IPS ENVIRONMENTAL AND ANALYTICAL SERVICES
Appleton, Wisconsin

PHASE I
CARY MILLPOND MANAGEMENT PLAN
WAUPACA COUNTY, WISCONSIN

REPORT TO:
CITY OF WAUPACA INLAND LAKES PROTECTION AND REHABILITATION DISTRICT

December, 1995

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GLOSSARY OF TERMS (1, 2, 3)

Best Management Land use practices to control the interactive **Practices (BMP's)** processes of
pesticide inflows.

Chlorophyll a Green pigment present in all green plant life and needed in photosynthesis. The amount present in lake water is related to the amount of algae and is therefore used as an indicator of water quality.

Drainage Lake Generally referred to as those natural lakes having inflowing and outflowing streams.

Edge A biologically diverse area located at the interface of differing habitat types.

Eutrophic From Greek for "well nourished", describes a lake of high photosynthetic activity and low transparency.

Eutrophication The process of lake aging or enrichment with nutrients, generally with associated increases in algae or weeds. The extent to which this process has progressed is described by trophic status terms, e.g., oligotrophic, mesotrophic, or eutrophic.

Littoral The shallow area of a lake from the shore to the depth where light no longer penetrates to the bottom.

Macrophyte Commonly referred to as lake "weeds", actually aquatic vascular plants that grow either floating, emergent or submergent in a body of water.

Mesotrophic A lake of intermediate productivity and clarity.

N/P Ratio Total nitrogen divided by the total phosphorus found in a water sample. A value greater than 15 indicates phosphorus to be limiting primary production.

Physicochemical Pertaining to physical and/or chemical characteristics.

GLOSSARY OF TERMS
(continued)

Residence Time — Commonly called the hydraulic residence time. The amount of time required to completely replace the lake's current volume of water with an equal volume of "new" water.

Secchi Depth — A measure of optical water clarity as determined by lowering a weighted Secchi disk (20 cm in diameter) into the water body to a point where it is no longer visible.

Watershed to Lake Ratio (W/L) Ratio — The area of the watershed divided by the lake surface area.

SUMMARY

Cary Millpond, an impoundment of the Crystal River, is located in the City of Waupaca, Waupaca County, Wisconsin. It is characterized by prolific aquatic plant growth, an abundant **littoral** zone, good water quality and increasing sedimentation which has continued to decrease recreational opportunities.

The majority of the relatively large Cary Millpond watershed can be characterized as a mixture of agricultural and woodlands of nearly level to moderately steep sandy soils. It drains an extensive (33,280 acres) watershed, although the area directly drained is 2,500 acres, as well as paved/residential areas through stormwater discharge pipes.

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

Sedimetation in Cary Millpond was estimated to be relatively high (like many impoundments). Sedimentation has reduced the capacity of the impoundment and contributed to increased **macrophyte** growth.

Management of the Cary Millpond should target continued monitoring, improved recreational access (through aquatic plant control), reduction of nutrient and sediment inflows to the system and exotic species control and prevention.

- Water quality monitoring should be continued to track trends and develop an accurate nutrient budget; event monitoring should be continued to further assess stormwater inputs.

- The feasibility of stormwater discharge reduction or redirection should be assessed.

- While plant growth provides benefits such as shoreline stabilization, nutrient uptake and fish food and habitat production, populations consist of nuisance levels of few species. Steps need to be taken to create access and **edge**[1] through plant cover. Plant management should include and emphasize steps to prevent introduction of new exotics to the system.

- Watershed wide **Best Management Practices (BMP's)** and lake management should be coordinated in conjunction for effective improvement and control of weed and sedimentation problems, but riparian management practices should also be encouraged.

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

INTRODUCTION

This report presents Phase I management planning efforts for development of the Lake Management Plan, Cary Millpond, Waupaca County, Wisconsin. Cary Millpond, located in the City of Waupaca, is a small (26 acre) impoundment of the Crystal River. The Cary Pond Dam was originally constructed prior to 1915 and is currently owned by the Shanack Foundry and Machine Company.

Water quality is generally good, but the pond contains dense concentrations of aquatic plants and filamentous algae which inhibit full recreational use of the pond. Historic management activities have generally targeted control of aquatic plants.

The City of Waupaca Inland Lakes Protection and Rehabilitation District (District) serves as the main steward for the resource. The District, received its first Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grant in October, 1993 and selected IPS Environmental & Analytical Services (IPS) of Appleton, Wisconsin as its consultant to begin management planning efforts. Phase I efforts included expanded knowledge of the pond's water quality, review of existing pond and watershed data, literature review and case history development, and evaluation of, and the need for, additional public access.

DESCRIPTION OF AREA

Cary Millpond is a **drainage lake** (posessing a permanent inlet and outlet) located in the City of Waupaca in Waupaca County (Fig. 1). It is actually an impoundment of the Crystal River which originates as an outflow from Long Lake of the Waupaca Chain O'Lakes and flows through Junction and Little Hope Pond prior to entering Cary Millpond. Like many other impoundments, Cary Millpond has extensive shallow areas (maximum depth = 6 feet, average depth = 1.8 feet, volume = 46.8 acre-feet) (4), exhibits periodic flushing (**residence time** = 6-7 hours), acts as a sediment trap (fills in) and is 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 pond is nearly level to steep (Fig. 2). The major soil types on the pond perimeter are well drained Tilleda loam on 6-12 percent slopes (mostly to the South), excessively drained Plainfield loamy sands on 2-30 percent slopes (to the North and West) and very poorly drained Cathro, Markey and Seelyeville mucks on nearly level slopes (5). Soil permeability is rapid in Plainfield soils and moderately rapid in Cathro, Markey, and Seelyeville soils.

