IPS ENVIRONMENTAL AND ANALYTICAL SERVICES
Appleton, Wisconsin

PHASE I
LAKE MANAGEMENT PLAN
LAKE IOLA
WAUPACA COUNTY, WISCONSIN

REPORT TO:
LAKE IOLA LAKE DISTRICT

December, 1992

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SUMMARY

Lake Iola is a 206 acre impoundment of the South Branch of the Little Wolf River located in and near the Village of Iola. The impoundment drains a relatively small (16,000 acre) primarily open/agricultural and forested watershed in a glacial moraine region. Lake Iola has widespread, nuisance aquatic plant growth which the lake district currently attempts to control with contracted, mechanical **macrophyte** harvester.

Lake Iola nutrient levels are lower than expected for natural lakes in the region and lower than an average for impoundments; event inflows, however, were considerably higher. Water clarity is such that the entire lake bottom receives sunlight during most of the growing season. Overall, water quality parameters indicated a **mesotrophic** to early **eutrophic** status.

Macrophytes were widespread and abundant; milfoils (Myriophyllum spp.), flat-stem pondweed (Potamogeton zosteriformes) and Illinois pondweed (Potamogeton illinoensis) were most abundant. Milfoils probably include Eurasian Milfoil (Myriophyllum spicatum), which is an exotic macrophyte known to displace native plant assemblages.

Sedimentation in Lake Iola was estimated to be relatively high (like many impoundments). Sedimentation has reduced the capacity of the impoundment, increased turbidity and contributed to increased macrophyte growth.

Overall, near- and long-term recommendations are designed to protect and enhance the resource through reduction of nutrients and sediment inputs to the system and creation of habitat for wildlife and fishery resources. Recommendations include:

- designation of upstream (wildlife) and downstream (recreational access) use zones,
- continued water quality monitoring to include the addition of a monitoring site in the South Branch of the Little Wolf River inlet,
- continued macrophyte harvest in the downstream areas of the impoundment including identification and selective control of Eurasian Milfoil beds,
- encouragement of riparian land management and implementation of **Best Management Practices (BMP's)** throughout the watershed,
- assessment of dredging options after designation of a watershed-wide erosion control plan.
- Steps should be taken to prevent spread of exotic species to (and potentially from) Lake Iola.

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

INTRODUCTION

Lake Iola is a relatively small impoundment of the South Branch of the Little Wolf River located in west-central Waupaca County, Wisconsin. The impoundment was created in 1870 by the construction of a dam to support grain and lumber mill businesses. Commercial usage of the dam ceased in the early 1960's. The dam is currently owned by Lake Iola Estates, Inc. (the real estate developer of much of the lake's southern perimeter) and other current landowners in a partnership arrangement. Default ownership/maintenance of the dam rests with the Village of Iola.

The Lake Iola Lake District (LILD) was formed in 1991 to direct and manage the preservation of the resource. The District is governed by an elected, five person, District Board of Commissioners. Three members are elected at large, one is appointed by the County Board and one by the largest local municipality by valuation within the District. The District currently has approximately 1200 voting members.

The LILD, in October 1990, decided to pursue development of a management plan under the Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grant Program. The LILD Commissioners selected IPS Environmental & Analytical

Services (IPS) of Appleton, Wisconsin as its consultant to develop the plan. A grant application to initiate development of the plan, incorporating required or recommended program components and the following objectives, was prepared, submitted, and approved in April, 1991:

- determine lake water quality and track trends,
- locate, quantify and identify aquatic plant populations,
- determine sediment inputs to the lake,
- increase the awareness of lake property owners and establish a continuing base of support for lake management efforts.

DESCRIPTION OF AREA

Lake Iola (T24N R11E S26,35) is a **drainage lake** (possessing a permanent inlet and outlet) located partially within the Village of Iola, Waupaca County, Wisconsin (Figure 1). The lake is actually an impoundment of the South Branch of the Little Wolf River created by a "stop-log dam" with a 7 foot head. Impoundments in general, have extensive shallow shelf areas, exhibit periodic flushing and "filling in" and are often prone to non-point source nutrient and sediment inputs because of relatively more extensive watersheds and effects of changing flow conditions of the parent river.

The general topography of Waupaca County is related to glacial activity; topography adjacent to the lake is nearly level to steep. Major soil types on the lake perimeter are well drained Richford sand and Rosholt loam on 2-20 percent slopes (southern portion of the basin), interspersed with poorly drained Seelyeville muck (northern half of basin). Soil permeability is rapid in Richford and Rosholt soils and very poor in Seelyeville muck. The three major soil types are generally unsuited for septic systems because of a high water table (Seelyeville) or inability to filter septate (Richford, Rosholt)(4). About 70-80 per cent of the approximately 100 lake homes are sewered to the Village of Iola wastewater treatment plant.

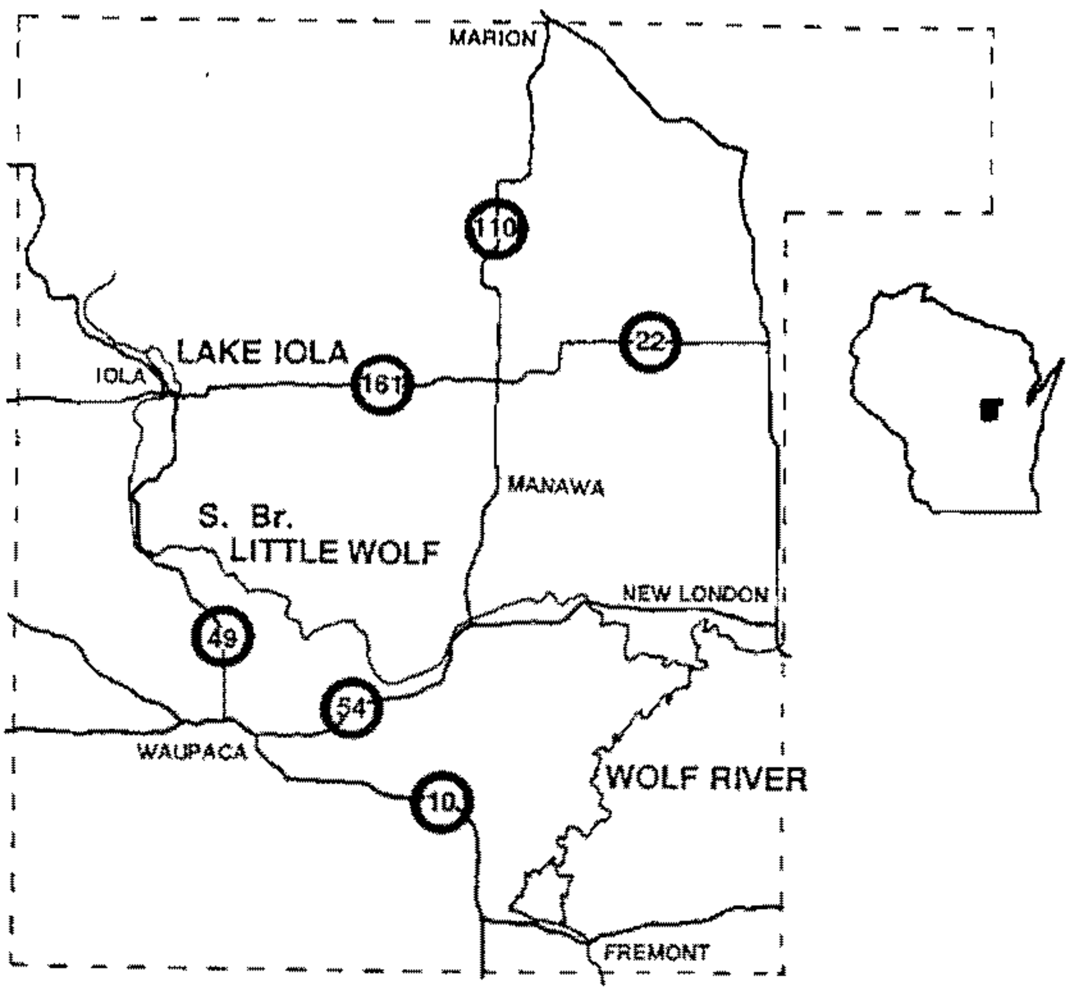

Figure 1. Location Map, Lake Iola, Waupaca County, WI.

