IPS ENVIRONMENTAL AND ANALYTICAL SERVICES
Appleton, Wisconsin

PHASE II
LAKE IOLA MANAGEMENT PLAN
WAUPACA COUNTY, WISCONSIN

REPORT TO:
LAKE IOLA LAKE DISTRICT

December, 1994

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SUMMARY

Lake Iola, Waupaca County, Wisconsin is characterized by good water quality, prolific aquatic plant growth and a lake-wide swimmer's itch problem. An initial resource assessment was made in 1992 (Phase I Lake Iola Management Plan); this document supplements the 1992 report and outlines further efforts toward development of a comprehensive lake management plan.

The majority of the relatively small Lake Iola watershed can be characterized as open or agricultural areas of nearly level sandy soils. Forested, wetland and more steeply sloped areas are common.

Lake Iola nutrient levels were low in comparison to most impoundments. Total phosphorus levels peaked at times of highest runoff (spring); total nitrogen peaks occurred at times of highest groundwater input to the system (winter). Event monitoring indicated two areas of concern each for phosphorus and nitrogen.

A comparison of aquatic plant control methods for Lake Iola indicated mechanical harvest to be cost-efficient for widespread application and SCUBA cutting to be the most effective control for localized areas. Eurasian Water Milfoil (*Myriophyllum spicatum*) was not found in Lake Iola but localized dense stands of Purple Loosestrife (*Lythrum salicaria*) were identified.

Recreational use of Lake Iola is impaired by aquatic plants and swimmer's itch. Designation of "use zones" help to maximize the potential for wildlife usage and minimize harvest efforts.

Recommendations for the continued management of the Lake Iola resource include:

- Areas of concern should be assessed for nutrient and sediment contributions to surface and groundwaters. Designation of the basin as a priority watershed would greatly facilitate this area-wide assessment.
- Water quality monitoring should be continued to track trends and develop an accurate nutrient budget. A monitoring site should be added the outlet, event samples should be collected at similar locations, and a staff gage should be placed at the inlet. Well testing should be encouraged given the high levels of nitrates in regular and event samples.
- Mechanical harvest should be continued. Cut areas should be located on a map and made available at public access points. Purple Loosestrife should be removed.
- Land purchase or park development should be considered to increase recreational opportunities for Lake Iola.
- A fishery survey should be completed in the next five years to determine the status of fish populations.

INTRODUCTION

This report presents Phase II management planning efforts for Lake Management Plan, Lake Iola, Waupaca County, Wisconsin. Specific physical properties of the resource, preliminary methods, and other introductory and technical information were presented in the Phase I report (printed in 1992).

Lake Iola is a small impoundment in the Village of Iola, with good recreational use potential, prolific aquatic plant growth, a lake-wide swimmer's itch problem and significant wildlife use. Historic management activities have generally targeted control of aquatic plants.

The Lake Iola Lake District (LILD) was formed in 1991, has 1200 voting members and serves as the main steward for the resource. The LILD, received its first Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grant in April, 1991 and selected IPS Environmental & Analytical Services (IPS) of Appleton, Wisconsin as its consultant to begin management planning efforts. Phase I efforts included assessment activities (for water quality and aquatic plants) and a public involvement program. The Phase II grant was received in September, 1992; Phase II efforts included continuation of the water quality monitoring and public involvement programs, more intensive review of areas of concern in the watershed, assessment of aquatic plant management techniques and development of recreational use alternatives for the impoundment.

DESCRIPTION OF AREA

Lake Iola is maintained by a "stop-log dam" with a seven-foot head. Like other impoundments, Lake Iola has extensive shallow areas (maximum depth = 10 feet, average depth = 4 feet) (1), exhibits periodic flushing (residence time = 21.1 days), acts as a sediment trap (fills in) and has a relatively large watershed (78 times more land than lake surface area) compared to natural lakes (2).

Major soil types near the lake are sands and loams with interspersed areas of muck. About 70-80 per cent of the approximately 100 lake homes are sewered to the Village of Iola wastewater treatment plant.

Predominant littoral substrates include silt (60%), sand (30%), and gravel (10%) (2). Dredging, stump removal, and channelization were completed during a 1965 - 1967 drawdown. Another drawdown was undertaken during the Winter of 1990 - 1991 in an attempt to control aquatic plants (3).

The LILD has contracted an aquatic plant harvester since 1991. Harvest efforts (two to four 40 hour cuts per year) targeted the downstream portion of the impoundment with emphasis on creation of openings for recreational and fishery access (Table 1) (3). Individual landowners have also treated localized areas with aquatic herbicides to control aquatic plants (Table 2) (4).

Public access to Lake Iola is available at three locations: west shore, off Lakeshore Drive - boat launch with vehicle parking; south shore, off County Hwy G - unimproved landing; and east shore, off Sunset Drive - beach area (no boat launch).

Wildlife observed during the planning effort include waterfowl (mallards, teal, wood ducks, Canada geese, sandhill cranes, great blue heron), beaver, muskrat, white-tailed deer, and various species of turtles and frogs.

Table 1. Summary of Mechanical Harvest Efforts, Lake Iola, 1991 - 1994 (3).

Year	Harvest Hours	Tonnage	Area Harvested
1991	120[1]	120[2]	240 acres[2]
1992	80[1]	80[2]	160 acres[2]
1993	120[1]	120[2]	240 acres[2]
1994	160[1]	161[1]	320 acres[1]

[1] Actual harvested data
[2] Based on 1994 data; tonnage as wet weight of plants

Table 2. Summary of Aquatic Herbicide Treatments, Lake Iola, 1991 - 1994 (4).

Year	Permits Issued	Chemical Used	Amount	Acreage Treated
1991	2	Aquakleen 2,4-D	50 lbs	0.44
		Cutrine +	25 lbs	
1992	2	Aquakleen 2,4-D	60 lbs	0.44
		Copper Sulfate	48 lbs	
1993	3	Navigate 2,4-D	25 lbs	0.18
		Diquat	0.3 gals	
		Aquakleen 2,4-D	40 lbs	0.44
		Cutrine +	30 lbs	
1994	1	2,4-D	2.8 lbs	0.017

METHODS

WATERSHED CHARACTERISTICS

Watershed information was entered in to the AGNPS (**AG**ricultural NonPoint Source) computerized modeling program (5). The AGNPS program is commonly used for intense watershed analysis. Because of large informational needs for analysis, the program was used as a mapping tool for the Lake Iola project.