__Figure 1. Location Map, Cary Millpond, Waupaca County, WI.

Figure 2. Watershed Land Slopes, Cary Millpond, Waupaca County, WI.

The Cary Millpond watershed is about 33,280 acres (6) although the area directly drained is 2,500 acres. Most of this area is a mixture of agricultural and woodlands with a small area being in urban development. The watershed to lake ratio (**W/L ratio**) is about 1280, meaning 1280 times more land than lake surface area drains to the lake. This value for the overall watershed, is much higher than the average for impoundments in Wisconsin (676). The average for drainage lakes (those having a permanent inlet and outlet) is 88. This relatively large number indicates an increased potential for flushing and non-point source nutrient inputs compared to other impoundments.

Figure 2. Watershed Land Slopes, Cary Millpond, Waupaca County, WI.

The pond has become dominated by certain undesirable aqautic plant species due to nutrient enrichment and siltation which hinder full recreational use of the resource. Incoming silt deposits in the pond basin contributes to the weed problem by providing absorbed nutrients. Sources of recent and continued sedimentation include stream bank erosion, surface runoff and storm sewers.

Four storm sewers are located within the immediate area and drain to Cary Millpond. Storm sewer discharge is untreated runoff from lawns, streets, parking lots and other paved areas and is a potential source of salts, sand, nutrients, pesticides, vegetative debris, oil, grease and potentially toxic pollutants.

METHODS

FIELD PROGRAM

Cary Millpond water samples were taken in January, May, June, August, and September, 1994 and February, May, June, July, and August, 1995. Samples were collected, mid-depth in the water column at Station 2101 (near dam) and Station 2102 (Crystal River - East of County E) (Table 1, Figure 4).

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 a Hydrolab Surveyor II; 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; 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 (7) methods. Winter water quality parameters included laboratory pH, total alkalinity, total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total

Table 1. Sampling Station Locations, Cary Millpond, 1994 - 1995.

REGULAR MONITORING

Site	Depth
2101	6.0 feet
2102	3.0 feet

EVENT MONITORING

Site	Description
CE1	Storm sewer West of County E
CE2	Crystal River East of County E
CE3	Storm sewer at West end of Riverside Avenue
CE4	Storm sewer West of Churchill Street

_Figure 4. Sample Sites, Cary Millpond, 1994 - 1995.

phosphorus and dissolved phosphorus. Spring parameters determined by the laboratory included laboratory pH, total alkalinity, total solids, total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus, dissolved phosphorus, **chlorophyll a**. Summer and late Summer laboratory analyses included total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus, dissolved phosphorus, and chlorophyll a.

In addition to regular monitoring sites, four event sampling sites were sampled (Figure 4) to assess nutrient inflows. Event sample sites were located at storm sewers within the Cary Millpond drainage basin. Samples were collected March 7, April 12, April 25, May 11, June 13, July 5, and August 10, 1994 and September 20, 1995.

Sediment Mapping

Sediment mapping was undertaken to estimate the quantity and location of sediment accumulations. An aluminum pole, marked with one foot increments, was used as a measuring device. A number of transects were established running north-south while one transect went the length of the pond (east-west, Fig. 5). Along each transect the measuring device was used to first, measure the depth of the water, and second, to measure the depth of soft sediment by pushing the device down until hard substrate was reached.

Figure 5. Sediment Profile Transect Locations, Cary

Millpond, Waupaca County, 1995.

OTHER

Water Quality Information

Additional lake information was retrieved from the WDNR Surface Water Inventory (6), Wisconsin Self Help Monitoring Program (8), the WDNR Wisconsin Lakes publication (4) 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 (5), 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, Waupaca County Floodplain 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

A summary of public involvement activities coordinated with the lake management planning process is outlined in Appendix I.

FIELD DATA DISCUSSION

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

Impoundments differ from natural lakes in that they characteristically have much larger watersheds, exhibit periodic flushing, and "fill-in" with deposition of the river's sediment load. While natural lakes tend toward a state of dynamic equilibrium, the physical, chemical and biological characteristics of impoundments can vary substantially over time as they are continuously affected by flow conditions of 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), which may be influenced substantially by flow release operations at the dam.

Cary Millpond is particularly prone to nutrient and sediment inputs because the impoundment drains a predominantly agricultural and woodlands watershed with few wetland and forested areas. The impoundment also has the potential to receive substantial input from four storm sewers. If nutrient and sediment inputs from the watershed can be minimized, periodic flushing during high flow periods may rapidly improve conditions in an impoundment.

Phosphorus is often the limiting major nutrient to algal and plant production in lakes. Total phosphorus during 1994-1995 monitoring ranged from 0.017 to 0.031 mg/l (parts per million, average = 0.021, median = 0.020, standard deviation (σ) = 0.005 mg/l) at Station 2101 (Table 2). Total phosphorus at Station 2102 (Crystal River inflow) ranged from 0.009 to 0.032 mg/l (average = 0.021, median = 0.020, σ = 0.006 mg/l) over the same period (Table 3). These were within or lower than levels measured in 1978 (Appendix II). Nitrogen to phosphorus ratios (**N/P ratio**) generally greater than 15 (for regular monitoring) indicated Cary Millpond Lake to be phosphorus limited (Tables 2 and 3, Figs. 6 and 7). Monitoring of storm sewers (Tables 4 and 5) during rain events showed significant inflow of nutrients. Summer phosphorus levels in 1994-1995 (0.017, 0.018, 0.019, 0.022, 0.031 mg/l; average = 0.021, median = 0.020, (σ) = 0.006 mg/l) at Site 2101 were, according to a recent compilation of summer total phosphorus levels in upper midwestern lakes (9), slightly lower than typical (.030 to .050 mg/l) for lakes in the transitional region in which Cary Millpond is located. The average summer total phosphorus value for Cary Millpond

Table 2. Water Quality Parameters, Station 2101, Cary Millpond, January 1994 - August 1995.