Lake Iola has a surface area of 206 acres, an average depth of about 4 feet, a maximum depth of 9 feet and a lake volume of approximately 824 acre-feet (5). The **fetch** is 1.5 miles in a northwest-southeast orientation and the width is 0.4 miles in a southwest-northeast orientation (6). The **residence time** for the impoundment was estimated to be 21.1 days.

The Lake Iola watershed is about 16,000 acres and predominantly open/agricultural. The watershed to lake ratio (**W/L ratio**) is about 78, meaning 78 times more land than lake surface area drains to the lake (6). This value is actually much lower than the average for impoundments in Wisconsin (676). The average for drainage lakes (those having a permanent inlet and outlet) is 88. This relatively lower number indicates a decreased potential for flushing and non-point source nutrient inputs compared to other impoundments.

Predominant **littoral** substrates include silt (60%), sand (30%), and gravel (10%) (6). Shoreline areas in the southern portion of the lake basin were modified during a lake drawdown (Spring 1965 -Spring 1967) for real estate development (6). Dredging, stump removal, and channelization were also completed at this time. Lake Iola was also partially drawn down during the Winter of 1990-1991 in an attempt to control macrophytes.

Fish species present in Lake Iola include: northern pike (Esox lucius), largemouth bass (Micropterus salmoides), rock bass (Ambloplites rupestris), yellow perch (Perca flavescens), black crappie (Pomoxis nigromaculatus), common sunfish (Lepomis spp.), bluegill (Lepomis macrochirus), black bullhead (Ictalurus melas), brown bullhead (Ictalurus nebulosus), yellow bullhead (Ictalurus natalis), white sucker (Catostomus commersoni), chubsucker (Erimyzon sucetta), and golden redhorse (Moxostoma erythrurum) (6). Recent fish management and stocking (Table 1) has been directed toward the largemouth bass, northern pike, and panfish fisheries; concern and actions have also been taken to protect/promote brown trout populations in the headwaters.

Table 1. Recent Fish Stocking, Lake Iola, Waupaca County, WI.

Year	Species	Number
1967	Largemouth Bass (fingerling)	5,000
1969	Bluegill (adult)	1,500
1969	Yellow Perch (adult)	500
1970	Bluegill (adult)	1,000

LILD contracted a macrophyte harvester in 1991-1992. Three cuts (120 hours) were completed in 1991 and two cuts (80 hours) were preformed in 1992. Efforts targeted the downstream portion of the impoundment only, with emphasis on creation of openings in the dense macrophyte canopy for recreational access. Areas have also been treated with copper sulfate and other chemicals in an attempt to control macrophyte populations (various dates).

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).

The impoundment is used by wildlife including migrating waterfowl (mallards, teal, and wood ducks) and muskrat. Beaver are known to dam upstream portions of the South Branch of the Little Wolf River (Pers. comm. WDNR and LILD).

METHODS

FIELD PROGRAM

Lake Iola water sampling was conducted in late-Spring (May 23/31), Summer (July 29), late-Summer (September 10), 1991 and in Winter (January 28), Spring (April 27) and Summer (July 1), 1992, at Station 0901, the deepest point (Table 2, Figure 2). Station 0901 was sampled either near-surface and near bottom (Winter, 1992) or at mid-depth (all other dates).

Physicochemical parameters measured in the field were **Secchi depth**, water temperature, pH, dissolved oxygen (DO), and conductivity. Field measurements were taken using a standard Secchi disk and either a Hydrolab Surveyor II or 4041 multiparameter meter; Hydrolab units were 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; delivery to the laboratory was made via overnight carrier. All laboratory analyses were conducted at the State Laboratory of Hygiene (Madison, WI) using WDNR or APHA (8) methods. Spring water quality parameters included laboratory pH, total alkalinity, total Kjeldahl nitrogen, ammonia nitrogen

Table 2. Sampling Station Locations, Lake Iola, 1991 - 1992.

WATER QUALITY

Regular Monitoring

Site	Latitude/Longitude	Depth
0901	44° 30' 58" 89° 07' 38"	10.0 ft.

Event Monitoring

Site	Description
09E1	Intermittent inlet draining adjacent lowlands
09E2	Permanent inlet draining land immediately North of the impoundment
09E3	South Branch of the Little Wolf River; drains most of the watershed (directly or indirectly) including Leer and Griffin Creeks, Grass, Long, Round, Siemer, North and Graham Lakes.

MACROPHYTE TRANSECTS

Transect	Latitude/Longitude Origin	End	Transect Length(m)	Bearing (Degrees)	Depth Range[1]
A	44° 31' 32" 89° 08' 29"	44° 31' 31" 89° 08' 29"	15	240	1/2
B	44° 31' 31" 89° 08' 09"	44° 31' 30" 89° 08' 10"	35	190	1/2
C	44° 31' 12" 89° 07' 55"	44° 31' 14" 89° 07' 54"	90	26	1/2/3
D	44° 30' 57" 89° 07' 48"	44° 30' 57" 89° 07' 47"	20	90	1/2/3
E	44° 30' 40" 89° 07' 45"	44° 30' 41" 89° 07' 41"	30	70	1/2/3

[1] 1 = 0.0 - 0.5m (0.0 - 1.7ft)
2 = 0.5 - 1.5m (1.7 - 5.0ft)
3 = 1.5 - 3.0m (5.0 - 10.0ft)