Parameters entered into the 385 cell (cell = 40 acres) database included soil type, slope, flow and cover type information. Cover type and flow information was taken from the United States Geological Survey 7.5' quadrangles for the area (6); soils information was taken from the Waupaca County Soils Survey (7). A weighted average was assigned for slope and other numeric data while absolute information (cover and soil type) was recorded as the category with the greatest area for the cell.

WATER QUALITY MONITORING

Lake Iola water samples were taken on February 1, April 21, August 18, and October 5, 1993 and January 27, May 26, July 25, and September 8, 1994. Samples were collected, mid-depth in the water column at Station 0901 (deepest point) and Station 0902 (inlet at Tressness Road) (Table 3, Figure 1). Parameters measured in the field were Secchi depth, water temperature, pH, dissolved oxygen (DO), and conductivity (see Phase I document for equipment and methods).

In addition to regular monitoring sites, twelve event sampling sites were located throughout the watershed (Figure 2) to help locate highest nutrient inflows. Event sample sites were located at road crossings of tributary streams and ditches. Samples were collected by members of the LILD (with IPS instruction) and were collected April 20 and June 6, 1993.

Flow to Lake Iola from the inlet at Tressness Road was measured on August 18, 1993 in an attempt to estimate nutrient loading to the impoundment. A Marsh McBirney Model 201 portable current meter was used to determine stream velocity at one foot, cross-sectional intervals. Velocity was measured at 60 percent of interval depth (where depth was less than 18 inches) and at 20 and 80 percent of interval depth (where depth was 18 inches or greater). Flow information (liters per year) was combined with nutrient information (milligrams per liter) to estimate nutrient loading (milligrams per year).

Table 3. Sampling Station Locations, Lake Iola, 1993 - 1994.

REGULAR MONITORING

Site	Depth
0901	10.0 feet
0902	3.0 feet

EVENT MONITORING

Site	Description
LE1	Small intermittent creek leading to Leer Creek at junction with North Lake Road (flow may not be present)
LE2	Leer Creek at junction with Roosevelt Road (flow should be present at all times)
LE3	Leer Creek at junction with Anderson Road (flow should be present at all times)
NE1	Small unnamed creek from North Lake at junction with Graham Lake Road (flow should be present at all times)
GE1	Small unnamed creek at junction with Snured Road (flow may not be present)
GE2	Griffin Creek at junction with Peterson Road (flow should be present at all times).
GE3	Small unnamed creek at junction with Highway 49 near Peterson Road (flow may not be present)
SE1	South Branch of the Little Wolf River at junction with Paulson Road (flow should be present at all times)
SE2	South Branch of the Little Wolf River at junction with Anderson Road (flow should be present at all times)
SE3	South Branch of the Little Wolf River at junction with Madson Road (flow should be present at all times)
SE4	South Branch of the Little Wolf River at junction with Tressness Road (flow should be present at all times)
UE1	Small unnamed creek at junction with Highway 49 between Anderson and Madson Roads (flow may not be present)

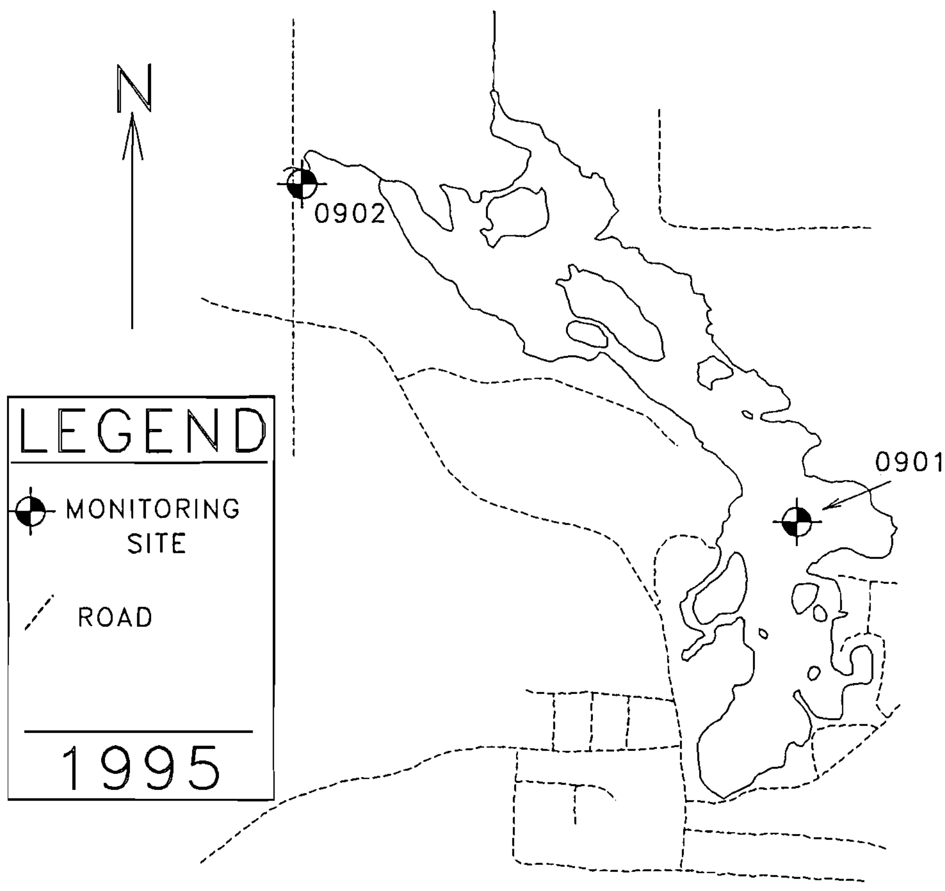

Figure 1. Sample Sites, Lake Iola, 1993 - 1994.