PARAMETER	SAMPLE[1]	DATE									
		01/31/94	05/10/94	06/29/94	08/04/94	09/21/94	02/08/95	05/16/95	06/19/95	07/24/95	08/17/95
Secchi (feet)		NR[2]	>5.0	>5.0	>5.0	>5.0	NR	>5.0	>5.0	>5.0	>5.0
Cloud Cover (percent)		0	0	60	100	100	NR	0	5	30	90
Temperature (degrees Celcius)	M	0.19	14.35	21.10	22.68	20.64	NR	16.85	26.20	25.00	22.74
pH (surface units)	M	NR	7.65	7.90	7.73	NR	NR	8.44	8.56	8.72	7.34
D.O. (mg/l)	M	11.92	11.22	10.44	7.42	8.42	NR	7.95	NR	8.02	NR
Conductivity (umhos/cm)	M	344	336	314	302	301	NR	340	271	350	320
Laboratory pH (surface units)	M	NR	8.40	NR	NR	NR	NR	8.55	NR	NR	NR
Total Alkalinity (mg/l)	M	NR	166	NR	NR	NR	NR	163	NR	NR	NR
Total Solids (mg/l)	M	NR	224	NR	NR	NR	NR	218	NR	NR	NR
Tot. Kjeld. Nitrogen (mg/l)	M	NR	0.3	NR	NR	0.46[3]	NR	0.5	NR	NR	NR
Ammonia Nitrogen (mg/l)	M	NR	0.028	NR	NR	0.035	NR	ND[4]	NR	NR	NR
$NO_2 + NO_3$ Nit. (mg/l)	M	NR	1.89	NR	NR	1.66	NR	1.68	NR	NR	NR
Total Nitrogen (mg/l)	M	NR	2.19	NR	NR	2.12	NR	2.18	--	--	NR
Total Phosphorus (mg/l)	M	0.024	0.021	0.017	NR	0.019[4]	NR	0.018	0.022	0.018	0.031
Dissolved Phos. (mg/l)	M	0.002	0.003	0.004	NR	NR	NR	ND	0.006	0.005	0.013
Nit./Phos Ratio	M	--	104.3	--	--	111.6	--	121.1	--	--	--
Chlorophyll a (ug/l)	S	NR	4.39	NR	NR	NR	NR	2.86	1.23	0.27	3.43

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

Table 3. Water Quality Parameters, Station 2102 (Crystal River -

Inlet), Cary Millpond, January 1994 - August 1995.

PARAMETER	SAMPLE[1]	DATE									
		01/31/94	05/10/94	06/29/94	08/04/94	09/21/94	02/08/95	05/16/95	06/19/95	07/24/95	08/17/95
Secchi (feet)		NR[2]	>3.0	>3.0	NR	>3.0	NR	>3.0	>3.0	>3.0	>3.0
Cloud Cover (percent)		0	0	60	100	100	0	0	5	30	100
Temperature (degrees Celcius)	M	0.17	16.49	21.09	20.42	17.77	0.43	17.15	25.93	25.53	21.62
pH (surface units)	M	6.47	7.56	7.72	7.48	NR	7.77	8.25	8.31	8.73	7.00
D.O. (mg/l)	M	11.68	8.68	9.51	6.71	7.79	14.14	6.66	7.45	NR	NR
Conductivity (umhos/cm)	M	356	333	321	335	312	355	250	342	355	313
Laboratory pH (surface units)	M	NR	8.36	NR	NR	NR	NR	8.43	NR	NR	NR
Total Alkalinity (mg/l)	M	NR	166	NR	NR	NR	NR	162	NR	NR	NR
Total Solids (mg/l)	M	NR	226	NR	NR	NR	NR	222	NR	NR	NR
Tot. Kjeld. Nitrogen (mg/l)	M	NR	0.2	NR	NR	0.42[3]	0.3	0.6	NR	NR	NR
Ammonia Nitrogen (mg/l)	M	NR	0.023	NR	NR	0.036	0.041	ND[4]	NR	NR	NR
$NO_2 + NO_3$ Nit. (mg/l)	M	NR	1.85	NR	NR	1.58	2.67	1.76	NR	NR	NR
Total Nitrogen (mg/l)	M	NR	2.05	NR	NR	2.00	2.97	2.36	NR	NR	NR
Total Phosphorus (mg/l)	M	0.020	0.018	0.020	0.025	0.020	0.009	0.023	0.023	0.019	0.032
Dissolved Phos. (mg/l)	M	0.002	0.004	0.004	0.007	NR	0.002	0.002	0.004	0.004	0.011
Nit./Phos Ratio	M	--	113.9	--	--	100	330	102.6	--	--	--
Chlorophyll <u>a</u> (ug/l)	S	NR	3.26	2.84	5.69	3.62	NR	11.0	NR	0.67	NR

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

Figure 6. Total Phosphorus Trends for Cary Millpond, 1994 - 1995.

Figure 7. Total Nitrogen Trends for Cary Millpond, 1994 - 1995.

Table 4. Event Nitrogen Parameters (in milligrams per liter), Cary Millpond, Waupaca County, 1994-1995.