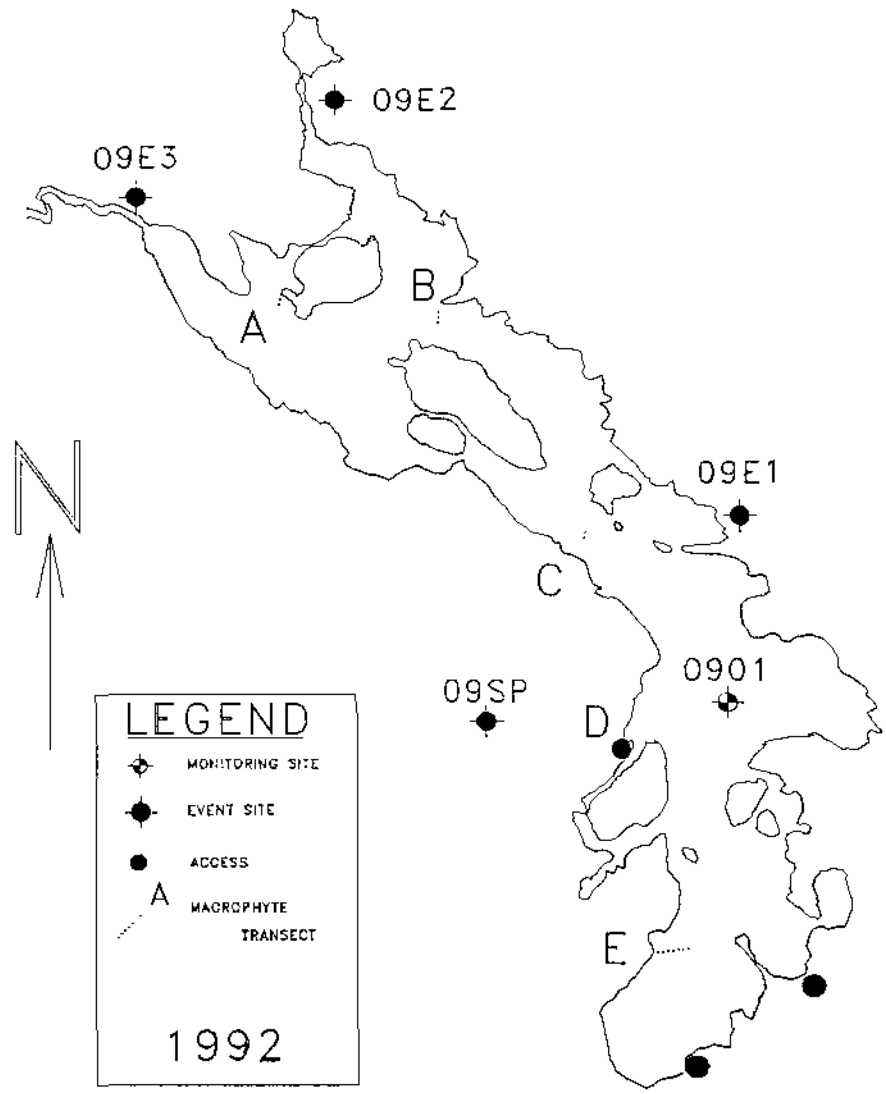

Figure 2. Sampling Sites, Lake Iola, Waupaca County, WI, 1991 - 1992.

nitrate/nitrite nitrogen, total phosphorus, dissolved phosphorus, total solids, and **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 parameters determined by the laboratory included total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus, and dissolved phosphorus.

In addition to regular monitoring sites, event sampling sites were located at three inlets [two unnamed sites (Stations 09E1, 09E2) and the South Branch of the Little Wolf River (Station 09E3)]. A single runoff sample was also taken from a farm (Station 09SP) to characterize its nutrient input to the lake. Event sample laboratory analyses included total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus and dissolved phosphorus.

Macrophyte surveys were conducted July 19 and August 29, 1991 using a method developed by Sorge et. al. and modified by the WDNR-Lake Michigan District (WDNR-LMD) for use in the Long Term Trend Lake Monitoring Program (9). Transect endpoints were established on-shore for use as reference from one sampling period to the next. These points were determined using a Loran Voyager Sportnav latitude/longitude locator and recorded with bearing and distance of the transect (line of collection) for future surveys. Five transects sampled in 1991 were chosen to provide information from various habitats and areas of interest.

Data were recorded from three depth ranges, i.e., 0 to 0.5 meters (1.7 feet), 0.5 to 1.5 meters (5.0 feet), and 1.5 to 3.0 meters (10.0 feet), as appropriate along each transect. Plants were identified (collected for verification as appropriate), density ratings assigned (see below), and substrate type recorded along a six foot wide path on the transect using a garden rake, snorkel gear or SCUBA where necessary. Macrophyte density ratings, assigned by species, were: 1 = Rare, 2 = Occasional, 3 = Common, 4 = Very Common, and 5 = Abundant. These ratings were treated as numeric data points for the purpose of simple descriptive statistics in the Field Data Discussion section of this report.

Sediment dating was performed on one of three sediment samples collected July 1, 1992 from a depositional area in the upstream reach of the impoundment (off the main channel of the South Branch of the Little Wolf River). Samples were collected by pushing a 8 foot (1.5" diameter) core liner into the substrate as far as possible (about 7 - 7.5 feet). The top of the core was capped, the core removed, and the bottom end capped.

Cores were frozen overnight, removed from the liner, and cut every 1 cm for the first 5 cm and every 2 cm thereafter. The sediment was then dried and sent the University of Wisconsin-Milwaukee Center for Great Lakes Studies for lead 210 analysis to determine time of deposition (in years before present).

OTHER

Water Quality Information

Additional lake information was retrieved from the WDNR Surface Water Inventory (10), Wisconsin Self Help Monitoring Program (11), the WDNR Wisconsin Lakes publication (5) and the WDNR WI LAKES 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 (4), aerial photographs, and United States Geological Survey quadrangle maps. This information, when considered questionable or outdated, was confirmed by field reconnaissance.

Ordinance information was taken from Waupaca County Zoning Ordinance, and Waupaca County Erosion Control and Animal Waste Management Plans which were acquired from the Waupaca County Land Conservation Department.

Public Involvement Program

Various public involvement activities were coordinated with the planning process; these activities are summarized in Appendix I.

FIELD DATA DISCUSSION

Impoundments differ from natural lakes in that they characteristically have much larger watersheds, exhibit periodic flushing, and "fill-in". While natural lakes tend toward a state of dynamic equilibrium, the physical, chemical and biological characteristics of impoundments are variable as they are continuously affected by the parent river. Physicochemical parameters and biological communities in reservoirs are longitudinally and transectionally related to basin morphometry, are temporally affected by flow conditions (in the upstream reach) and water mass retention time (in the lower reach), and are influenced by flow release operations at the dam.

Lake Iola, by general definition, is a drainage lake because it has a permanent inlet and outlet stream. Due to relatively shallow average depth of the inundated area and subsequent sedimentation, Lake Iola provides habitat very conducive to aquatic plant growth.

Land in the Lake Iola watershed is primarily open/agricultural (54%) and forested (32%) (Figure 3). Wetland (various areas not shown, 10%) and other surface waters (4%) are also present. The **immediately adjacent watershed** consist of residential and open/agricultural areas with areas of wetland.