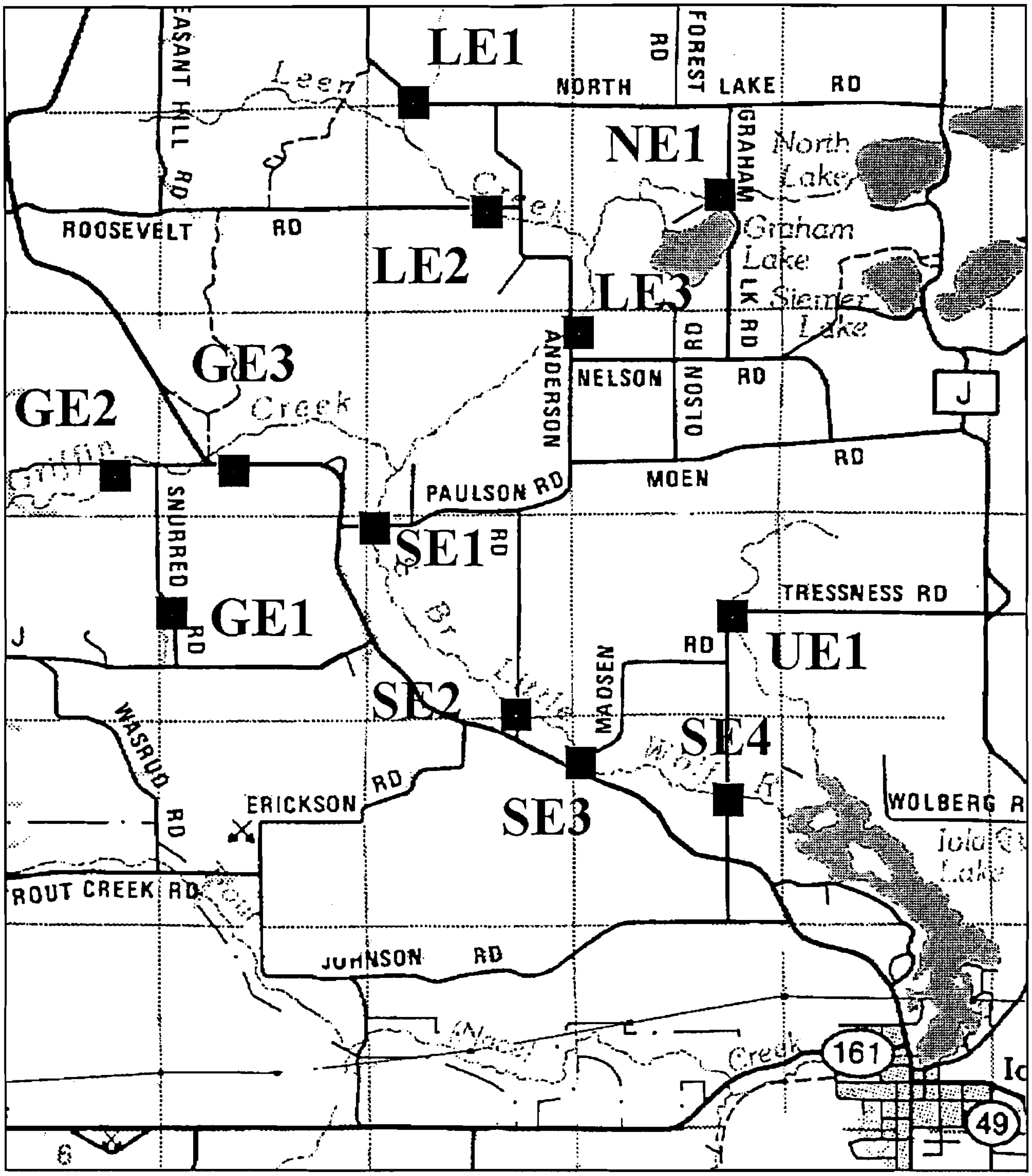

Figure 2. Event Sample Sites, Lake Iola, 1993 - 1994.

AQUATIC PLANT CONTROL

Aquatic plant surveys were conducted in Phase I to assess the types and amounts of plants in Lake Iola. Phase II aquatic plant activities included assessment of aquatic plant control techniques. Control methods evaluated included aquatic herbicides, mechanical harvest, benthic barriers (screening), and SCUBA cutting (clear and selective).

Control areas were established at the public beach and off of the largest island. Treatment plots were spaced about 50 feet apart. Because benthic barriers came in 7 feet by 100 foot rolls (and were subsequently quartered for ease of placement and removal), control plots for mechanical harvest, benthic barrier and chemical treatment were sized at 28 by 24 feet. Because of the labor intensive nature of SCUBA cutting, 10 - one square meter plots were used.

Aquatic Herbicide Treatment

A local licensed chemical applicator was contracted to treat areas of similar size with granular 2,4-dichlorophenoxy acetic acid (2,4-D). 2,4-D was selected as it is most effective on water milfoil (the dominant aquatic plant in Lake Iola). The actual treatment area was limited to 15 by 25 feet due to a limited supply of the chemical.

Mechanical Harvest

The harvester contracted by the LILD was solicited to harvest areas similar in size to the other treatments. An Aquarius EH-220, with a five foot cutting width, a maximum five foot cutting depth and a capacity of 3000 pounds (200 cubic meters) was used for harvest efforts (8). Harvested plants were unloaded from the harvester via a conveyor to a dump truck (2 ton capacity) at the public landing. Plants were disposed of at various farm locations in or near Iola.

Benthic Barriers

Two rolls of seven by one-hundred foot polyvinyl coated fiberglass screening were quartered for ease of handling. Two inch seams were sewn for every ten feet of screen (and on the ends) and 1/2" iron rebar was placed in the seam to weight the screens.

Screens were rolled onto the lake bottom perpendicular to the shoreline with slight overlap of adjacent pieces. Anchors were placed at each end of the screens and buoys were located at the corners of the treatment zone.

SCUBA Cutting

Circular SCUBA plots were delineated by 1.5 inch PVC sand filled tubing marked with red duct tape. Five plots were located at the corners and seams of benthic barriers at each treatment site. Five plots were clear cut (all vegetation cut off at the lake bottom), and five plots were selectively cut (only nuisance or undesirable species removed). Plants were cut with either a pruning shears or hedge clippers.