DATE PARAMETER	Event[1]	CE1	CE2	CE3	CE4
03-07-94	**0.016/0.0[2]**				
TKN		**0.8**	**1.8**	**2.7**	**1.2**
NH_4-N		**0.162**	**0.173**	**0.331**	**0.252**
NO_2+NO_3-N		**0.106**	**0.068**	**0.151**	**0.725**
Tot. N		**0.906**	**1.868[3]**	**2.851**	**1.925**
04-12-94	**0.0/0.0**				
TKN		**0.8**	**0.9**	**1.0**	**0.7**
NH_4-N		**0.199**	**0.325**	**0.270**	**0.171**
NO_2+NO_3-N		**0.027**	**0.249**	**0.168**	**0.583**
Tot. N		**0.827**	**1.149**	**1.168**	**1.283**
04-25-94	**0.0/2.35**				
TKN		**1.2**	**0.4**	**1.4**	**1.6**
NH_4-N		**0.074**	**0.086**	**0.232**	**0.825**
NO_2+NO_3-N		**0.415**	**1.65**	**0.286**	**1.62**
Tot. N		**1.615**	**2.05**	**1.686**	**3.22**
05-11-94	**0.0/0.0**				
TKN		**0.9**	**NS[4]**	**0.9**	**0.9**
NH_4-N		**0.512**	**NS**	**0.630**	**0.206**
NO_2+NO_3-N		**0.820**	**NS**	**0.801**	**2.78**
Tot. N		**1.72**	**NS**	**1.701**	**3.68**
06-13-94	**0.1/0.034**				
TKN		**0.6**	**0.3**	**0.9**	**0.8**
NH_4-N		**0.075**	**0.059**	**0.094**	**0.192**
NO_2+NO_3-N		**0.567**	**1.79**	**0.769**	**1.5**
Tot. N		**1.167**	**2.09**	**1.669**	**2.3**
07-05-94	**0.93/2.98**				
TKN		**0.6**	**0.6**	**0.5**	**0.7**
NH_4-N		**0.281**	**0.350**	**0.297**	**0.297**
NO_2+NO_3-N		**0.309**	**0.349**	**0.343**	**0.377**
Tot. N		**0.909**	**0.949**	**0.843**	**1.077**
08-10-94	0.0/0.6				
TKN		0.6	0.9	0.6	1.0
NH_4-N		0.152	0.168	0.145	0.126
NO_2+NO_3-N		0.183	0.133	0.170	0.265
Tot. N		0.783	1.033	0.770	1.265
09-20-95	0.29/0.8				
TKN		0.2	0.3	0.3	0.3
NH_4-N		0.043	0.035	0.063	0.070
NO_2+NO_3-N		1.66	1.70	1.60	1.62
Tot. N		**1.86**	**2.00**	**1.90**	**1.92**

SAMPLE SITE: CE1, CE2, CE3, CE4

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[1] rainfall (in.): day prior/ day of; [2] 2.0 inches snow-melt recorded; [3] bold values sig ($\propto$ = 0.01) greater than event mean; [4] NS = no sample collected

Table 5. Event Phosphorus Parameters (in milligrams per liter), Cary Millpond, Waupaca County, 1994-1995.

DATE

PARAMETER		SAMPLE SITE			
	Event[1]	CE1	CE2	CE3	CE4
03-07-94	**0.016/0.0**[2]				
Diss. P		**0.124**	**0.075**	**0.185**	**0.113**
Tot. P		**0.25**[3]	**0.44**	**0.31**	**0.29**
04-12-94	**0.0/0.0**				
Diss. P		**0.059**	**0.036**	**0.100**	**0.041**
Tot. P		**0.23**	**0.161**	**0.21**	**0.192**
04-25-94	**0.0/2.35**				
Diss. P		**0.024**	**0.004**	**0.178**	**0.008**
Tot. P		**0.16**	**0.031**	**0.35**	**0.09**
05-11-94	**0.0/0.0**				
Diss. P		**0.026**	**NS**[4]	**0.018**	**0.006**
Tot. P		**0.076**	**NS**	**0.051**	**0.089**
06-13-94	**0.1/0.034**				
Diss. P		**0.048**	**0.003**	**0.062**	**0.014**
Tot. P		**0.112**	**0.026**	**0.144**	**0.090**
07-05-94	**0.93/2.98**				
Diss. P		**0.016**	**0.011**	**0.011**	**0.003**
Tot. P		**0.060**	**0.066**	**0.056**	**0.123**
08-10-94	0.0/0.6				
Diss. P		0.091	0.075	0.090	0.069
Tot. P		**0.159**	**0.152**	0.139	**0.144**
09-20-95	0.29/0.8				
Diss. P		0.003	0.002	0.003	0.116
Tot. P		0.016	0.013	0.015	0.015

[1] rainfall (in.): day prior/ day of; [2] 2.0 in. snow-melt recorded; [3] bold values sig ($\propto$ = 0.01) greater than event mean; [4] NS = no sample collected

was also somewhat lower than what was found in a summary of 100 Wisconsin impoundments (ave. = 0.064, median = 0.035, σ = 0.100 mg/l) and well below that for impoundments with 0-14 day residence times (ave. = 0.094, median = 0.075, σ = 0.079) (10).

Nitrogen is highly variable between lakes and should only be analyzed on a relative or trend basis within the same lake. Total in-lake total nitrogen levels were significantly higher (ave. = 2.16, median = 2.18, σ = 0.38) than expected levels for impoundments (ave. = 1.06, median = 0.94, σ = 0.54), drainage lakes (ave. = 0.95, median = 0.83, σ = 0.55), and lakes in the central region of Wisconsin (ave. = 0.72, median = 0.69, σ = 0.31) (10). Inlet total nitrogen levels (ave. = 2.34, median = 2.21, σ = 0.45) were only slightly higher than those in-lake.