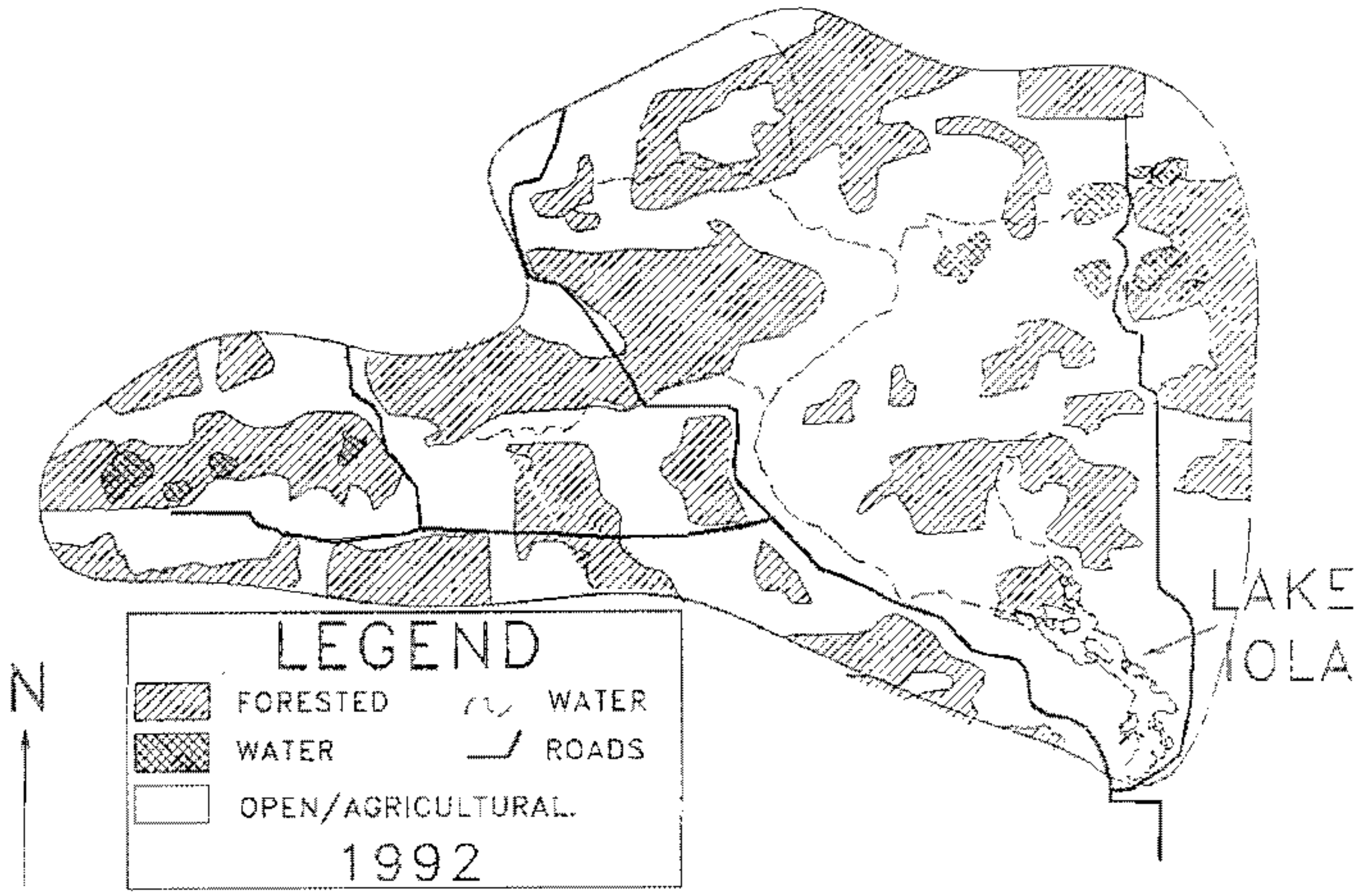

Figure 3. Land Uses in the Lake Iola Watershed, 1992.

Phosphorus is often the limiting major nutrient in algal and plant production. Total phosphorus levels during the 1991-1992 monitoring ranged from 0.005 to 0.029 mg/l (parts per million) with an average value of 0.017 mg/l [median = 0.017, standard deviation (σ) = 0.007 mg/l] (Table 3). Nitrogen to phosphorus ratios (**N/P ratio**) greater than 15 indicated Lake Iola to be phosphorus limited. Samples taken at mid-depth are considered indicative of the entire water column since Lake Iola is a well mixed impoundment.

Summer total phosphorus levels in 1991 and 1992 (0.014, 0.016, 0.018 mg/l, ave = 0.016, median = 0.016, σ = 0.002 mg/l) were, according to a recent compilation of summer total phosphorus levels in upper midwestern lakes (12), lower than typical (0.030 to 0.050 mg/l) for natural lakes in the transitional region in which Lake Iola is located. Characteristically, impoundments would have higher total phosphorus averages than natural lakes; Lake Iola total phosphorus is considerably lower than an average for 100 Wisconsin impoundments (ave. = 0.064, median = 0.035, σ = 0.100 mg/l). Average summer total phosphorus in Lake Iola was also lower than that found for a summary of 69 waterbodies (lakes and impoundments) with similar retention times (average = 0.085, median = 0.040, σ = 0.161 mg/l) (7).

Event monitoring (Table 4) indicated significantly higher levels

Table 3. Water Quality Parameters, Station 0901, Lake Iola, 1991 - 1992.

Parameter (Units)	Date						
	05/23/91[1] 05/31/91	07/29/91	09/10/91	01/28/92	01/28/92	04/27/92	07/01/92
Depth (feet)	6	5	5	3	6	6	5
Secchi (feet)	>10	>10	>10	NR[2]	-	5	>9
Cloud Cover (%)	80	-	-	90	-	0	90
Water Temperature (°F)	23.05	20.37	21.41	0.02	0.52	8.11	20.56
Dissolved Oxygen (mg/L)	8.24	6.35	4.70	10.72	1.63	10.00	11.72
pH - Field (SU)	7.65	7.78	7.70	8.20	7.63	7.71	8.29
Conductivity (μmhos/cm)	349	392	387	412	476	299	362
pH - Laboratory (S.U.)	8.4	NR	NR	NR	NR	8.30	NR
Alkalinity (mg/l $CaCO_3$)	205	NR	NR	NR	NR	64	NR
Total Solids (mg/L)	250	NR	NR	NR	NR	226	NR
Dissolved Phosphorous (mg/l)	0.005	0.004	ND[3]	ND	ND	ND	ND
Total Phosphorous (mg/l)	0.029	0.018	0.014	0.005	0.007	0.021	0.015
Ammonia - Nitrogen (mg/L)	0.070	0.059	0.020	0.096	0.135	0.093	0.089
$NO_2 + NO_3$ - Nitrogen (mg/l)	0.309	0.010	0.020	2.06	1.93	0.705	0.548
Total Kjeldahl Nitrogen (mg/l)	0.8	0.5	0.5	0.3	0.3	0.8	0.5
Total Nitrogen (mg/L)	1.109	0.51	0.52	2.36	2.23	1.505	1.048
N/P Ratio	38.2	28.3	37.1	472.0	318.6	71.7	69.9
Chlorophyll a (μg/L)	12	8	3	NR	NR	6	2[4]

[1] Laboratory Readings 05/23/91, Field Readings 05/31/91
[2] NR = No Reading
[3] ND = Not Detectable
[4] Results approximate

Table 4. Event Water Quality Parameters, Lake Iola, 1992.

PARAMETER	UNITS	STATION						
		0951	0951	0962	0962	0963	0963	0952
Date		05/12/92	07/15/92	05/17/92	07/13/92	05/17/92	07/13/92	05/15/92
Total Kjeldahl N	mg/l	0.6	0.7	1.5	1.9	1.9	0.9	1.0
Ammonia Nitrogen	mg/l	0.023	0.013	0.047	0.061	0.023	0.041	0.046
NO_2+NO_3 Nitrogen	mg/l	ND[1]	ND	0.429	0.804	1.03	1.46	0.997
Total Nitrogen	mg/l	<0.607	<0.707	1.929	2.704	2.93	2.36	1.997
Total Phosphorus	mg/l	0.025	0.066	0.064	0.110	0.090	0.069	0.038
Diss. Phosphorus	mg/l	0.009	0.022	0.002	0.019	0.004	0.008	ND[1]
N/P Ratio		<24.3	<10.7	30.1	24.6	32.6	34.2	26.9

[1] ND = Not Detectable

of total phosphorus. Event total phosphorus from the three sample sites ranged from 0.025 to 0.110 mg/l (ave. = 0.066, median = 0.066, σ = 0.027 mg/l).

Nitrogen is highly variable between lakes and should only be analyzed on a relative or trend basis within the same lake. Total in-lake nitrogen for 1991-1992 monitoring ranged from about 0.51 to 2.36 mg/L. Highest nitrate/nitrite and ammonia readings occurred under ice cover. Event monitoring ranged from about 0.607 to 2.93 mg/l. Highest levels were detected at Station 09E3 with considerably higher levels of nitrate/nitrite nitrogen.

Other indicators of lake **eutrophication** status, in addition to nutrients include light penetration and algal production. Numerous summarative indices have been developed, based on a combination of these and other parameters, to assess or monitor lake eutrophication or aging. The Trophic State Index (TSI) developed by Carlson (13) 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 levels nor in Secchi transparency reduction unrelated to algal growth (e.g. that associated with color). TSI numbers for Lake Iola, in general, indicated a primarily mesotrophic status (Figures 4-6).

