	NR	8.21	NR	NR	NR	NR	NR	NR
Total Alkalinity (mg/l)	S	NR	NR	NR	167	NR	NR	NR	175	NR	NR
	B	NR	NR	NR	191	NR	NR	NR	NR	NR	NR
Total Solids (mg/l)	S	NR	NR	NR	198	NR	NR	NR	208	NR	NR
	B	NR	NR	NR	226	NR	NR	NR	NR	NR	NR
Tot. Kjeld. Nitrogen (mg/l)	S	0.2	0.3	0.4	0.3	0.3	0.2	0.4	0.2	0.36[3]	0.39[3]
	B	0.6	2.1	0.4	0.5	0.3	0.9	0.4	0.4	0.79[3]	NR
Ammonia Nitrogen (mg/l)	S	0.025	0.015	0.237	0.032	0.017	0.025	0.178	0.024	0.015	0.012
	B	0.251	0.823	0.275	0.175	0.030	0.603	0.226	0.082	0.508	NR
NO_2 + NO_3 Nit. (mg/l)	S	0.139	0.145	0.357	0.392	0.054	0.212	0.372	0.339	0.093	0.081
	B	0.345	ND[4]	0.329	0.371	0.101	ND	0.331	0.416	ND	NR
Total Nitrogen (mg/l)	S	0.339	0.445	0.757	0.692	0.354	0.412	0.772	0.539	0.883	0.471
	B	0.945	2.1	0.729	0.871	0.401	0.9	0.731	0.816	0.79	--
Total Phosphorus (mg/l)	S	0.007	0.006	0.008	<0.02	0.008	0.005	0.017	0.005	0.011	ND
	B	0.018	0.033	0.008	<0.02	0.008	0.018	0.004	0.015	0.021	NR
Dissolved Phos. (mg/l)	S	0.002	ND	0.003	ND	ND	0.003	ND	NR	ND	ND
	B	ND	ND	0.003	ND	ND	ND	ND	NR	ND	NR
Nit./Phos Ratio	S	48.4	74.2	94.6	--	44.3	82.4	45.4	107.8	80.3	--
	B	52.5	63.6	91.1	--	50.1	50.0	182.8	54.4	37.6	--
Chlorophyll a (ug/l)	S	3	2.47	NR	2.59	2.63	2.19	NR	2.79	2.41	1.69

[1] S = surface, B = bottom; [2] NR = no reading; [3] holding time exceeded by SLOH; [4] ND = not detectable

Table 8. Water Quality Parameters, Station 1404, Knight Lake, Chain O' Lakes, July 1992 - May 1993.

PARAMETER	SAMPLE[1]	DATE			
		07/14/92	09/23/92	02/03/93	05/18/93
Secchi (feet)		27.5	14.1	NR[2]	11.9
Cloud Cover (percent)		90	0	10	80
Temperature (degrees Celcius)	S	19.25	15.36	1.88	NR
	B	9.03	9.33	4.79	NR
pH (surface units)	S	8.18	8.58	7.25	NR
	B	6.86	7.68	6.75	NR
D.O. (mg/l)	S	9.15	7.87	9.33	NR
	B	0.16	0.57	0.88	NR
Conductivity (umhos/cm)	S	292	307	344	NR
	B	394	406	381	NR
Laboratory pH (surface units)	S	NR	NR	NR	8.42
	B	NR	NR	NR	7.74
Total Alkalinity (mg/l)	S	NR	NR	NR	163
	B	NR	NR	NR	208
Total Solids (mg/l)	S	NR	NR	NR	200
	B	NR	NR	NR	246
Tot. Kjeld. Nitrogen (mg/l)	S	0.3	0.4	0.2	0.4
	B	0.5	1.0	0.4	0.4
Ammonia Nitrogen (mg/l)	S	0.045	0.079	0.124	0.055
	B	0.221	0.773	0.232	0.219
NO_2 + NO_3 Nit. (mg/l)	S	0.669	0.596	1.49	0.662
	B	0.262	0.018	0.864	0.557
Total Nitrogen (mg/l)	S	0.969	0.996	1.69	1.062
	B	0.762	1.018	1.264	0.957
Total Phosphorus (mg/l)	S	0.010	0.014	0.005	<0.02
	B	0.061	0.106	0.024	0.02
Dissolved Phos. (mg/l)	S	0.002	0.002	0.003	ND[3]
	B	0.023	0.028	0.020	0.002
Nit./Phos Ratio	S	96.9	71.1	338.0	-
	B	12.5	9.8	52.7	47.9
Chlorophyll a (ug/l)	S	2	2.94	NR	2.91

[1] S = surface, B = bottom; [2] NR = no reading; [3] ND = not detectable;

Table 9. Water Quality Parameters, Station 1405, Orlando Lake, Chain O' Lakes, July 1992 - September 1994.