Event monitoring indicated slightly higher total phosphorus levels for Site CE2 (on March 7, 0.44 mg/l) (Table 5). The average total phosphorus for all event sites was 0.14 mg/l (median = 0.16, σ = 0.015), respectively. Highest total nitrogen levels were observed at Site CE4 (April and May, 1994) and Site CE3 (March, Table 4). Total nitrogen levels for all event sites averaged 1.62 mg/l (median = 1.69, σ = 0.35). Overall nitrogen levels were likely related to groundwater inflow or to stormwater inputs.

Other indicators of lake **eutrophication** status include light penetration and algal production. Numerous summaritive indicies 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 (11) utilizes Secchi transparency, chlorophyll a, and total phosphorus. As with most indicies, 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 Cary Millpond with respect to in-lake total phosphorus (Figure 14) indicated a mesotrophic to eutrophic classification; application of TSI's to event sample results would indicate a highly eutrophic situation. TSI numbers varied between mesotrophic and slightly eutrophic for total phosphorus. Secchi depth TSI trends were not applicable since readings were recorded "to bottom" on all sample dates. A statistical summary of 100 Wisconsin impoundments indicated an average chlorophyll a readings of 22.3 ug/l compared to the 1994-1995 in-lake average of 2.44 ug/l for Cary Millpond.

Figure 8. Trophic State Index for Total Phosphorus and Chlorophyll a, Cary Millpond, 1994 - 1995.

Mathematical formulas for estimating sedimentation suggested significant sedimentation taking place in Cary Millpond. 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 sedimentation rate (unitless number) of 2.1 (Table 6). 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 Cary Millpond Lake 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 Cary Millpond to have a sedimentation rate about one-half that expected in impoundments (Table 6). The third estimate equates sedimentation rate with 10 divided by the lake's mean depth (in meters).

Table 6. Sedimentation Rates for Wisconsin Impoundments, Natural Lakes and Cary Millpond as Determined by Three Estimates.[1]

Sedimentation Rate Based on:	Impoundments	Natural Lakes	Cary Pond
Phosphorus	-	-	2.1
FR	5.8	1.1	2.6
10/mean depth (m)	5.4	2.4	6.6

[1] Adapted from "Limnological Characteristics of Wisconsin Lakes" (10)

This estimate may also be in error since the average depth may have changed since last determined. This estimate shows Cary Millpond 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 decrease because flushing rate would be higher (less lake volume) and the mean depth would be lower; it may then be assumed that the FR and mean depth rates probably overestimated sedimentation. Lakes are estimated to fill in from 0.10 to 0.50 inches per year (1).

Sediment deposition in Cary Millpond overall averaged 2.47 feet for all six transects (Figs. 9-14). On a longitudinal basis sediment depth was relatively consistent in a downstream progression. Transectionally, sediment depth was greater in shallower shelf areas (less flow, abundant macrophytes) when compared to sediment depth within the original channel.

Gage readings taken April - June 1994, a high low or normal flow period averaged ? (Table 7). These gage readings translate to flows ranging from about ?? to ??? cfs. Daily variability was (what?) based on measurement units.

Figure 9. Sediment Profile (points A-E orientated North to South), Transect #1.

Figure 10. Sediment Profile (points A-D orientated North to

South), Transect #2.

Figure 11. Sediment Profile (points A-E orientated North to South), Transect #3.

Figure 12. Sediment Profile (points A-E orientated North to South), Transect #4.

Figure 13. Sediment Profile (points A-E orientated West to East), Transect #5.

Figure 14. Sediment Profile (points A-D orientated North to South), Transect #6.

Table 7. Water Level Readings, Cary Millpond, April 1994 - June 1994.

Date	Gage Reading
04/4	0.76
04/14	1.3
04/15	1.5
04/16	1.85
04/17	NR
04/18	0.8
04/19	0.8
04/20	1.0
04/21	1.3
04/22	0.6
04/24	0.8
04/25	1.6
04/26	1.6
04/27	1.3
04/28	1.0
04/29	1.2
05/2	0.8
05/3	1.2
05/4	1.3
05/5	1.7
05/6	0.8
05/7	0.8
05/8	1.0
05/9	0.8
05/10	0.8
05/11	1.2
05/12	0.8
05/13	1.0
05/16	1.1
05/17	1.2
05/18	0.9
05/19	1.4
05/20	0.8
05/24	NR[1]
05/25	1.1
05/26	1.0
05/27	1.4
05/28	0.6
05/30	0.6

Date	Gage Reading
06/1	0.6
06/2	1.2
06/3	0.6
06/6	0.9
06/7	1.3
06/10	1.0
06/13	1.4
06/14	1.1
06/15	0.6
06/16	1.0
06/17	0.9
06/20	1.2
06/21	1.1
06/22	0.8
06/23	0.6
06/24	0.6
06/25	1.1
06/26	1.3
06/27	1.1
06/28	NR[1]
06/29	1.3

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[1] No Reading; water level below gage

BASELINE CONCLUSIONS

Cary Millpond water quality, despite nutrient inflow from the watershed and storm sewers is fair to good. The in-lake nutrient readings overall, were less than expected for average impoundments and for lakes in the region. This, coupled with comparatively low chlorophyll a and good transparency, suggested that the nutrients are probably being bound in sediments, utilized by the extensive macrophyte assemblages or rapidly flowing through the system.

Base flows to Cary Millpond 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 pond bottom during the open water season. Event monitoring indicated four storm sewer sites contributing significant phosphorus and/or nitrogen concentrations.

Macrophyte growth is widespread, very abundant and dominated by a few species. Adequate water clarity and nutrients and predominantly soft, shallow shelf areas make condtitions in Cary

Millpond conducive to nuisance aquatic plant growth. The most abundant species were coontail and common waterweed; both have the potential to grow in nuisance proportions. Recreational use

of the resource is restricted by dense macrophytic growth throughout much of the open-water season. Herbicides have periodically been applied to attempt control (Appendix III).