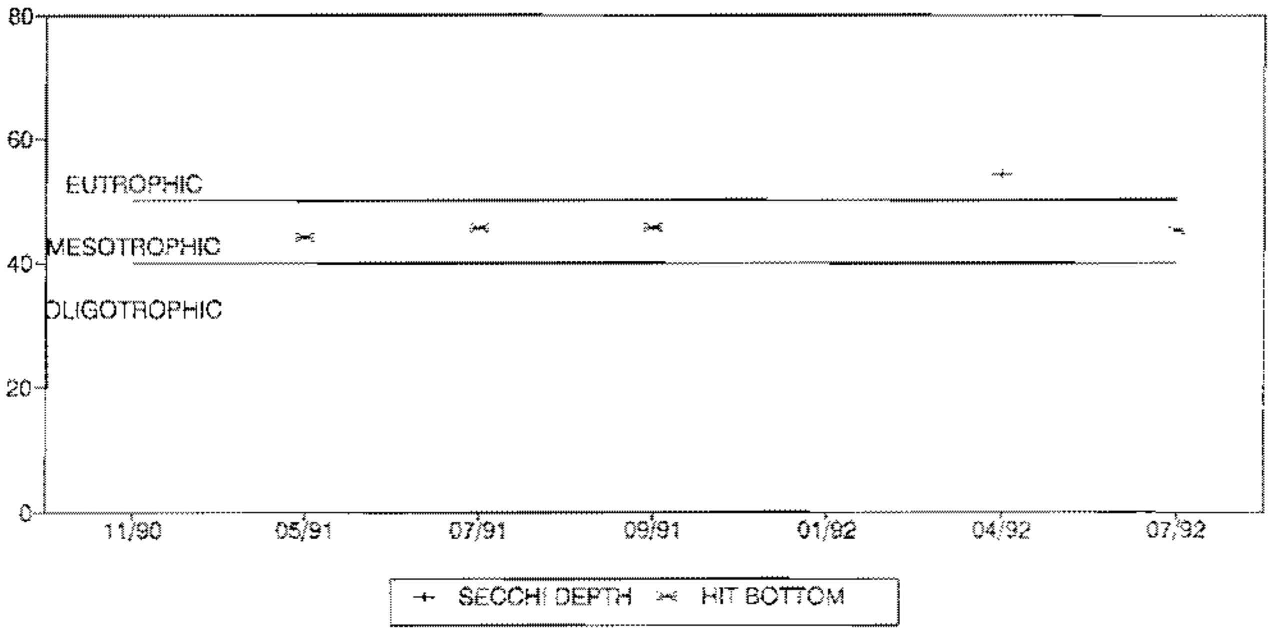

Figure 4. Trophic State Index for Secchi Depth, Lake Iola.

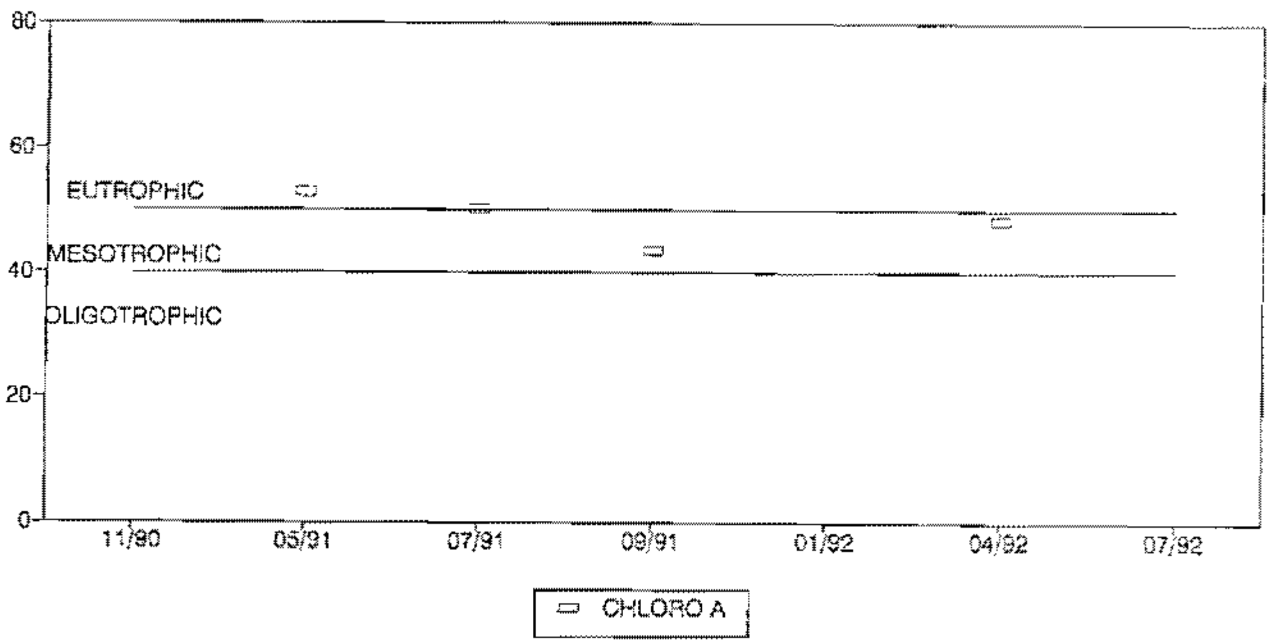

Figure 5. Trophic State Index for Chlorophyll a, Lake Iola.

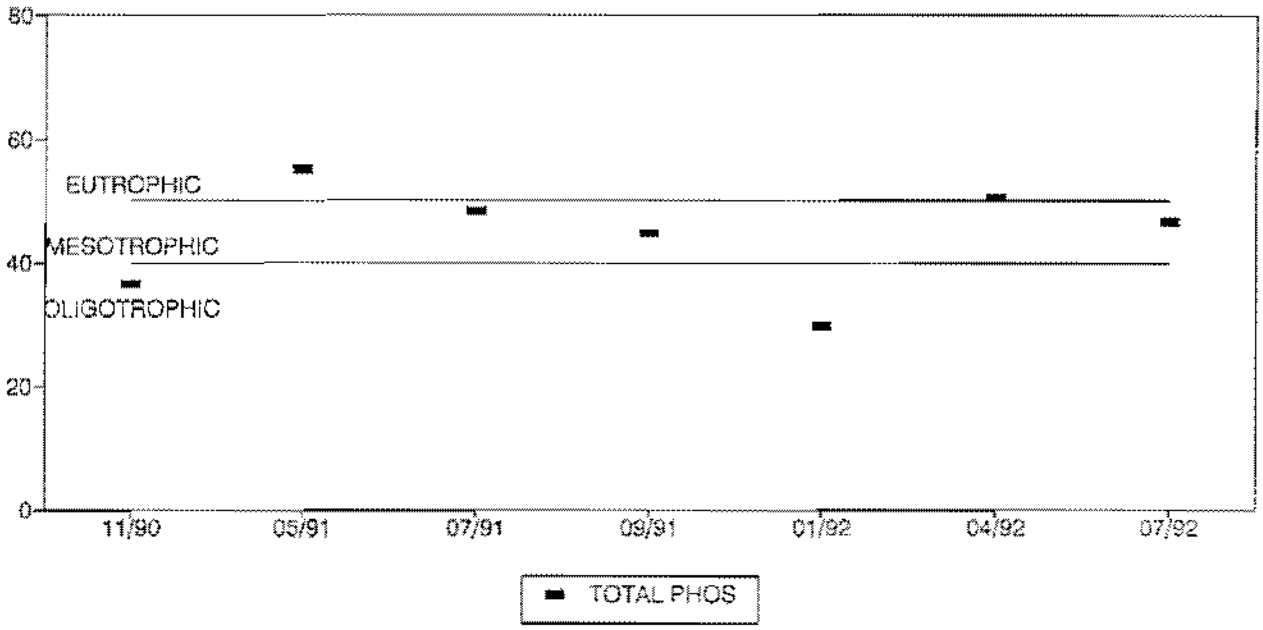

Figure 6. Trophic State Index for Total Phosphorus, Lake Iola.