PUBLIC INVOLVEMENT PROGRAM

Public involvement activities were coordinated to inform and educate the LILD about lake management in general and specifics regarding the Lake Iola resource. Activities included news releases, IPS newsletters, meeting attendance and presentations to the LILD. A summary of public involvement activities is outlined in Appendix I.

FIELD DATA DISCUSSION

Water quality and aquatic plant growth in Lake Iola are influenced by watershed characteristics. Watershed area, soil and cover types, slopes and land uses all directly and indirectly influence the Lake Iola resource.

WATERSHED CHARACTERISTICS

AGNPS program results for the approximately 15,400 acre Lake Iola watershed were:

- Cover types - forested (5,520 acres, 36%), open/agricultural (8,560 acres, 56%), wetland (1080 acres, 7%) and urban (240 acres, 1%) (Figure 3).
- Soil types - sands (12,000 acres, 78%), silt (2,800 acres, 18%) and water (600 acres, 4%) (Figure 4).
- Slopes - 0-5% (10,560 acres, 69%), 6-10% (3,320 acres, 22%), 16-21% (1,280 acres, 8%) and 11-15% (240 acres, 1%) (Figure 5).

Areas of concern include 12 open/agricultural areas (480 acres) with slopes greater than 10% (Figure 6). Other areas of concern include sand soils with nearly level slope (0 - 5%) which are prone to rapid infiltration with a greater potential for groundwater contamination (Figure 7). Other suspect areas include feedlots near waterways and stream bank pasture areas.

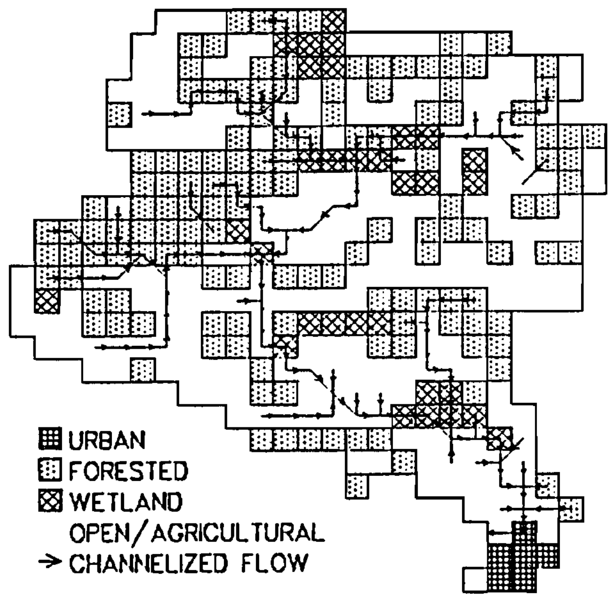

Figure 3. Watershed Cover Types, Lake Iola, Waupaca County, Wisconsin.

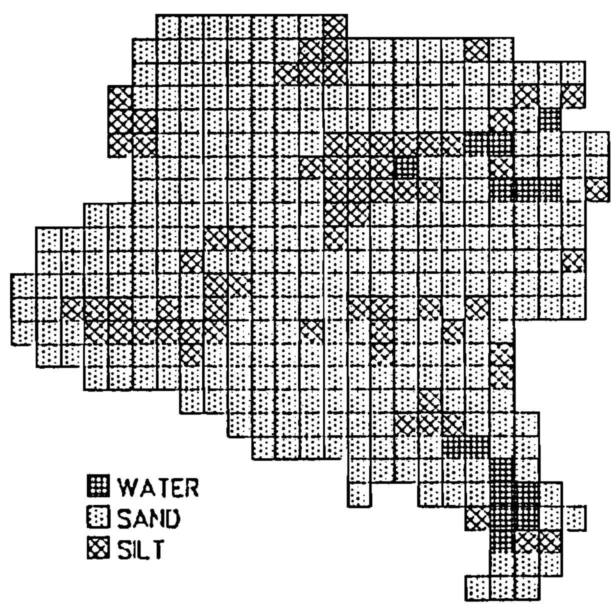

Figure 4. Watershed Soil Textures, Lake Iola, Waupaca County, Wisconsin.

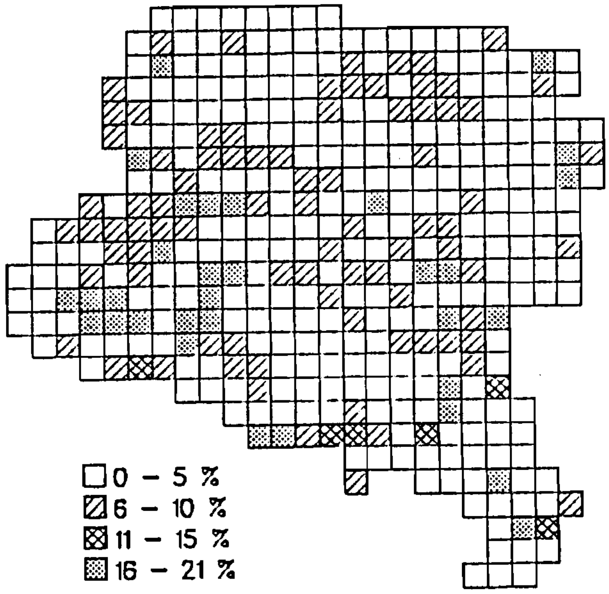

Figure 5. Watershed Land Slopes, Lake Iola, Waupaca County, Wisconsin.