PARAMETER	SAMPLE[1]	DATE									
		07/14/92	09/23/92	02/03/93	05/20/93	08/17/93	10/06/93	02/15/94	05/02/94	08/02/94	09/21/94
Secchi (feet)		24.5	14.6	NR[2]	17.2	16.0	12.2	NR	17.5	12.6	14.5
Cloud Cover (percent)		80	0	10	90	100	0	0	10	0	100
Temperature (degrees Celcius)	S	19.84	15.55	2.22	14.53	22.50	13.00	2.33	10.17	22.73	20.29
	B	8.11	8.91	4.33	5.72	6.93	7.23	4.19	6.28	8.63	9.06
pH (surface units)	S	8.35	7.97	7.41	NR	7.67	NR	6.70	NR	8.09	NR
	B	6.97	7.04	6.82	NR	6.09	NR	6.38	NR	6.33	NR
D.O. (mg/l)	S	9.31	7.96	9.37	10.43	8.16	10.01	8.35	10.96	9.84	9.13
	B	0.13	0.58	0.32	0.35	0.18	0.59	0.38	0.72	0.34	0.95
Conductivity (umhos/cm)	S	287	300	341	311	300	336	350	303	298	289
	B	376	407	372	403	392	441	369	374	403	399
Laboratory pH (surface units)	S	NR	NR	NR	8.29	NR	NR	NR	NR	NR	NR
	B	NR	NR	NR	7.49	NR	NR	NR	NR	NR	NR
Total Alkalinity (mg/l)	S	NR	NR	NR	161	NR	NR	NR	NR	NR	NR
	B	NR	NR	NR	217	NR	NR	NR	NR	NR	NR
Total Solids (mg/l)	S	NR	NR	NR	200	NR	NR	NR	NR	NR	NR
	B	NR	NR	NR	262	NR	NR	NR	NR	NR	NR
Tot. Kjeld. Nitrogen (mg/l)	S	0.3	0.4	0.3	2.6[3]	0.4	0.4	0.3	NR	0.48	0.40
	B	3.4	3.9	1.2	0.3[3]	2.5	4.8	1.1	1.1	4.06	NR
Ammonia Nitrogen (mg/l)	S	0.059	0.102	0.117	1.83[3]	0.045	0.043	0.153	NR	0.024	0.050
	B	1.68	2.58	0.919	0.087[3]	1.58	3.50	0.709	0.702	0.941	NR
NO_2 + NO_3 Nit. (mg/l)	S	0.645	0.561	1.56	0.036[3]	0.602	0.722	1.44	NR	0.454	0.580
	B	ND[4]	ND	0.241	0.645[3]	ND	ND	0.465	0.204	ND	NR
Total Nitrogen (mg/l)	S	0.945	0.961	1.86	2.636[3]	1.002	1.122	1.74	NR	0.934	0.45
	B	3.4	3.9	1.441	0.945[3]	2.5	4.80	1.565	NR	4.06	--
Total Phosphorus (mg/l)	S	0.006	0.009	0.004	0.21[3]	0.007	0.009	0.014	NR	0.015	0.010
	B	0.49	0.39	0.070	<0.02[3]	0.26	0.58	0.050	0.057	0.091	NR
Dissolved Phos. (mg/l)	S	0.002	0.002	0.003	ND	ND	0.002	ND	NR	0.002	ND
	B	0.25	0.19	0.043	0.075	0.153	0.340	0.026	NR	ND	NR
Nit./Phos Ratio	S	157.5	106.8	465.0	12.6	143.1	124.7	124.3	NR	62.3	--
	B	6.9	10.0	20.6	--	9.6	8.3	31.3	NR	44.6	--
Chlorophyll a (ug/l)	S	2	3.01	NR	0.96	1.62	3.73	NR	NR	3.21	3.46

[1] S = surface, B = bottom; [2] NR = no reading; [3] Probable labeling error; [4] ND = not detectable

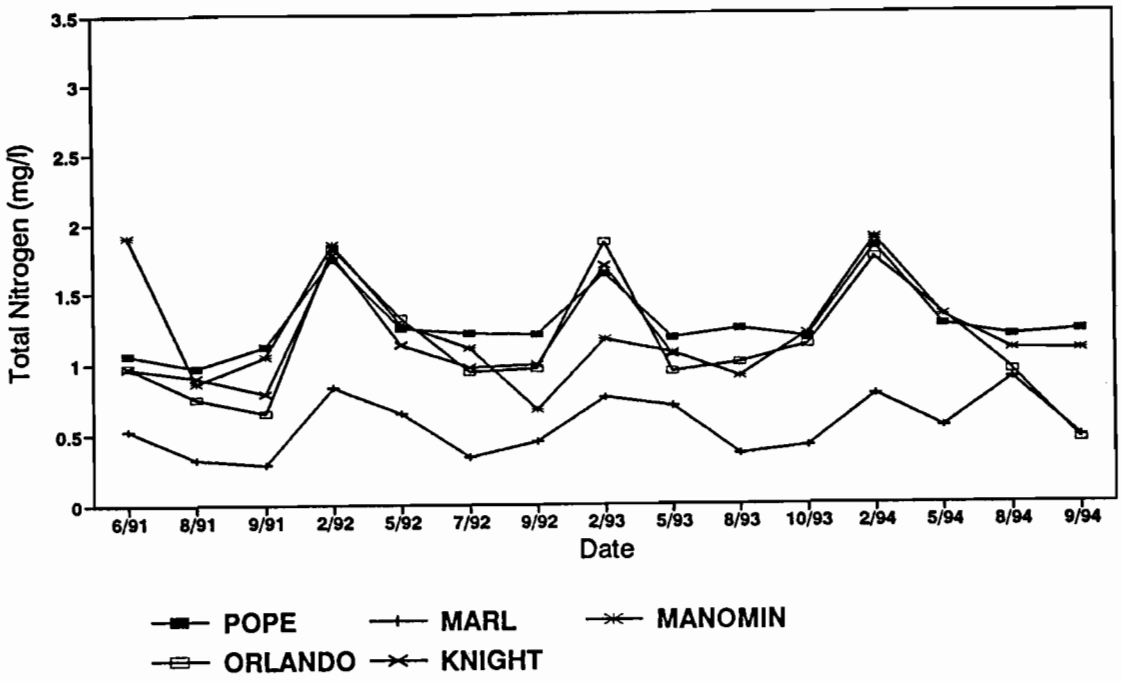

Figure 4. Surface Total Nitrogen Trends for the Little Chain, 1991 - 1994.