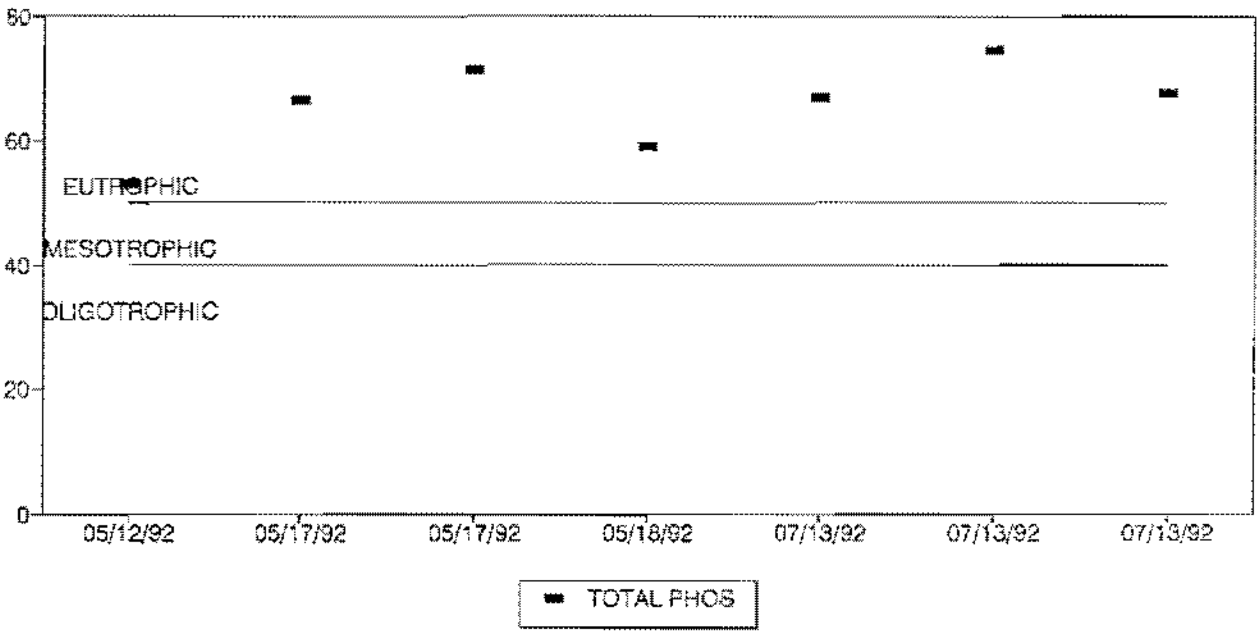

Figure 7. Trophic State Index for Total Phosphorus, Event Monitoring, Lake Iola.

Application of TSI's to event sample results would indicate a eutrophic situation (Figure 7).

During recent macrophyte surveys, macrophytes (Table 5) were found at all 26 sample sites (sample sites = number of depth ranges sampled on both dates) and often at nuisance levels (Tables 6-8, Appendix III). Water milfoil (Myriophyllum spp.) was widespread and most abundant (observed at 20 sites) and may include the exotic Eurasian Milfoil (Myriophyllum spicatum). Species determination was not verifiable because the plants lacked necessary flower parts; plants did possess, however, leaves with 12-15 pairs of leaflets and red tinged stems and shoots (characteristics normally associated with Eurasian Milfoil). Eurasian Milfoil, when present, can spread quickly, and is known to occur at nuisance levels (14) and often displaces more desirable native vegetation and can alter plant and animal assemblages within a lake. Milfoils are able to reproduce by seeds, winter buds, and by fragmentation (15). Care must be taken to remove all cut plants when harvesting to avoid introduction of the plant to previously unpopulated areas.

Flat-stem pondweed (Potamogeton zosteriformis, observed at 18 sites), and Illinois pondweed (Potamogeton illinoensis, 16 sites) were also common and relatively abundant. These are more desirable plants which are characteristically found on soft

Table 5. Macrophyte Species Observed, Lake Iola, 1991 (14).

Taxa	Code
Coontail (*Ceratophyllum demersum*)	CERDE
Muskgrass (*Chara* sp.)	CHASP
Common waterweed (*Elodea canadensis*)	ELOCA
Filamentous algae	FILAL
Small duckweed (*Lemna minor*)	LEMMI
Water milfoil (*Myriophyllum* spp.)	MYRSPE
Bushy pondweed (*Najas* sp.)	NAJSP
Nitella (*Nitella* sp.)	NITSP
Yellow pond lily (*Nuphar* sp.)	NUPSP
White water lily (*Nymphaea* sp.)	NYMSP
Large-leaf pondweed (*Potamogeton amplifolious*)	POTAM
Leafy pondweed (*Potamogeton foliosus*)	POTFO
Illinios pondweed (*Potamogeton illinoensis*)	POTIL
Floating-leaf pondweed (*Potamogeton natans*)	POTNA
Sago pondweed (*Potamogeton pectinatus*)	POTPE
Small pondweed (*Potamogeton pusillus*)	POTPU
Flat-stem pondweed (*Potamogeton zosteriformis*)	POTZO
Great bladderwort (*Utricularia vulgaris*)	UTRVU
Arrowhead (*Sagittaria* sp)	SAGSP
Rush (*Scirpus* sp.)	SCISP
Bur-reed (*Sparganium* sp.)	SPASP
Broad-leaf cattail (*Typha latifolia*)	TYPLA
Eel grass (water celery) (*Vallisneria americana*)	VALAM

Table 6. Occurrence and Abundance of Macrophytes by Depth, Lake Iola, July 1991.

CODE	Depth Ranges 1 (N=5) % of Sites	1 (N=5) Σ Abundance (range)	2 (N=5) % of Sites	2 (N=5) Σ Abundance (range)	3 (N=3) % of Sites	3 (N=3) Σ Abundance (range)
CERDE	60	6(1-3)	40	2(1)	67	4(1-3)
CHASP	0	0	0	0	0	0
ELOCA	40	3(1-2)	20	2(2)	0	0
FILAL	80	14(3-4)	40	8(4)	0	0
LEMMI	40	3(1-2)	0	0	0	0
MYRSPE	80	12(3)	80	10(2-3)	100	13(3-5)
NAJSP	20	1(1)	0	0	0	0
NITSP	40	4(1-3)	0	0	0	0
NUPSP	60	5(1-2)	60	8(2-3)	0	0
NYMSP	60	7(1-4)	80	11(2-3)	0	0
POTAM	60	7(1-3)	40	6(1-5)	67	5(1-4)
POTFO	0	0	20	1(1)	0	0
POTIL	40	3(1-2)	60	4(1-2)	100	5(1-2)
POTNA	20	2(2)	40	4(2)	0	0
POTPE	40	5(2-3)	80	9(1-4)	0	0
POTZO	40	5(2-3)	80	7(2-3)	67	3(1-2)
SAGSP	20	1(1)	20	1(1)	0	0
SCISP	20	4(4)	40	4(1-3)	0	0
SPASP	0	0	0	0	0	0
TYPLA	80	12(2-4)	40	3(1-2)	0	0
UTRVU	0	0	0	0	0	0
VALAM	0	0	40	4(1-3)	0	0

substrates and turbid water; they are rated as a good waterfowl food (seeds, roots and stems) and provide food and cover for fish (14).

Two generally accepted methods to estimate sedimentation utilize Lead-210 or Cesium-137 isotopes (1). Lead-210 dating of a sediment core taken near the main channel in the upstream reach

Table 7. Occurrence and Abundance of Macrophytes by Depth, Lake Iola, August 1991.