Mathematical formulas estimated sedimentation to be significant and possibly severe in upstream reaches of the impoundment. Physical characteristics of the impoundment and storm sewer inflows contribute significantly to sedimentation of Cary Millpond.

Public access is limited since the pond is surrounded by either relatively steep slopes and/or private landowners. A public access sight would be feasible to further utilize recreational use of the pond. In order for this to take, place a parcel of land would have to be available either through purchase or donation.
************** Address public access!!!****************

MANAGEMENT ALTERNATIVES AND RECOMMENDATIONS

Water Quality and Sedimentation

Cary Millpond is an impoundment with basin characteristics prone to sedimentation, non-point source runoff and changing water quality. Water quality is good and 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 pond 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 Cary Millpond are outlined in Appendix IV.

While inflows from the upstream watershed and stormwater discharge 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 (12), 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 (12). Clearly, upland management and stabilization of buffers between agricultural land uses, housing developments, and the lake or streams will reduce sediment entry into the pond. Placement of a low berm in this area can enhance effectiveness of the buffer strip by further retarding runoff during rainfalls.

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 Cary Millpond applicability.

Dredging is a drastic and costly form of habitat alteration. Before any dredge plan is developed or implemented on Cary Millpond, 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 Cary Millpond could 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 Cary Millpond 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 (15). 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 (14). 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 macrophyte harvest. Macrophyte growth on Cary Millpond 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. Harvest is, however, area selective, relatively inexpensive and removes nutrients from the lake system.

Selective SCUBA assisted harvest has been shown to selectively manage macrophytes. It can be used in deeper areas and to target only specific species or nuisance growth areas. This method is labor intensive, but has proved to effectively reduce nuisance plant levels for up to two years (13). With the large area of potential macrophyte management in Cary Millpond, SCUBA assisted harvest as a widespread application is probably not applicable, but may be implemented on small, localized populations of 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.

Implementation

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

The Cary Millpond watershed is located within the political jurisdiction of the City of Waupaca, 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 Cary Millpond plan are summarized in Appendix VI. Potential sources of funding are listed in Appendix VII.

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APPENDIX I

SUMMARY OF PUBLIC INVOLVEMENT ACTIVITIES

Cary Millpond Management Plan

The City of Waupaca Inland Lakes Protection & Rehabilitation District initiated steps to develop a comprehensive lake management plan under the Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grant Program in the Fall of 1993. A public involvement program was immediately initiated as part of the planning process. The following is a summary of Phase I public involvement efforts.

Planning Advisory Committee

A working group comprised of District Commissioners, WDNR and IPS representatives was established at the start of the program. The group provided planning direction and served as main reviewer of the draft plan document.

Brochures

A informational brochure titled "Cary Millpond Management Planning Program" was developed and distributed which outlined objectives, elements and ways for District members to get involved in the planning process.

A plan summary brochure was also produced. It was made available for District use and distribution when the plan document was approved by WDNR. The brochure described the main features of plan development, plan recommendations and other pertinent information. Another plan brochure will be produced upon conclusion of Phase II.

Meetings

IPS presented progress reports, provided information about the resource and interpretations of these results.

Print Media

A quarterly IPS newsletter entitled "Lake Management News" was developed and distributed to the District for the Board's use and distribution among the membership.

APPENDIX II

HISTORIC WATER QUALITY DATA

Cary Millpond, Waupaca County, WI

Total Phosphorus Values: 01/78 - 11/78

(Source: WDNR)

INLET SITE

DATE	TOTAL P. (ug/l)	TSI
01/13/78	170	68
02/06/78	160	67
02/13/78	80	62
03/08/78	42	57
03/17/78	24	53
04/11/78	17	50
04/27/78	16	50
05/09/78	21	52
05/18/78	16	50
05/25/78	15	49
06/08/78	22	52
06/19/78	18	51
06/29/78	16	50
07/08/78	24	53
07/22/78	18	51
08/03/78	17	50
08/17/78	14	49
09/02/78	22	52
09/16/78	24	53
09/29/78	28	54
10/11/78	29	54
10/27/78	31	55
11/02/78	35	56
11/16/78	25	53
11/27/78	28	54

APPENDIX III

HISTORICAL HERBICIDE APPLICATIONS

Cary Millpond

(Source: WDNR)

YEAR	HERBICIDE	AMOUNT	AREA TREATED
1957	Arsenic	720 lbs	15 acres
1958	Arsenic	1272 lbs	11.8 acres
1976	Diquat	10 gal	6 acres
1977	Diquat	8 gal	6 acres

APPENDIX IV
Review of Best Management Practices (BMP's)(1)

Conservation Tillage: A farming practice that leaves stalks or stems and roots intact in the field after harvest. Its purpose is to reduce water runoff and soil erosion compared to conventional tillage whuere the topsoil is mixed and turned over by a plow. Conservation tillage is an umbrella term that includes any farming practice that reduces the number of times the topsoil is mixed. Other terms that are used instead of conservation tillage are (1) minimum tillage where one or more operations that mixed the topsoil are eliminated; and (2) no-till where the topsoil is left essentially undisturbed.