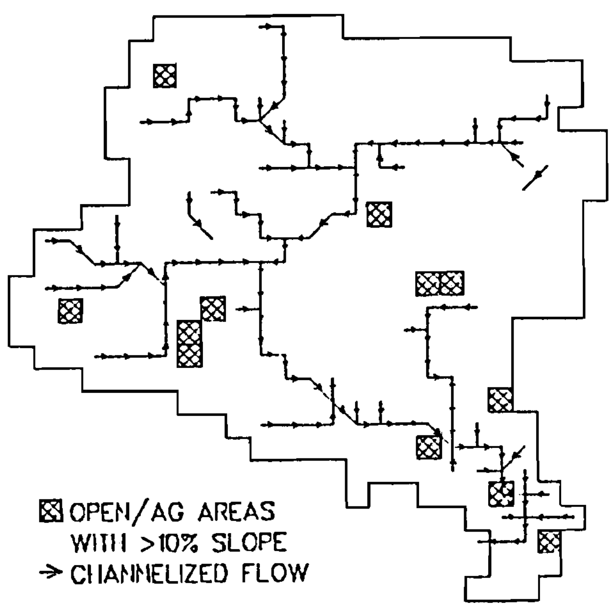

Figure 6. Open/Agricultural Areas with Greater than 10% Land Slope, Lake Iola, Waupaca County, Wisconsin.

Stream bank pasture areas are present on Griffin and Leer Creeks and on the South Branch of the Little Wolf River (9).

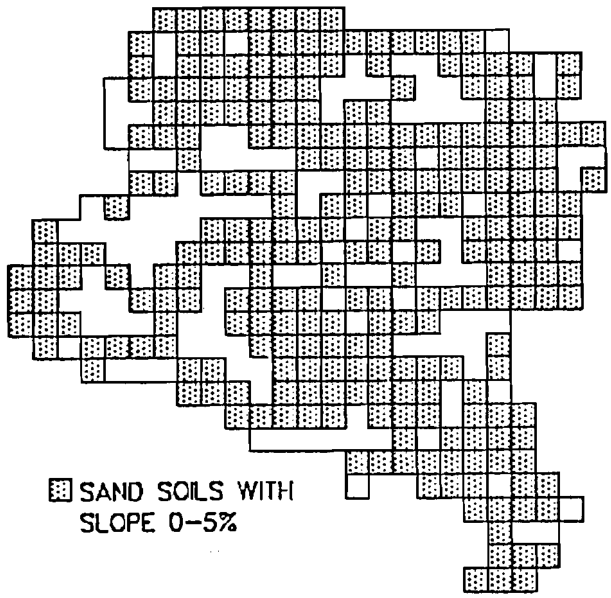

Figure 7. Sandy Soils with 0 - 5% Land Slope, Lake Iola, Waupaca County, Wisconsin.

WATER QUALITY

In-lake phosphorus (ave. = 0.013, σ = 0.005 mg/l) (Tables 4 and 5) and inlet phosphorus (ave. = 0.018, σ = 0.003 mg/l) were well below expected levels for impoundments (ave. = 0.064, σ = 0.100 mg/l), drainage lakes (ave. = 0.040, σ = 0.064) and lakes in the central region of Wisconsin (ave. = 0.020, σ = 0.021) (10).

NOTE: Some total phosphorus data are indicated to have exceeded the recommended holding time before analysis. A study has shown,

Table 4. Water Quality Parameters, Station 0901 (Deepest Point), Lake Iola, February 1993 - October 1994.

PARAMETER	SAMPLE[1]	DATE							
		02/01/93	04/21/93	08/18/93	10/05/93	01/27/94	05/26/94	07/25/94	09/08/94
Secchi (feet)		NR[2]	4.0	>9.0	>8.0	NR	>12.0	>8.0	>9.0
Cloud Cover (percent)		0	10	100	0	100	40	100	0
Temperature (degrees Celsius)	M	0.68	8.38	21.80	9.54	0.45	16.42	21.45	17.98
pH (surface units)	M	6.85	7.60	6.98	7.60	6.35	7.74	7.60	7.54
D.O. (mg/l)	M	7.65	11.20	4.34	11.30	8.86	9.40	8.56	10.8
Conductivity (umhos/cm)	M	425	256	385	410	437	441	380	360
Laboratory pH (surface units)	M	NR	8.17	NR	NR	NR	8.14	NR	NR
Total Alkalinity (mg/l)	M	NR	135	NR	NR	NR	217	NR	NR
Tot. Kjeld. Nitrogen (mg/l)	M	0.4	0.6	0.6	0.5	0.4	NR	0.7	0.49[3]
Ammonia Nitrogen (mg/l)	M	0.155	0.030	0.100	0.045	0.188	0.014	0.054	0.028
NO_2 + NO_3 Nit. (mg/l)	M	2.01	0.795	0.466	1.04	2.29	1.96	0.220	0.364
Total Nitrogen (mg/l)	M	2.41	1.395	1.066	1.54	2.69	NR	0.920	0.854
Total Phosphorus (mg/l)	M	0.004	0.022	0.012	0.009	0.009	0.018	0.0150[3]	0.0140[3]
Dissolved Phos. (mg/l)	M	0.003	0.003	0.002	0.003	0.003[3]	ND[4]	ND	ND
Nit./Phos Ratio	M	602.5	63.4	88.8	171.1	298.9	NR	61.3	61.0
Chlorophyll a (ug/l)	M	NR	4.65	1.56	1.09	NR	4.80	3.71	1.69

[1] M = Mid-depth; [2] NR = no reading; [3] Holding time exceeded by SLOH;
[4] ND = not detectable;

Table 5. Water Quality Parameters, Station 0902 (Inlet), Lake Iola, February 1993 - October 1994.