CODE	Depth Ranges 1 (N=5) % of Sites	Σ Abundance (range)	2 (N=5) % of Sites	Σ Abundance (range)	3 (N=3) % of Sites	Σ Abundance (range)
CERDE	20	3(3)	40	6(3)	33	2(2)
CHASP	0	0	0	0	33	2(2)
ELOCA	0	0	60	7(2-3)	33	2(2)
FILAL	40	4(2)	60	5(1-2)	0	0
LEMMI	20	3(3)	0	0	0	0
MYRSPE	40	5(2-3)	80	12(2-4)	100	11(3-4)
NAJSP	0	0	40	5(2-3)	0	0
NITSP	0	0	0	0	33	2(2)
NUPSP	40	3(1-2)	40	4(1-3)	0	0
NYMSP	40	4(1-3)	40	5(2-3)	0	0
POTAM	20	1(1)	20	2(2)	0	0
POTFO	0	0	20	1(1)	0	0
POTIL	40	4(2)	60	7(2-3)	100	8(2-3)
POTNA	0	0	20	1(1)	0	0
POTPE	60	6(2)	60	5(1-2)	33	2(2)
POTZO	40	4(2)	100	11(2-3)	100	7(2-3)
SAGSP	20	3(3)	20	2(2)	0	0
SCISP	20	3(3)	0	0	0	0
SPASP	20	3(3)	20	1(1)	0	0
TYPLA	60	8(2-4)	0	0	0	0
UTRVU	0	0	20	3(3)	0	0
VALAM	40	3(1-2)	60	5(1-2)	67	8(4)

of the impoundment was inconclusive, due primarily to equipment malfunction, and the results, which indicated little current sedimentation, are very suspect. Mathematical formulas for estimating sedimentation suggested significant sedimentation taking place in Lake Iola. One formula (probably the most accurate of the three to be discussed), is based on inflowing and in-lake average annual total phosphorus levels and indicated a

Table 8. Abundance Distribution and Substrate Relations for Selected Macrophytes, Lake Iola, 1991.

Transect	Substrate	MYRSPE	POTZO	FILAL	POTIL	NYMSP	POTPE	CERDE	TYPLA	NUPSP	VALAM	POTAM
		J[1] A	J A	J A	J A	J A	J A	J A	J A	J A	J A	J A
A1	SAND/SILT	0 0	2 0	3 0	0 0	0 0	3 0	3 3	2 2	2 2	0 0	3 0
A2	SILT/MUCK	3 0	2 3	4 2	0 0	2 0	4 1	1 3	2 0	2 3	0 0	5 0
B1	SAND/GRAVEL	3 3	3 0	4 0	0 0	2 0	0 2	2 0	0 0	2 0	0 0	3 0
B2	MK/GRAV/RK	2 4	0 2	4 2	1 0	3 3	1 2	0 3	0 0	3 0	0 0	1 0
C1	SAND/GRAVEL	3 0	0 2	4 0	1 2	0 0	0 2	1 0	4 0	0 0	0 1	1 0
C2	SAND/MUCK	0 3	3 2	0 0	1 2	3 0	0 0	1 0	1 0	3 1	0 1	0 0
C3	MUCK	3 3	2 2	0 0	2 2	0 0	0 0	3 0	0 0	0 0	0 0	4 0
D1	SAND/MUCK	3 0	0 0	3 2	2 2	1 1	0 0	0 0	3 2	1 1	0 0	0 1
D2	SAND	2 2	0 2	0 1	0 2	0 0	2 2	0 0	0 0	0 0	3 2	0 0
D3	SILT/SAND	5 4	0 3	0 0	1 3	0 0	0 0	1 2	0 0	0 0	0 4	1 0
E1	SAND	3 2	0 2	0 2	0 0	4 3	2 2	0 0	3 4	0 0	0 2	0 0
E2	SAND/SILT	3 3	2 2	0 0	2 3	3 2	2 0	0 0	0 0	0 0	1 2	0 2
E3	SILT/SAND	5 4	1 2	0 0	2 3	0 0	0 2	0 0	0 0	0 0	0 4	0 0

Species Code

[1] J = July survey, A = August survey

sedimentation rate (unitless number) of 29.0 (Table 9). Another estimate of sedimentation rate (FR) was derived using the square root of the flushing rate (which equals the inverse of the retention time). This estimate for Lake Iola is probably low because retention time, based on lake volume, has not recently been determined, e.g., after further filling in of the basin. The FR estimate indicated Lake Iola to have a sedimentation rate

Table 9. Sedimentation Rates for Wisconsin Impoundments, Natural Lakes and Lake Iola as Determined by Three Estimates.[1]

Sedimentation Rate Based on:	Impoundments	Natural Lakes	Lake Iola
Phosphorus	-	-	29.0
FR	5.8	1.1	4.2
10/mean depth (m)	5.4	2.4	8.2

[1] Adapted from "Limnological Characteristics of Wisconsin Lakes" (7)

about that expected for impoundments. The third estimate equates sedimentation rate with 10 divided by the lake's mean depth (in meters). This estimate may also be in error since the average depth may have changed since last determined. This estimate also indicated Lake Iola to have a higher sedimentation rate than expected for impoundments. If data for the last two estimates were modified to account for filling in, the estimates would increase because flushing rate would be higher (decreased lake volume) and the mean depth would be lower; it may then be assumed that these methods underestimated sedimentation.

Lakes are estimated to fill in from 0.10 to 0.50 inches per year (1). Using this estimate, combined with the sedimentation factors in Table 9, sedimentation for impoundments would range from 0.2 inches to 2.6 inches per year; Lake Iola sedimentation rates would be estimated between 0.3 and 1.9 inches per year (7).

BASELINE CONCLUSIONS

Lake Iola is a small impoundment located partially in the Village of Iola. Physical characteristics of the impoundment make Lake Iola prone to sedimentation, prolific macrophyte growth, non-point source nutrient inflows, and variable water quality as affected by that of parent river flow conditions.

- In-lake nutrient levels, despite a primarily open/agricultural watershed, were less than expected for natural lakes in the region and less than an average for impoundments. Event samples, however, show considerably higher levels of nutrients entering the system during/after major runoff events. Water clarity is such that the entire lake bottom receives adequate sunlight for macrophytic growth most of the growing season.
- Recreational use of the resource is restricted by widespread and abundant macrophytic growth throughout much of the open-water season. Local macrophyte growth is often dominated by a few species. Most abundant species include milfoils (which probably includes Eurasian Milfoil) and flatstem and Illinois pondweeds (relatively more desirable macrophytes). Adequate water clarity, nutrients and predominantly soft,

shallow shelf areas make conditions in Lake Iola (like many other impoundments) conducive to nuisance aquatic plant growth.

- Lake Iola sedimentation was estimated by Lead-210 dating as low but results are considered inconclusive and suspect. Mathematical formulas estimated sedimentation to be significant and possibly severe in upstream reaches of the impoundment. Physical characteristics of the impoundment, particularly as they relate to a relatively larger (than natural lakes) and predominantly agricultural watershed, contribute significantly to sedimentation of Lake Iola.

MANAGEMENT ALTERNATIVES DISCUSSION

WATER QUALITY AND SEDIMENTATION

Lake Iola is an impoundment with basin characteristics prone to sedimentation, non-point source runoff and changing water quality. Water quality is good but macrophyte growth is dominated by a few species at nuisance levels. Recreational use of the impoundment is currently impaired by macrophyte growth throughout open-water periods as the lake is impassible shortly after ice-out. Sedimentation is probably significant and may be severe, especially in the upstream reaches of the impoundment.

Before drastic management measures are taken to reclaim or "rejuvenate" the resource, steps must be taken to reduce sediment and nutrient inputs to the extent possible and/or practical. Efforts should be made to identify runoff or erosion prone areas and control nutrient and sediment inflows on a watershed-wide basis. Major emphasis should be given to implementation of BMP's to reduce nutrient and sediment inputs to the drainage basin. Some BMP's pertinent to Lake Iola are outlined in Appendix IV.

While inflows from the upstream watershed are probably of greatest significance, riparian land use practices can, cumulatively, have a significant influence on water quality and landowner diligence should, in any case, be strongly emphasized and encouraged. Common sense approaches are relatively easy and can be very effective in minimizing inputs.

Yard practices can minimize both nutrient and sediment inputs. Lawn 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 (16), 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, increase infiltration (to filter nutrients and soil particles), and 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 (16).

A number of informational sources for people with questions regarding land management are outlined in Appendix V.