CRITERIA		REMARKS
1.	Effectiveness	
	a) Sediment	Fair to excellent, decreases sediment input to streams and lakes. (40-90% reduced tillage, 50-95% no tillage).
	b) Nitrogen (N)	Poor, no effect on nitrogen input to streams and lakes.
	c) Phosphorus (P)	Fair to excellent, can reduce the amount of phosphorus input to streams and lakes. (40-90% reduced tillage, 50-95% no tillage).
	d) Runoff	Fair to excellent, decreases amount of water running off fields carrying sediment and phosphorus.
2.	Capital Costs	High, because requires purchase of new equipment by farmer.
3.	Operation and Maintenance	Less expensive than conventional tillage. Potential increase in herbicide costs. Potential increase in net farm income.
4.	Longevity	Good, approximately every five years the soil has to be turned over.
5.	Confidence	Fair to excellent.
6.	Adaptability	Good, but may be limited in northern areas that experience late cool springs, or in heavy, poorly drained soils.
7.	Potential Treatment Side Effects	Potential increase in herbicide effects and insecticide contamination of surface and groundwater. Nitrogen contamination of groundwater.
8.	Concurrent Land Management Practices	Consider fertilizer management and integrated pest management.

Integrated Pest Management: Pests are any organisms that are harmful to desired plants, and they are controlled with chemical agents called pesticides. Integrated pest management considers factors such as how much pesticide is enough to control a problem, the best method of applying the pesticides, the appropriate time for application and the safe handling, storage and disposal of pesticides and their containers. Other considerations include using resistant crop varieties, optimizing crop planting time, optimizing time of day application, rotating crops and biological controls.

CRITERIA		REMARKS
1.	Effectiveness	
	a) Sediment	No effect, but pesticides attached to soil particles can be carried to streams and lakes.
	b) Nitrogen (N)	No effect.
	c) Phosphorus (P)	No effect.
	d) Runoff	No effect, but water is the primary route for transporting pesticides to lakes and streams.
2.	Capital Costs	No effect.
3.	Operation and Maintenance	Farming cost, potential reduction in pesticide costs and an increase in net farm income.
4.	Longevity	Poor, as pesticides are applied one or more times per year to address different pests and different crops.
5.	Confidence	Fair to excellent, reported pollutant reductions range from 20-90%.
6.	Adaptability	Methods are generally applicable wherever pesticides are used: forest, farms, homes.
7.	Potential Treatment Side Effects	Potential for ground and surface water contamination. Toxic components may be available to aquatic plants and animals.
8.	Concurrent Land Management Practices	See crop rotation, conservation tillage.

APPENDIX IV
Review of Best Management Practices (BMP's)
(continued)

Street Cleaning: Streets and parking lots can be cleaned by sweeping which removes large dust and dirt particles or by flushing which removes finer particles. Sweeping actually removes solids so pollutants do not reach receiving waters. Flushing just moves the pollutants to the drainage system unless the drainage system is part of the sewer system. When the drainage system is part of the sewer system, the pollutants will be treated as wastes in the sewer treatment plant.

CRITERIA		REMARKS
1.	Effectiveness	
	a) Sediment	Poor, not proven to be effective.
	b) Nitrogen (N)	Poor, not proven to be effective.
	c) Phosphorus (P)	Poor, not proven to be effective.
	d) Runoff	No effect.
2.	Capital Costs	High, because it requires the purchase of equipment by community.
3.	Operation and Maintenance	Unknown but reasonable vehicular maintenance would be expected.
4.	Longevity	Poor, have to sweep frequently throughout the year.
5.	Confidence	Poor.
6.	Adaptability	To paved roads, might not be considered a worthwhile expenditure of funds in communities less than 10,000.
7.	Potential Treatment Side Effects	Unknown.
8.	Concurrent Land Management Practices	Detention/Sedimentation basins.

Streamside Management Zones (Buffer strips): Considerations in streamside management include maintaining the natural vegetation along a stream, limiting livestock access to the stream, and where vegetation has been removed, planting buffer strips. Buffer strips are strips of plants (grass, trees, shrubs) between a stream and an area being disturbed by man's activities that protects the stream from erosion and nutrient impacts.

CRITERIA		REMARKS
1.	Effectiveness	
	a) Sediment	Good to excellent, reported to reduce sediment from feedlots on 4% slope by 79%.
	b) Nitrogen (N)	Good to excellent, reported to reduce nitrogen from feedlots on 4% slope by 84%.
	c) Phosphorus (P)	Good to excellent, reported to reduce phosphorus from feedlots on 4% slope by 67%.
	d) Runoff	Good to excellent, reported to reduce runoff from feedlots on 4% slope by 67%.
2.	Capital Costs	Good, moderate costs for fencing material to keep out livestock and for seeds for plants.
3.	Operation and Maintenance	Excellent, minimal upkeep.
4.	Longevity	Excellent, maintains itself indefinitely.
5.	Confidence	Fair, because of the lack of intensive scientific research.
6.	Adaptability	May be used anywhere. Limitations on types of plants that may be used between geographic areas.
7.	Potential Treatment Side Effects	With trees, shading may increase the diversity and number of organisms in the stream with the possible reduction of algae.
8.	Concurrent Land Management Practices	Conservation tillage, animal waste management, livestock exclusion, fertilizer management, pesticide management, ground cover maintenance, proper construction, use, maintenance of haul roads and skid trails.

APPENDIX IV
Review of Best Management Practices (BMP's)
(continued)

Contour Farming: A practice where the farmer plows across the slope of the land. This practice is applicable on farm land with a 2-8 percent slope.