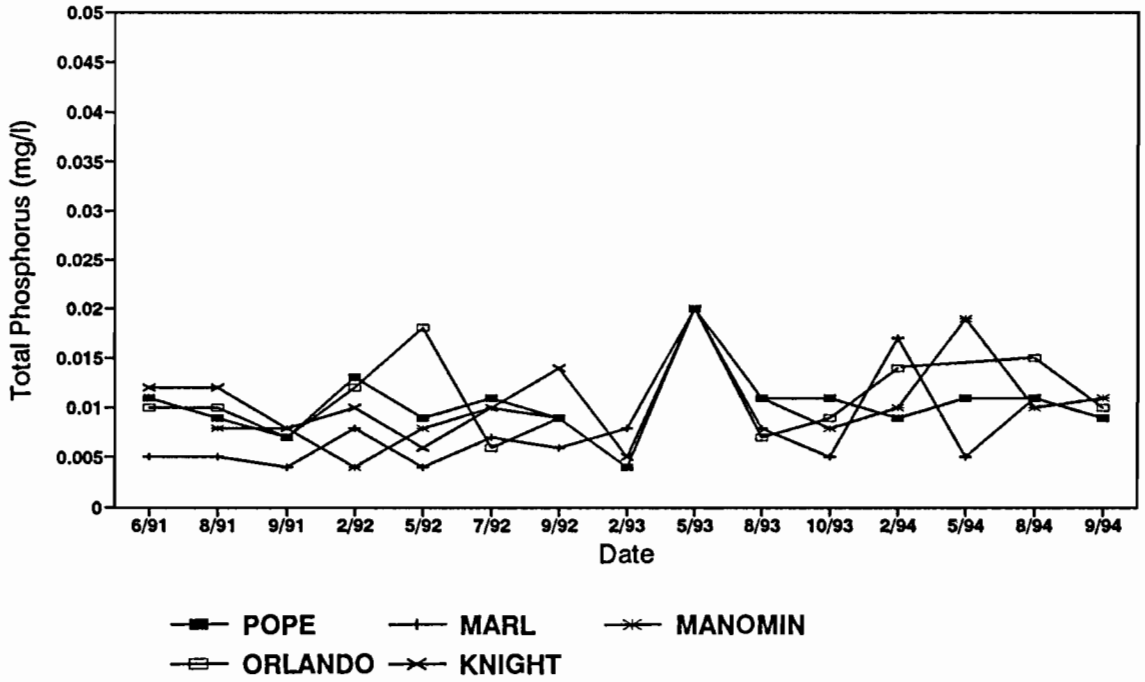

Figure 5. Surface Total Phosphorus Trends for the Little Chain, 1991 - 1994.

Average total nitrogen for site 14E1 (Hartman's Creek) for regular and event monitoring was 0.76 mg/l; average total phosphorus was 0.020 mg/l (Table 10).

Hartman's Creek flow was estimated (9) at 5.90 cfs (3.81 mgd); this flow, when combined with field instantaneous measurements of total phosphorus and nitrogen, yielded loading rates of 15.0 kilograms (33.0 pounds) phosphorus and 330.9 kilograms (729.4 pounds) nitrogen per year to Pope Lake. Similarly, Emmon's Creek inputs to Long Lake of the Lower Chain at an average flow of 30.3 cfs (19.6 mgd) were estimated at 1,110 kilograms (2,448 pounds) phosphorus and 46,580 kilograms (102,690 pounds) nitrogen (Fig. 6-8). These inputs far exceeded the TWRPW Project phosphorus input estimate of 1,313 pounds.

Table 10. Event and Regular Water Quality Parameters, Station 14E1, Hartman's Creek at Rural Road, Chain O' Lakes, October 1993 - August 1994

PARAMETER	SAMPLE[1]	DATE				
		10/06/93	02/15/94	05/03/94[2]	07/06/94[2]	08/01/94[2]
Temperature (degrees Celcius)	M	13.89	2.69	NR[3]	NR	NR
pH (surface units)	M	7.49	6.74	NR	NR	NR
D.O. (mg/l)	M	5.94	15.50	NR	NR	NR
Conductivity (umhos/cm)	M	203	351	NR	NR	NR
Tot. Kjeld. Nitrogen (mg/l)	M	0.4	0.3	0.3	0.4	0.45[4]
Ammonia Nitrogen (mg/l)	M	0.039	0.241	0.035	0.062	0.058
NO_2 + NO_3 Nit. (mg/l)	M	0.423	1.07	0.199	0.099	0.163
Total Nitrogen (mg/l)	M	0.823	1.37	0.499	0.499	0.613
Total Phosphorus (mg/l)	M	0.014	0.007	0.017	0.039	0.021
Dissolved Phos. (mg/l)	M	ND[5]	0.002	NR	0.003	ND
Nit./Phos Ratio	M	58.8	195.7	29.4	12.8	29.2