MACROPHYTES

Management of macrophyte populations is often a major objective for lakes and particularly shallow impoundments. Macrophytic growth can positively affect the resource through forage fish and wildlife production/protection, shoreline stabilization and nutrient uptake. Nuisance levels of macrophytes, however, can cause organic sediment build-up, preclude development of desirable diverse plant populations, reduce aesthetics, reduce DO (potential fishkills), impair recreational use and contribute to the development of stunted panfish populations. Macrophyte management should be carefully implemented and consider different use areas of the lake. Numerous methods of macrophyte control and management are available ranging from radical habitat alteration to more subtle habitat manipulation and are discussed below relative to Lake Iola applicability.

Dredging is a drastic and costly form of habitat alteration. Before any dredge plan is developed or implemented on Lake Iola, steps must be taken to ensure dredging results will be most cost-effective (i.e., last as long as possible). Only when erosion and nutrient control measures are implemented (to the extent practical) on a watershed-wide basis, should a dredging plan be considered feasible. A dredge plan should involve as little sediment removal as possible (be cost effective) to create access and edge (removal to a depth at which macrophyte growth would be retarded due to reduced sunlight). A basic plan for Lake Iola should involve dredging a relatively smaller area in the upstream reach (wildlife/fish production/protection zone) as a catchment basin for future sedimentation (extend the longevity between dredges) and a larger area in the lower reaches adjacent to deepest areas for increased access (most cost effective area) and edge. Emphasis should also be given to the potential for redistribution of existing unconsolidated sediment beds in the feasibility/design stage.

Chemical treatment for macrophyte control has been shown to eradicate some undesirable species and leave others intact. The WDNR strongly discourages the use of chemicals because of nutrient release, oxygen depletion, sediment accumulation, bioaccumulation and other unknown environmental hazards including invasion potential from nuisance exotics. Chemical effects are nondiscriminate and may harm desireable or beneficial plant populations. Chemical use in the past has shown no lasting effect on controlling plant populations and should not be considered for Lake Iola at this time.

Aquatic plant screens have been shown to reduce plant densities in other lakes and may be applicable in near-shore areas here. A fiberglass screen or plastic sheet is placed and anchored on the sediment to prevent plants from growing. This may also make some sediment nutrients unavailable for algal growth. Screens should be removed each fall and cleaned in order to last a number of years. Screens are generally used in small areas of concern, e.g., around beaches, landings or piers.

A newer technique of rototilling sediments to destroy plant roots appears to be effective in controlling plant growth for a relatively longer period than harvesting. The process is about the same cost per hour as a contracted macrophyte harvester (17). A potential problem is disturbance of the sediments and resuspension of nutrients or toxics.

Installation of floating platforms (black plastic attached to wooden frames) just after ice-out can shade the sediments, restrict plant growth and help to open corridors for swimming or boat navigation. Shading is usually required for three weeks to two months to impact nuisance plant growth (18). A drawback is that the area cannot be used while the platform is in place.

Remaining control methods consist, in one form or another, of macrophyte harvest. It is a commonly used technique which can be applied on a widespread or localized basis. Its efficiency, based on method of harvest, can vary substantially with depth.

Several conditions should be considered with respect to continued macrophyte harvest. Macrophyte growth on Lake Iola is dense and widespread; even intense harvest efforts will probably not manage all areas of concern in the impoundment. Milfoils, coontail and common waterweed all spread easily by fragmentation; strong consideration should be given to the potential of these species to become even more dominant by becoming better established where competing macrophytes have been removed.

Macrophyte harvesting is typically conducted with a mechanical harvester which cuts the vegetation and removes (harvests) it onto a platform for out-lake disposal. Given the precautions regarding potential nuisance species dispersal and the ability of some plants to survive and spread when detached from the substrate, harvest practices may even enhance the nuisance macrophyte problem through seed dispersal, fragmentation or incomplete removal. Indiscriminate power boat usage, through formation of "prop cut" floating weed masses, may also contribute to this problem. Harvest is, however, area selective, relatively inexpensive and removes nutrients from the lake system. Continued harvest should play a major role in the future management of Lake Iola macrophytes.

Selective SCUBA assisted harvest has been shown to selectively manage macrophytes. It can be used in deeper areas and to target only desired species (e.g., Eurasian milfoil) or nuisance growth areas. This method is labor intensive, but has proved to effectively reduce nuisance plant levels for up to two years (17). With the large area of potential macrophyte management in Lake Iola, SCUBA assisted harvest as a widespread application is probably not applicable, but may be implemented on small, localized populations of Eurasian Milfoil or other nuisance macrophytes.

Raking weeds (using an ordinary garden rake) in the frontage area can be a very effective localized plant control method when done on a regular basis. Such concentration on the problem shallow water areas would reduce efforts expended on other control methods.

MANAGEMENT RECOMMENDATIONS

Management recommendations for Lake Iola should address near- and long-term objectives to enhance and protect the resource. Objectives should concentrate primarily on the immediate lake area in the near-term, and extend to, after further assessment and decision making, to the entire Lake Iola watershed in the long-term. Lake Iola should continue to be managed as two basic use areas: an upstream wildlife production/protection zone and a lower recreationally usable area with improved access.

Near-term objectives should emphasize continued water quality trend monitoring, continued implementation of macrophyte harvesting with specific objectives, and acquisition of data needed to determine practical and cost effective long-term alternatives for sediment reduction and macrophyte management.

- Water quality monitoring should be continued to maintain an up-to-date base of water quality information and to track trends throughout future management of the resource. An additional monitoring site should be added at the South Branch of the Little Wolf River.

- Macrophyte management should be a major work effort in lower reaches of Lake Iola. _Myriophyllum_ bed identification and control should be emphasized. Harvest efforts should emphasize mechanical creation of edge, complete removal of cut plants and channel marking to maximize access and minimize the potential for spread of nuisance macrophytes.

- While dredging may be a long-term management objective, it should be considered only after reduction of existing sediment loading, to the extent practical, and assessment of feasibility. Near-term emphasis should be given to riparian land use practices, including buffer strips, berms, fertilizer and yard waste management to help reduce sediment and nutrient inflows from the watershed immediately adjacent to the basin and parent river.

- The LILD, in cooperation with towns, the county and the state, should take an active role in protecting the Lake Iola resource from invasion by exotic, potentially harmful species. By posting signs at boat landings, providing educational brochures and educating the public about harmful species and there prevention, infiltration of purple loosestrife and Eurasian milfoil and other exotic species may be slowed or even stopped.

Long-term objectives should emphasize reduction of sediment and nutrient inflows from non-point sources in the upper watershed.

- The Lake Iola watershed is relatively smaller than most impoundments and may be more manageable for this reason. Implementation of BMP's on a watershed-wide basis will help to control nutrient and sediment inputs to the Lake Iola system and increase the longevity of in-lake management practices. Efforts should be made to obtain cost-share funding for BMP's offered on local, county, state and federal levels.
- Dredging should be considered in future management of Lake Iola. Implementation of a dredge plan should only be considered when watershed-wide BMP's are implemented. A basic plan for Lake Iola may well involve dredging a small upstream area (for future sedimentation retention) and a larger downstream area (for increased access, creation of edge, and management of <u>Myriophyllum</u>).

IMPLEMENTATION

The success of any lake management plan relates directly to the ability of the association/district to obtain funds and regulatory approval necessary to implement the plan. The LILD does have specific legal or financial powers (to adopt ordinances or levy taxes or special assessments) to meet plan objectives, if necessary.

The Lake Iola is located within the political jurisdictions of the Town of Iola, County of Waupaca and the State of Wisconsin. These units have the power to regulate land uses and land use practices. Waupaca County ordinances and plans possibly pertinent to the Lake Iola plan are summarized in Appendix VI.

Potential sources of funding are listed in Appendix VII.

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