PARAMETER	SAMPLE[1]	DATE							
		02/01/93	04/21/93	08/18/93	10/05/93	01/27/94	05/26/94	07/25/94	09/08/94
Secchi (feet)		>1.5	>3.0	>1.0	>2.0	>2.0	>2.0	>2.0	>3.0
Cloud Cover (percent)		0	0	100	0	100	40	100	0
Temperature (degrees Celsius)	M	1.86	6.42	15.48	7.48	0.31	14.01	13.77	11.62
pH (surface units)	M	7.77	7.60	6.81	7.08	7.07	7.14	7.09	6.90
D.O. (mg/l)	M	11.70	10.59	7.88	9.26	12.60	10.80	8.57	8.71
Conductivity (umhos/cm)	M	401	301	414	431	424	421	437	416
Laboratory pH (surface units)	M	NR[2]	NR	NR	NR	NR	NR	NR	NR
Total Alkalinity (mg/l)	M	NR	NR	NR	NR	NR	NR	NR	NR
Tot. Kjeld. Nitrogen (mg/l)	M	0.3	NR	0.7	0.4	0.4	NR	0.4	0.44[3]
Ammonia Nitrogen (mg/l)	M	0.044	NR	0.244	0.019	0.073	0.013	0.026	0.019
$NO_2 + NO_3$ Nit. (mg/l)	M	2.44	NR	2.13	2.43	2.68	2.11	2.18	2.60
Total Nitrogen (mg/l)	M	2.74	NR	2.83	2.83	3.08	NR	2.58	3.04
Total Phosphorus (mg/l)	M	0.012	NR	0.019	0.015	0.022	0.018	0.0200[3]	0.0200[3]
Dissolved Phos. (mg/l)	M	0.005	NR	0.006	0.003	0.006	ND[4]	0.005	ND
Nit./Phos Ratio	M	228.3	NR	148.9	188.7	140.0	NR	129.0	152.0
Chlorophyll a (ug/l)	M	NR	NR	3	2.58	NR	5.64	2.97	2.33

[1] M = Mid-depth; [2] NR = no reading; [3] Holding time exceeded by SLOH; [4] ND = not detectable;

however, that phosphorus data remains accurate for samples analyzed well after the 28 day holding time (11).

In-lake total nitrogen levels were slightly higher (ave. = 1.55, σ = 0.67) than expected levels for impoundments (ave. = 1.06, σ = 0.54), drainage lakes (ave. = 0.95, σ = 0.55), and lakes in the central region of Wisconsin (ave. = 0.72, σ = 0.31) (10). Inlet total nitrogen levels (ave. = 2.85, σ = 0.17) were significantly higher than those in-lake; the difference was primarily attributable to higher NO_2 + NO_3 nitrogen in the samples (Tables 4 and 5).

In-lake regular monitoring data (1991 - 1994) indicated a trend of highest total phosphorus at times of highest overland runoff (Spring) with lowest total phosphorus during Winter (Figure 8). The trend for total nitrogen was highest levels during times of highest groundwater input (Winter) and lowest levels during Summer months.

Event monitoring indicated significantly higher total phosphorus levels for Site SE2 (on June 1, 0.103 mg/l) and Site GE3 (April 21 and June 1, 0.120 and 0.180 mg/l) (Tables 6 and 7). The average for all sites was 0.034 mg/l (σ = 0.033) and 0.051 mg/l (σ = 0.045) for April and June, respectively.

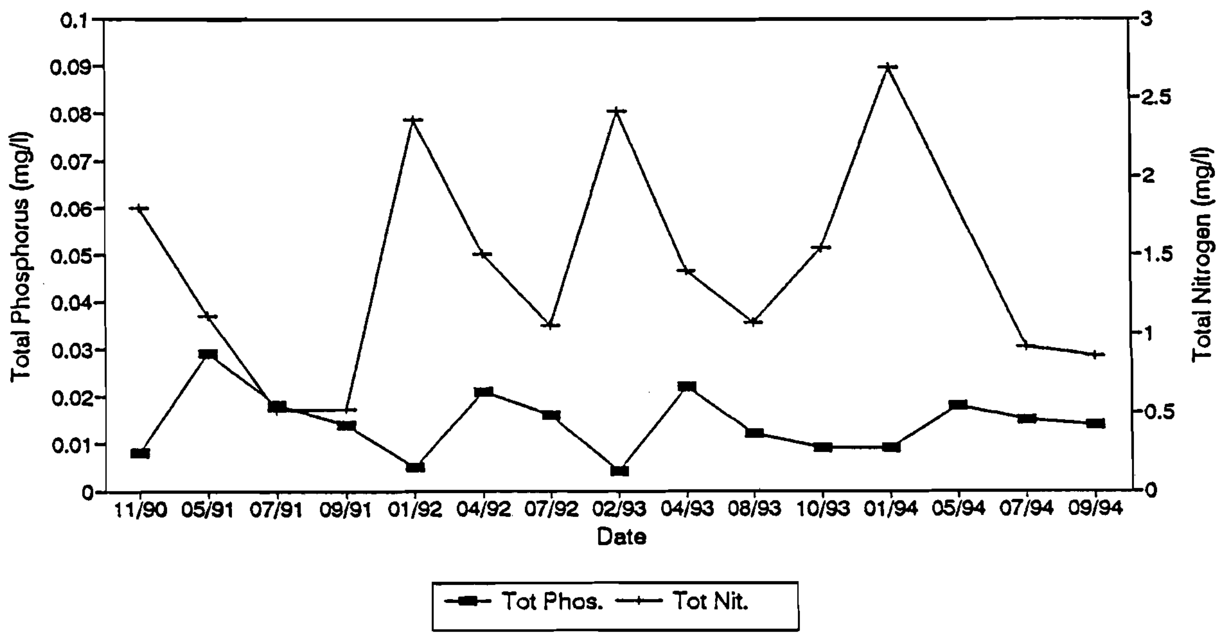

Figure 8. Total Phosphorus and Total Nitrogen Trends for Lake Iola, 1991 - 1994.

Highest total nitrogen levels were observed at Site LE2 (April and June) and Site SE2 (June). Total nitrogen levels for all sites averaged 1.51 mg/l (σ = 0.60) and 1.42 mg/l (σ = 0.58) for the April and June sample dates, respectively. Higher than expected total nitrogen levels (for impoundments) were observed at a number of event sample sites are most likely attributable to high background nitrate levels in groundwater.

Lake Iola inflow on August 18, 1993 (considered typical for this preliminary estimate of nutrient loading) was 16.3 cubic feet per second (1.886 million gallons per year or 2,605 million liters per year). For 1993 - 1994, total phosphorus averaged 0.018

Table 6. Event Water Quality Parameters, Lake Iola, April 21, 1993.