[1] M = mid-depth; [2] event date; [3] NR = no reading;
[4] holding time exceeded by SLOH; [5] ND = not detectable

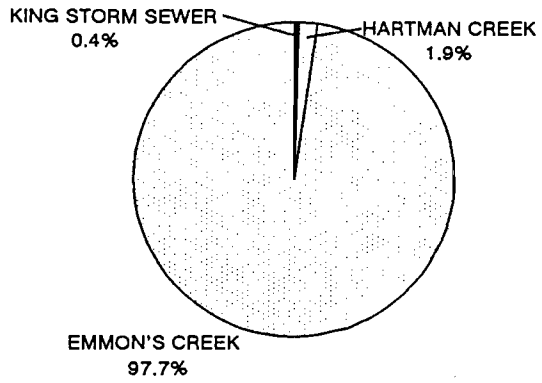

Figure 6. Average Flow Contribution from Overland Sources, Chain O' Lakes, 1994.

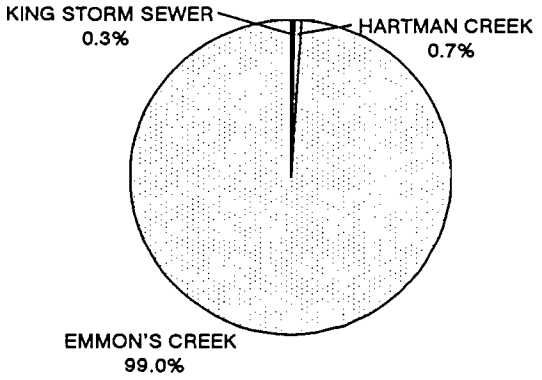

Figure 7. Average Nitrogen Contribution from Overland Sources, Chain O' Lakes, 1994.

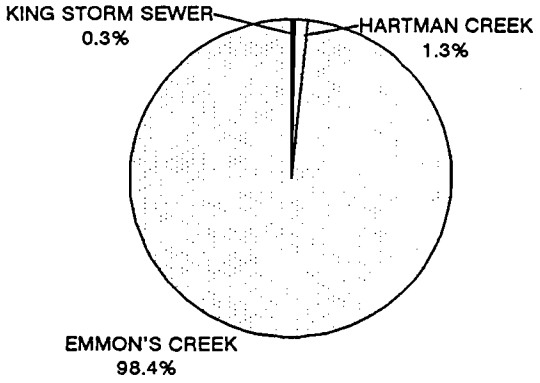

Figure 8. Average Phosphorus Contribution from Overland Sources, Chain O' Lakes, 1994.

Recreational Use

About 43% of all Chain O' Lakes respondents indicated they were permanent residents. Average occupancy for all respondents was 7.8 months (Table 11); seasonal residents averaged 4.7 months.

Table 11. Comparison of Recreational Use Parameters for Various User Groups, Chain O' Lakes, Waupaca County, Wisconsin.

Parameter	User Group			
	Little Chain	Fast Lakes	Slow Lakes	Entire Chain
Average monthly occupancy	8.6	7.5	8.1	7.8
Average number of watercraft (per response)	2.6	3.1	2.7	2.9
Average number of adults (per respondent household)	2.5	2.4	2.4	2.4
Average number of children 12 - 18 years old (per respondent household)	0.5	0.6	0.3	0.4
Average number of children less than 12 years old (per respondent household)	0.6	0.5	0.5	0.5
Average respondent age	57.6	59.1	57.7	58.3
Percent of respondents leaving comments	71.0	51.9	44.9	48.0

Respondents indicated a total of 1222 watercraft with an average of 2.9 per household (Table 11). Pro-rated (to include all landowners) results would estimate almost 2,300 watercraft on the

Chain O' Lakes, or 3.2 boats per acre (not including visitor watercraft). Most common watercraft types (in order) were canoes, pontoon boats, row/paddle boats and boats with less than 25 horsepower motors.

The number of Little Chain resident responses, compared to the number of responses for other user groups, was relatively small. Their opinion, however, differed somewhat from those of the Chain, as a whole, or from "fast" [wake lake residents (Rainbow, Round, Columbia and Long Lakes)] or "slow" [no wake lake residents (all others)] lake user groups (Table 12).

Little Chain respondents agreed (88% "strongly agree" or "agree" responses) there are too many watercraft on the Chain [primarily on weekends and holidays (App. II)] and that the number of watercraft cause safety problems (82%) (primary causes identified as non-resident and commercial watercraft) and diminish user enjoyment. They were rather evenly split on the issue of adequate water safety enforcement on weekdays (57%), weekends (57%) and holidays (50%). Concensus was in favor of enactment of more ordinances and limiting boat numbers.

Respondents fully agreed that there was adequate public boater access to the Chain (100%). Most disagreed ("strongly disagree" or "disagree" responses) with establishment of a park

(62%) or public restrooms (62%) on the Chain, and they were nearly evenly split on the establishment of a public beach.

Table 12. Percentage of "Strongly Agree" and "Agree" Responses for Various User Groups, Chain O' Lakes, Waupaca County, Wisconsin.

Opinion	User Group			
	Little Chain	Fast Lakes	Slow Lakes	Entire Chain
There are too many watercraft on the Chain	88	79	77	77
The current number of watercraft causes safety problems	82	77	75	76
There is adequate water safety enforcement:				
weekdays	57	82	85	84
weekends	57	60	69	65
holidays	50	58	62	60
Additional water use regulations need to be enacted and enforced	76	62	61	61
There should be limits set on the number of watercraft	71	54	54	54
There is adequate public boater access to the Chain	100	92	90	91
There should be more public restrooms on the Chain	38	52	47	50
There should be a public swimming beach on the Chain	47	36	34	35
There should be a public park on the shoreline of the Chain	38	29	29	29

Exotic Species

Eurasian Water Milfoil was not observed in the Little Chain O' Lakes; aquatic plant surveys (1991) and visual observations (1991 - 1994) indicated only native water milfoil species (mainly *Myriophyllum exalbescens*), present in the Little Chain. There were no observations of Zebra Mussels.

Purple Loosestrife was not present in the Little Chain, but is established in nearby Chain O' Lakes project groups. Purple Loosestrife is an exotic plant with a bright purple flower, originally propagated in the United States by the horticulture industry for flower gardens. It blooms late June to July and produces seeds soon after. The plant is able to outcompete native wetland vegetation and modify entire plant (and thus animal) assemblages.

BASELINE CONCLUSIONS

Watershed Characteristics

TWRPW Program well sample nitrate results, despite some instances of concern (e.g., > 10 mg/l), indicated that the Chain O' Lakes subwatershed had the lowest average nitrate readings for the entire Tomorrow/Waupaca River Watershed. Surface water samples indicated variable nitrate readings for the Chain subwatershed with highest readings in Murray and Radley Creeks.

Sediment/nutrient delivery for the Chain subwatershed of the TWRPW Project appraisal was estimated to be lower than all other subwatersheds. The Chain O' Lakes subwatershed contained almost 8% of the surface drained farmland but was estimated at only 6% of the sediment delivery; no stream degradation was observed for the 21.8 miles of streams in the Chain subwatershed.

Water Quality

Regular water quality monitoring in the Little Chain during Phase II, as during Phase I, indicated good to very good water quality. Hartman's Creek inflow appeared to slightly elevate nutrient levels in the more downstream Little Chain lakes. Surface total phosphorus levels were generally similar to that in the other Chain lakes and exhibited, as a whole, weak to variable seasonal trends. Total nitrogen was highest during periods when

groundwater input was of the greatest influence (Winter) and lowest during summer stratification. In-lake nutrients for all lakes continued to be near or below levels expected for stratified lakes, lakes in the central region of Wisconsin and lakes in the ecoregion in which the Chain is located; marl precipitation apparently reduces phosphorus levels in at least some Chain lakes.

Flow and nutrient contribution via Hartman's Creek, according to the TWRPW Project, is relatively small compared to other overland sources to the Chain (Fig. 6-8). These estimates of total overland nutrient input to the Chain appear questionable because of the considerable discrepancy between the TWRPW Project and the estimated flow - field measured phosphorus estimate methods.

Recreational Use

Little Chain resident responses to the recreational use survey differed from those of the Chain as a whole and from "fast" and "slow" lake user groups. Watercraft use on the Chain is high and respondents generally agreed that the current number of watercraft caused safety problems and diminished recreational enjoyment. Little Chain Residents were evenly divided regarding adequate water safety enforcement on weekdays, weekends and during holiday periods of heavy recreational use and were more agreeable (than other Chain user groups) towards additional use

regulations and limiting the number of watercraft on the Chain. There was relatively low interest in establishment of public restrooms on the Chain, but respondents were more agreeable as to the need for a public swimming beach or park when compared to other Chain user groups.

Exotic Species

There were no observations of Zebra Mussels or Eurasian Water Milfoil in the Chain. Purple Loosestrife, which is widely distributed in Wisconsin and Waupaca County, has become established in several areas of the Upper, Lower, and Middle Chains and the potential for colonization of the Little Chain should be considered high.

MANAGEMENT RECOMMENDATIONS

Watershed: The Chain O' Lakes is significantly influenced by groundwater and receives some surface water inflow from the watershed. Residents should be made aware of the potential effects of watershed uses on their resource. In addition to a continuous focus on "yard management", they should be strongly encouraged to keep abreast of and support the TWRPW Project.

- Residents in the Little Chain watershed should have private wells tested for nitrates and/or pesticide levels.

- Groundwater samples should be collected at various points in the Chain O' Lakes watershed to determine areas of concern.

Water Quality: Water quality in the Little Chain is currently very good but a focused monitoring strategy should be continued. These data could provide a long term trend assessment and detect detrimental influences before effects become widespread or severe.

- Marl, Pope, and Orlando Lake sites should be considered "indicator lakes" for Little Chain trend monitoring. Surface only samples during Winter, after ice out and three times during the Summer would minimize collection and laboratory analysis costs.

- More event samples should be collected at Site 14E1; flow determination and rainfall monitoring would enhance the value of this information.

- Groundwater nutrient and flow direction/rates should be collected for the Chain O' Lakes system when feasible.