PARAMETER	SAMPLE SITE											
	LE1	LE2	LE3	NE1	GE1	GE2	GE3	UE1	SE1	SE2	SE3	SE4
TKN (mg/l)	0.8	0.7	0.7	0.6	NS[1]	0.3	0.6	NS	NS	0.5	NS	0.6
NH_4-N (mg/l)	0.014	0.013	0.080	0.177	NS	0.016	0.018	NS	NS	0.028	NS	0.023
NO_2+NO_3-N (mg/l)	0.844	1.85	1.09	0.430	NS	0.378	0.139	NS	NS	1.30	NS	1.27
Total N (mg/l)	1.644	2.55	1.79	1.030	NS	0.678	0.739	NS	NS	1.80	NS	1.87
Total P (mg/l)	0.027	0.023	0.019	0.014	NS	0.014	0.120	NS	NS	0.024	NS	0.028
Diss. P (mg/l)	0.006	0.006	0.003	0.003	NS	0.006	0.085	NS	NS	0.007	NS	0.008
N/P Ratio	60.9	110.9	94.2	73.6	NS	48.4	6.2	NS	NS	75.0	NS	66.8

[1] NS = no sample collected

Table 7. Event Water Quality Parameters, Lake Iola, June 1, 1993.

PARAMETER	SAMPLE SITE											
	LE1	LE2	LE3	NE1	GE1	GE2	GE3	UE1	SE1	SE2	SE3	SE4
TKN (mg/l)	1.0	1.2	1.2	0.7	0.4	0.6	1.0	0.4	1.1	1.5	1.1	1.2
NH_4-N (mg/l)	0.028	0.033	0.029	0.073	0.028	0.030	0.046	0.028	0.029	0.031	0.032	0.034
NO_2+NO_3-N (mg/l)	0.278	1.05	0.559	0.272	0.012	0.215	0.047	0.381	0.677	0.714	0.733	0.679
Total N (mg/l)	1.278	2.25	1.759	0.972	0.412	0.815	1.047	0.781	1.777	2.214	1.833	1.879
Total P (mg/l)	0.041	0.042	0.040	0.022	0.011	0.025	0.180	0.014	0.047	0.103	0.042	0.048
Diss. P (mg/l)	NS[1]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
N/P Ratio	31.2	53.6	44.0	44.2	37.5	32.6	5.8	55.8	37.8	21.5	43.6	39.1

[1] NS = no sample collected

milligrams per liter (n = 6) and total nitrogen averaged 2.8 mg/l (n = 5). Estimated loading based on these figures were about 100 pounds total phosphorus per year and about 16,100 pounds total nitrogen per year. An accurate nutrient budget would require development of a stage/discharge relationship and daily or weekly stage observations.

Harvest data for Shawano Lake (12) showed phosphorus and nitrogen to be 0.18% and 2.37%, respectively, of the wet weight of harvested aquatic plants. Based on 161 tons harvested in 1994, harvest efforts were estimated to have removed 18.8 pounds of phosphorus and 249.6 pounds of nitrogen from Lake Iola.

AQUATIC PLANT CONTROL

Aquatic herbicide treatment, mechanical harvest, benthic barriers and SCUBA cutting were selected for evaluation based upon their applicability for the Lake Iola resource. Additional plant control methods were reviewed for other situations (Table 8). It is important to note that chemical treatment and mechanical harvesting are applicable for extensive or lake-wide treatments (e.g., acres); benthic barriers and SCUBA cutting are more intensive, localized applications, applicable for small treatment areas (e.g., square feet).

Table 8. Comparison of Aquatic Plant Control Alternatives for Lake Iola, Waupaca County, Wisconsin.

	MECHANICAL HARVESTING	AQUATIC HERBICIDES	DREDGE	ROTOTILL	SCUBA	BOTTOM SCREENS	DRAWDOWN	BIOLOGICAL
Effects on Ecosystem	Removes plant material, some small fish	possible residual effects	removes preferred habitat, disturbs sediment	disturbs sediments	removes plant material	covers plants	decreased water quality downstream, possible fishery effects	needs more research
Effective Large-scale	yes	yes	yes	yes	no	no	yes	yes
Effective Small-scale	no	yes	yes	no	yes	yes	no	no
Species Selective	possibly	possibly	yes	no	yes	no	no	yes
Removes Nutrients	yes	no	yes	no	yes	no	no	no
WDNR Acceptability	high-minimal environmental impacts	medium-permit required	low-many environmental impacts	medium-sediment impacts	high-minimal impacts	medium-for small areas permit required	medium-limited success	low-many unknowns
Public Acceptability	high-immediate benefits	medium/low-many "anti-chemical" advocates	medium	medium/low-new technology	high-immediate effects	medium-difficult to maintain	medium/high-will allow frontage clean-up	low

Table format taken from "Minnesota Aquatic Plant Control Draft Reconnaissance Report," August 1989.

Aquatic Herbicide Treatment

The aquatic herbicide 2,4-D (in granular form) was applied at the recommended rate of 7.5 pounds per 2000 square feet (1.4 pounds per treatment plot). Plants appeared affected, but not killed, three weeks after treatment. Eight weeks after treatment, plants appeared healthy but growth appeared stunted compared to untreated plant populations.

Total cost for 750 square feet (both areas) was $82.30 including: $16.80 for the 2,4-D (2.8 pounds @ $6.00 per pound), $45.50 for labor (1.75 hours @ $26.00 per hour), and $20.00 for the permit. Estimated costs for a ten acre area (a more realistic treatment size) would be $1,425.00 including: $535.00 for the chemical, $620.00 for labor, and $270.00 for the permit ($20.00 fee plus 10 acres @ $25.00 per acre) (Table 9) or $142.50 per acre.

Given the questionable results with this treatment, a second treatment may be needed later in the season, raising total costs to $2,580.00, or $258.00 per acre. A local chemical applicator suggests the use of a Diquat/Cutrine/Aquathol mix for the control of water milfoil and claims the results would be two to three times better than those for 2,4-D. Costs for ten acres of this type of control total $3,010.00 (chemical, labor and permit), or $301.00 per acre. A second treatment may also be necessary with this type of treatment (13).

Mechanical Harvest

Aquatic plants were harvested from a similar sized area as other treatments. All plants were harvested (with the exception of algae on the lake bottom and floating duckweed) and well defined

Table 9. Cost Comparison for Recommended Aquatic Plant Control Strategies, Lake Iola, Waupaca County, Wisconsin.