Recreational Use: Chain O' Lakes resident recreational use survey results suggest that use, during summer weekends and holidays, is at or near saturation levels and that most perceive the problems related to non-resident and commercial watercraft. Survey results also suggest that the opinions of the Little Chain user group differ from those of other user groups. There does not appear, however, to be a clear concensus that additional regulations are desirable to address the situation. The CLPOA, then, should form a committee, or enlist some outside assistance, to address direct education or prevention measures to attempt minimization of use conflicts; these may include

- Development of maps for distribution which define best potential use zones for different recreational activities (skiing, fishing, canoeing, SCUBA diving/snorkeling, pleasure boating, dining, snowmobiling, etc.),

- Brochures, for visitors at access points, emphasizing "water

use ethics" along with information on available restrooms, access points and applicable regulations and ordinances,

- Development of water accessible restrooms and waste disposal facilities for boaters,

- Initiation of a reasonable ramp fee at some/all access points with the money collected directed toward access maintenance or lake management/protection activities, and

- Riparian landowners education about pertinent ordinances (dock design/size, boat numbers per pier, building near lakeshores, near-lake improvements, etc.).

Exotic Species: Of the three exotic species of most current concern, only purple loosestrife appears to be established in the Chain O' Lakes.

- Identified purple loosestrife stands should be treated as soon as it is practical to do so; localized growth areas or individual plants should be treated first and more extensive growth areas later. It is best to treat plants before flowering (May to mid June). Plants are treated by cutting the top off and spraying the remainder with a Roundup-surfactant mix; plants in standing water should be treated

with a Rodeo-surfactant mix. Chemicals can be applied using hand spray bottles or larger chemical sprayers. Sites should be revisited in subsequent years to treat remnant individuals.

- An exotic species watch group should be organized to monitor or remove exotic species (i.e., Purple Loosestrife, Zebra Mussels and Eurasian Water Milfoil) when encountered. Members should coordinate with the WDNR Exotic Species Program and inform the CLPOA membership and public on the hazards of exotic species as they relate to the Chain O' Lakes.

Public Involvement: Informational and educational programs for the CLPOA membership and public should be continued. Meetings, presentations, newsletters and/or news releases should continue to include information on groundwater and surface water quality, recreational use issues and the spread or control of exotic species.

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7. Omernik, James M. et. al. 1988. "Summer Total Phosphorus in Lakes: A Map of Minnesota, Wisconsin, and Michigan, USA." Environmental Management 12(6): 815-825.

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9. Wisconsin Department of Natural Resources. 1994. Flow and Nutrient Data for Hartman Creek, Emmon's Creek and Crystal River. Unpublished.

APPENDIX I
RECREATIONAL USE SURVEY RESULTS
Little Chain O' Lakes Management Plan

Name of Lake: _____

RECREATIONAL USE SURVEY
Chain O'Lakes Property Owners Association

The Chain O'Lakes Association is leading a coordinated effort to develop a Comprehensive Lake Management Plan for the Chain O'Lakes. The first phase of this three-phased program is focusing on obtaining and analyzing information about the lakes. One particular area of interest is learning more about your recreational use of the Chain O'Lakes.

Please take the time to complete this questionnaire. After you have completed the questionnaire your Neighborhood Chairperson will pick it up within one week.

All replies are confidential. Please do not sign your name to the survey. Only through your help can we develop a successful, comprehensive plan! The results of the survey will be available before the end of this year. We thank you for your cooperation!

PROPERTY USE

1. What year did you purchase your property on the Chain O'Lakes? _____
   N = 16; Ave.= 1968; Range = 1920-1989
2. What year did you buy or build your current dwelling on the Chain O'Lakes?
   _____
   N = 16; Ave. = 1975; Range = 1951-1992
   a. No dwelling on property ___
   N = 0
3. If you do not have a dwelling on your property, what year do you plan to build?
   _____
   N = 0
   a. Don't plan to build ___

(IF YOU DO NOT HAVE A DWELLING ON YOUR PROPERTY, SKIP TO QUESTION # 7.)

4. How many months per year do you occupy your dwelling on the Chain O'Lakes?
   _____
   N = 17; Ave. = 8.6; Range = 2-12
5. Do you rent out your dwelling? (Please check (x) your response below.)

   a. Yes ___ b. No ___
   N = 17; Yes = 1; No = 16
   c. If yes, how many weeks per year? _____
   N = 1; Ave. = 8.0; Range = 8-8
6. Do you let others use your dwelling? (Please check (x) your response below)

   a. Yes ___ b. No ___
   N = 17; Yes = 6; No = 11
   c. If yes, how many weeks per year? _____
   N = 6; Ave. = 13.6; Range = 1-52

APPENDIX I
(continued)

WATER USE

7. Please identify the type and number of watercraft/horsepower (HP) you own.

Watercraft Type	Number	Watercraft Type	Number
a. sailboat	0	g. Motor boat 50-100 HP	2
b. canoe or kayak	22	h. motor boat over 100 HP	0
c. row boat/ paddleboat (no motor)	10	i. personalized watercraft; i.e., jet ski	0
d. pontoon boat	1	j. other, please list	
e. motor boat less than 25 HP	9	_____	0
f. motor boat 26-50 HP	1	_____	____

8. Do you allow others, besides the property owner or renter, to keep water craft on your property? (Please check (x) your response below.)

a. Yes ___ b. No ___

N = 17; Yes = 1; No = 16

c. If yes, please identify the type/horsepower of the watercraft.

Watercraft Type	Number	Watercraft Type	Number
a. sailboat	0	g. motor boat 51-100 HP	0
b. canoe or kayak	1	h. motor boat over 100 HP	0
c. row boat/ paddleboat (no motor)	0	i. personalized watercraft; i.e., jet ski	0
d. pontoon boat	0	j. other, please list	
e. motor boat less than 25 HP	0	_____	0
f. motor boat 26-50 HP	0	_____	____

APPENDIX I
(continued)

9. Where is the permanent residence(s) of the other watercraft owners? (city/state)

_____

_____

a. ___ no others have watercraft on our property

Oshkosh=1

APPENDIX I
(continued)

(FOR QUESTIONS 10, 11, 12, AND 15, THE TERM "PLEASURE BOATING" REFERS TO THE USE OF THE BOAT FOR RIDING AND SIGHTSEEING ONLY - NOT FOR FISHING OR WATER SKIING. "PONTOONING" REFERS TO PLEASURE BOATING USING A PONTOON.)

10. Please indicate how you spend your time on the Chain O'Lakes. Please check (x) the amount of water use for each surface water use category.

	Amount of Time Spent*			
Surface Water Use	Frequently	Occasionally	Seldom	Never
a. Sailing	0	0	0	14
b. Canoeing	5	6	3	1
c. Pleasure Boating	3	7	5	1
d. Personal Water Craft (i.e., Jet Ski)	0	0	0	14
e. Water Skiing	0	0	2	12
f. Fishing	2	8	6	1
g. Swimming & Sunbathing	10	5	1	1
h. Pontooning	0	1	3	11
i. Bird Watching/ Wildlife Watching	10	4	2	1
j. Viewing Natural Beauty	10	4	3	0
k. Other - please specify	Bike			

* Frequently = at least 1 time per week.
Occasionally = at least 1 time per month.
Seldom = 3-4 times a year.

APPENDIX I
(continued)

11. Please indicate how <u>other adults</u> (18 and over) in your residence spend their time on the Chain O'Lakes.

Surface Water Use	Amount of Time Spent*			
	Frequently	Occasionally	Seldom	Never
a. Sailing	0	0	0	13
b. Canoeing	4	6	3	1
c. Pleasure Boating	3	2	5	3
d. Personal Water Craft (i.e., Jet Ski)	0	0	0	13
e. Water Skiing	0	0	1	12
f. Fishing	1	9	5	0
g. Swimming & Sunbathing	7	4	3	1
h. Pontooning	0	1	1	11
i. Bird Watching/ Wildlife Watching	8	4	2	1
j. Viewing Natural Beauty	8	4	3	0
k. Other - please specify		Volleyball, Golf		

* Frequently = at least 1 time per week.
Occasionally = at least 1 time per month.
Seldom = 3-4 times a year.

APPENDIX I
(continued)

12. Please indicate how youth (under age 18) in your residence spend their time on the Chain O'Lakes.

Surface Water Use	Amount of Time Spent			
	Frequently	Occasionally	Seldom	Never
a. Sailing	0	0	0	11
b. Canoeing	2	4	3	2
c. Pleasure Boating	1	5	3	3
d. Personal Water Craft (i.e., Jet Ski)	0	0	1	10
e. Water Skiing	0	0	2	8
f. Fishing	1	6	3	2
g. Swimming & Sunbathing	7	3	1	1
h. Pontooning	0	2	1	8
i. Bird Watching/ Wildlife Watching	4	4	2	2
j. Viewing Natural Beauty	4	4	3	1
k. Other - please specify	Bike	Volleyball,Golf	Horseriding	

* Frequently = at least 1 time per week.
Occasionally = at least 1 time per month.
Seldom = 3-4 times a year.

APPENDIX I
(continued)

13. How do you get your boat(s) in the water on the Chain O'Lakes? (Please check (x) your response below.)

a. 10 private launch site c. 1 commercial launch site

b. 3 public launch site d. 0 other (please list)

In addition to "other" replies, there were the following multiple responses: 2 - private and commercial

14. Please indicate how frequently members of your household picnic at the Chain O'Lakes. Please check (x) the frequency for each category.

	Amount of Picnicking*			
Picnic Location	Frequently	Occasionally	Seldom	Never
a. Own yard	5	6	2	4
b. Neighbor's yard	0	3	3	9
c. Private park or beach	0	1	3	10
d. In a boat on the lake	0	3	4	7
e. County park	0	1	3	10

* Frequently = at least 1 time per week.
Occasionally = at least 1 time per month.
Seldom = 3-4 times a year.

APPENDIX I
(continued)

15. How often do members of your household go to other lakes besides the Chain O'Lakes for recreational uses? Please check (x) the frequency for each category.