	AQUATIC HERBICIDES[1]	MECHANICAL HARVEST[2]	BOTTOM SCREENS	SELECTIVE CUTTING	CLEAR CUTTING
Material Costs	$142.50	none	$300.00	none	none
Amount of Labor	included	0.5 h/acre	10 h/ 1000 ft^2	7.0 h/ 1000 ft^2	10 h/ 1000 ft^2
Total Costs[3]	$142.50/acre	$ 40.00/acre	$600.00/ 1000 ft^2	$210.00/ 1000 ft^2	$300.00/ 1000 ft^2

[1] For 2-4-D granular application; does not include permit fee

[2] Reflects 1994 contracted harvesting costs for Lake Iola

[3] Labor costs estimated at $30/hour

channels were present after harvest. Plants grew back to the surface in about a three week period. Regrowth or recolonization was most rapid for water milfoil (Myriophyllum sp.), coontail (Ceratophyllum demersum) and certain pondweeds (Potomageton sp.). Harvests for Lake Iola were 3 - 5 weeks apart.

The mechanical harvester was contracted at a rate of $80.00 per hour. Three cuts were made in 1994 (40, 40 and 80 hours each). The harvester operated at a rate of two acres per hour for a cost of $40.00 per acre. The LILD was not billed for time loading, unloading or travel (Table 9).

Benthic Barriers

Screening was very effective in controlling plant growth. Except for a few stems of muskgrass (Chara sp.), all aquatic plants were controlled. Weights appeared adequate and the 25 foot sections of screens were easily handled. Screens allowed gas bubbles (from decomposition) to pass through.

Costs for screening total about $840.00 per 1,400 square feet (both treatment plots) including: $420.00 for materials ($400.00 for screening and $20.00 for iron rebar) and $420.00 for labor (14 hours @ $30.00 per hour). The labor total includes placement, removal, cleaning and storage of the screens. Cost per 1,000 square feet would be about $600.00 (Table 9).

SCUBA Cutting

SCUBA cut plots were clear cut or selectively cut. Clear cut areas showed no regrowth of cut stems. Nuisance species (milfoil and coontail) also showed no grow-back in selectively cut areas. A few new plants did begin to grow, however, in clear and selective plots. SCUBA cut areas were effective and have been shown to remain effective up to two years after cutting.

Equalized costs for clear cutting would total $420.00 per 1,400 square feet (14 hours @ $30.00 per hour); selective cutting would total about $300.00 (10 hours @ $30.00 per hour). Costs per 1,000 square feet would be $300.00 and $210.00 respectively (Table 9).

BASELINE CONCLUSIONS

- Areas of concern for the watershed include high sloped open agricultural areas (480 acres), sandy soils with low slopes (10,560 acres), stream bank pastured areas and feedlots near overland flow. Many highly erodible lands do have management plans in place to limit soil loss.

- Base flows to Lake Iola contain low amounts of phosphorus (and probably sediment) but relatively high amounts of NO_2 + NO_3 nitrogen. Seasonal dissolved oxygen levels in the impoundment are above those necessary to support aquatic life. Water clarity is such that sunlight can penetrate to the entire lake bottom during the open water season. Swimmer's itch continues to limit recreational use of the impoundment. Event monitoring indicated three sites with significant phosphorus and/or nitrogen concentrations.

- Lake Iola habitat supports widespread, nuisance aquatic plant growth. Eurasian Water Milfoil was not observed in Lake Iola; large areas of Purple Loosestrife were present, however, near the public beach and the

Tressness Road access point. Mechanical harvest was found to be a cost efficient method for widespread aquatic plant control. Mechanical harvest which requires rather frequent reapplication for effective control also helps to remove nutrients, create recreational and fishery access and provides immediate results with few environmental side effects. Screening and SCUBA cutting provided more effective, long-term control for localized areas.

- Recreational use is improved by harvest efforts but reduced by the lake-wide swimmer's itch problem. Fish populations were last surveyed with by the WDNR 1983 - 1984.

MANAGEMENT RECOMMENDATIONS

- Future management should target areas of concern; efforts relative to erosion control and barnyard runoff reduction, manure containment, fertilizer management and stream fencing should be emphasized. The South Branch of the Little Wolf River is ranked "high" in the DNR Nonpoint Source Program; efforts should be made to obtain priority watershed status to help identify and address concerns basin-wide. Application for priority watershed status is in progress but funding is not likely before 1999.

- Water quality monitoring should be continued to track trends and develop a better nutrient budget for the impoundment. Monitoring should include regular (quarterly) sampling of the inlet, outlet and deepest point and event sampling of similar sites. Self-help secchi monitoring should be continued; rainfall monitoring should be initiated. Private well testing for nitrates should be encouraged throughout the watershed given the high nitrate + nitrite nitrogen inflows (presumably) from groundwater. A staff gauge should be placed at the inlet to Lake Iola.

- Mechanical harvest should be continued for widespread aquatic plant control in the downstream portion of the impoundment; small channels in upstream portions (especially around islands and piers) should also be harvested. Management for wetland habitat (with side benefits of nutrient removal) should be considered for the upstream reach. Areas harvested (especially channels) should be buoyed or identified on a map and made available at access points. Screening and SCUBA/hand removal should be encouraged for small localized areas where harvester access is limited. Drawdown may be considered for Lake Iola. Drawdown will allow control of some aquatic plants, but more importantly will allow landowners to more effectively manage frontage areas.

- Land purchase may be pursued for park development or wetland protection near the lake and/or throughout the watershed. Park development and wetland protection will help to increase awareness, increase recreational opportunities and protect water quality. Signs should be posted at access points informing lake users of Eurasian Water Milfoil, Purple Loosestrife and Zebra Mussels. A sign reading "remove weeds for trailer" should be painted on the main ramp. Purple Loosestrife should be removed where present, possibly with the help of volunteer organizations.

- The Lake Iola fishery should be assessed in the next five years to determine the status of the fishery. Fishery management will help to increase recreational opportunities for the resource. No practical method for the control of swimmer's itch is readily available or affordable. Feeding of waterfowl should be strongly discouraged.

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