	Amount of Time Spent*			
Surface Water Use	Frequently	Occasionally	Seldom	Never
a. Sailing	0	0	0	13
b. Canoeing	0	1	2	11
c. Pleasure Boating	0	2	3	9
d. Personal Water Craft (i.e., Jet Ski)	0	0	0	13
e. Water Skiing	0	0	1	12
f. Fishing	2	1	4	6
g. Swimming & Sunbathing	0	3	5	7
h. Pontooning	0	1	0	13
i. Bird Watching/ Wildlife Watching	2	4	5	4
j. Viewing Natural Beauty	2	6	6	2
k. Other - please specify	Bike	Windsurf	Walk	

* Frequently = at least 1 time per week.
Occasionally = at least 1 time per month.
Seldom = 3-4 times a year

APPENDIX I
(continued)

16. How often do members of your household use water craft on other lakes besides the Chain O'Lakes?

a. 0 frequently
b. 4 occasionally
c. 6 seldom
d. 7 never

17. How often are members of your household likely to participate in the following winter sports activities?

Activity	Amount of Use* Frequently	Occasionally	Seldom	Never
a. Ice fishing	0	4	7	5
b. Cross country skiing	6	3	3	4
c. Snowmobiling	0	2	2	9
d. Ice skating	1	5	3	5
e. Ice boating	0	0	0	13
f. Snow shoeing	0	0	1	12
g. Other - please specify	Walk(2)	Ski	Walk	

* Frequently = at least 1 time per week.
Occasionally = at least 1 time per month.
Seldom = 3-4 times a year

APPENDIX I
(continued)

WATER USE CONFLICTS

18. There are too many watercraft on the Chain. (Please check (x) your response.)

a. 9 strongly agree
b. 6 agree
c. 2 disagree
d. 0 strongly disagree

If you "strongly agree" or "agree", when?

a. 0 weekdays b. 2 weekends c. 0 holidays

In addition to "other" replies, there were the following multiple responses: 10 - weekends and holidays; 3 - all

d. Please identify lake(s). _____

19. The current number of watercraft causes water safety problems. (Please check (x) your response below.)

a. 7 strongly agree
b. 7 agree
c. 3 disagree
d. 0 strongly disagree

20. If you "strongly agree" or "agree" with statement #19, what do you feel are the cause(s). (Please check (x) all appropriate responses below.)

a. 0 private residential watercraft
b. 1 commercial watercraft activities and rentals
c. 4 non-residential watercraft
d. 0 other, please specify _____

In addition to "other" replies, there were the following multiple responses: 2 - b & c; 3 - a, b & c; 4 - a & c

21. The current number of watercraft diminishes the ability to enjoy the Chain O'Lakes from the water or from the shore.

	strongly agree	agree	disagree	strongly disagree
a. weekdays	3	3	6	1
b. weekends	7	8	2	0
c. holidays	7	9	1	0

APPENDIX I
(continued)

22. There is adequate water safety enforcement during: (Please check (x) all appropriate responses below.)

	strongly agree	agree	disagree	strongly disagree
a. weekdays	0	8	4	2
b. weekends	0	8	4	2
c. holidays	0	7	5	2

23. Surface water use conflicts on the Chain O'Lakes are extensive enough that additional surface water use regulations need to be enacted and enforced? (Please check (x) your response below.)

a. 6 strongly agree
b. 7 agree
c. 4 disagree
d. 0 strongly disagree

24. There should be limits set on the number of watercraft that can use the surface water at particular times. (Please check (x) your response below.)

a. 4 strongly agree
b. 8 agree
c. 5 disagree
d. 0 strongly disagree

25. There is adequate public boater access to the Chain. (Please check (x) your response below.)

a. 6 strongly agree
b. 11 agree
c. 0 disagree
d. 0 strongly disagree

APPENDIX I
(continued)

26. There should be more public rest rooms on the Chain. (Please check (x) your response below.)

a. __2__ strongly agree
b. __4__ agree
c. __9__ disagree
d. __1__ strongly disagree

1. If you "strongly agree" or "agree" with statement #26, docking facilities should be provided for the rest rooms.

a. __4__ strongly agree
b. __2__ agree
c. __2__ disagree
d. __0__ strongly disagree

2. These facilities should be provided by:

	strongly agree	agree	disagree	strongly disagree
a. private sector	1	5	1	0
b. public sector	1	3	0	1

27. There should be a public swimming beach on the Chain. (Please check (x) your response below.)

a. __2__ strongly agree
b. __6__ agree
c. __5__ disagree
d. __4__ strongly disagree

28. There should be a public park with picnicking and shelter on the shoreline of the Chain. (Please check (x) your response below.)

a. __1__ strongly agree
b. __5__ agree
c. __6__ disagree
d. __4__ strongly disagree

APPENDIX I
(continued)

DEMOGRAPHICS

29. How many adults (18 years or over) including yourself reside in your household?
N = 17; Ave. = 2.5; Range = 1-4

30. How many children over 12 but under 18 reside in your household? ____
N = 14; Ave. = 0.5; Range = 0-3

31. How many children 12 or under reside in your household? ____
N = 15; Ave. = 0.6; Range = 0-4

32. What was your age on your last birthday? ____
N = 17; Ave. = 57.6; Range = 44-73

33. What are the occupations of you and your spouse? (Please check (x) your response(s) below.)

3	professional, i.e., teacher, doctor, lawyer	0	craftsman, foreman, operator
0	sales/clerical	0	service worker
0	farmer	1	homemaker
0	manager, administrator	0	self-employed business owner
0	student	4	retired
0	unemployed	1	other, please specify _____

37. If you have comments or suggestions about this survey or the lake management planning effort, please respond below.

12 respondents had comments and which will be reviewed later.