CRITERIA		REMARKS
1.	**Effectiveness**	
	a) Sediment	**Good on moderate slopes (2 to 8 percent slopes), fair on steep slopes (50 percent reduction).**
	b) Nitrogen (N)	**Unknown.**
	c) Phosphorus (P)	**Fair.**
	d) Runoff	**Fair to good, depends on storm intensity.**
2.	**Capital Costs**	**No special effect.**
3.	**Operation and Maintenance**	**No special effect.**
4.	**Longevity**	**Poor, it must be practiced every time the field is plowed.**
5.	**Confidence**	**Poor, not enough information.**
6.	**Adaptability**	**Good, limited by soil, climate, and slope of land. May not work with large farming equipment on steep slopes.**
7.	**Potential Treatment Side Effects**	**Side effects not identified.**
8.	**Concurrent Land Management Practices**	**Fertilizer management, integrated pesticide management, possibly streamside management.**

Contour Stripcropping: This practice is similar to contour farming where the farmer plows across the slope of the land. The difference is that strips of close growing crops or meadow grasses are planted between strips of row crops like corn or soybeans. Whereas contour farming can be used on 2-8 percent slopes, contour stripcropping can be used on 8-15 percent slopes.

CRITERIA		REMARKS
1.	**Effectiveness**	
	a) Sediment	**Good, 8 to 15 percent slopes, provides the benefits of contour plowing plus buffer strips.**
	b) Nitrogen (N)	**Unknown, assumed to be fair to good.**
	c) Phosphorus (P)	**Unknown, assumed to be fair to good.**
	d) Runoff	**Good to excellent.**
2.	**Capital Costs**	**No special effect unless farmer cannot use the two crops.**
3.	**Operation and Maintenance**	**No special effect.**
4.	**Longevity**	**Poor, must be practiced year after year.**
5.	**Confidence**	**Poor, not enough information.**
6.	**Adaptability**	**Fair to good, may not work with large farming equipment on steep slopes.**
7.	**Potential Treatment Side Effects**	**Side effects not identified.**
8.	**Concurrent Land Management Practices**	**Fertilizer management, integrated pesticide management.**

APPENDIX IV
Review of Best Management Practices (BMP's)
(continued)

Range and Pasture Management: The objective of range and pasture management is to prevent overgrazing because of too many animals in a given area. Management practices include spreading water supplies, rotating animals between pastures, spreading mineral and feed supplements or allowing animals to graze only when a particular plant food is growing rapidly.

CRITERIA		REMARKS
1.	Effectiveness	
	a) Sediment	Good, prevents soil compaction which reduces infiltration rates.
	b) Nitrogen (N)	Unknown.
	c) Phosphorus (P)	Unknown.
	d) Runoff	Good, maintains some cover which reduces runoff rates.
2.	Capital Costs	Low, but may have to develop additional water sources.
3.	Operation and Maintenance	Low.
4.	Longevity	Excellent.
5.	Confidence	Good to excellent. Farmer must have a knowledge of stocking rates, vegetation types, and vegetative conditions.
6.	Adaptability	Excellent.
7.	Potential Treatment Side Effects	None identified.
8.	Concurrent Land Management Practices	Livestock exclusion, riparian zone management and crop rotation.

Crop Rotation: Where a planned sequence of crops are planted in the same area of land. For example, plow based crops are followed by pasture crops such as grass or legumes in two to four year rotations.

CRITERIA		REMARKS
1.	Effectiveness	
	a) Sediment	Good when field is in grasses or legumes.
	b) Nitrogen (N)	Fair to good.
	c) Phosphorus (P)	Fair to good.
	d) Runoff	Good when field is in grasses or legumes.
2.	Capital Costs	High if farm economy reduced. Less of a problem with livestock which can use plants as food.
3.	Operation and Maintenance	Moderate, increased labor requirements. May be offset by lower nitrogen additions to the soil when corn is planted after legumes, and reduction in pesticide application.
4.	Longevity	Good.
5.	Confidence	Fair to good.
6.	Adaptability	Good, but some climatic restrictions.
7.	Potential Treatment Side Effects	Reduction in possibility of groundwater contamination.
8.	Concurrent Land Management Practices	Range and pasture management.

APPENDIX IV
Review of Best Management Practices (BMP's)
(continued)

Terraces: Terraces are used where contouring, contour strip cropping, or conservation tillage do not offer sufficient soil protection. Used in long slopes and slopes up to 12 percent; terraces are small dams or a combination of small dams and ditches that reduce the slope by breaking it into lesser or near horizontal slopes.

CRITERIA		REMARKS
1.	**Effectiveness**	
	a) Sediment	**Fair to good.**
	b) Nitrogen (N)	**Unknown.**
	c) Phosphorus (P)	**Unknown.**
	d) Runoff	**Fair, more effective in reducing erosion than total runoff volume.**
2.	**Capital Costs**	**High initial costs.**
3.	**Operation and Maintenance**	**Periodic maintenance cost, but generally offset by increased income.**
4.	**Longevity**	**Good with proper maintenance.**
5.	**Confidence**	**Good to excellent.**
6.	**Adaptability**	**Fair, limited to long slopes and slopes up to 12 percent.**
7.	**Potential Treatment Side Effects**	**If improperly designed or used with poor cultural and management practices, they may increase soil erosion.**
8.	**Concurrent Land Management Practices**	**Fertilizer and pesticide management.**

Animal Waste Management: A practice where animal wastes are temporarily held in waste storage structures until they can be utilized or safely disposed. Storage units can be constructed or reinforced concrete or coated steel. Wastes are also stored in earthen ponds.

CRITERIA		REMARKS
1.	**Effectiveness**	
	a) Sediment	**Not applicable.**
	b) Nitrogen (N)	**Good to excellent.**
	c) Phosphorus (P)	**Good to excellent.**
	d) Runoff	**Not applicable.**
2.	**Capital Costs**	**High because of the necessity of construction and disposal equipment.**
3.	**Operation and Maintenance**	**Unknown.**
4.	**Longevity**	**Unknown.**
5.	**Confidence**	**Fair to excellent if properly managed.**
6.	**Adaptability**	**Good.**
7.	**Potential Treatment Side Effects**	**The use of earthen ponds can possibly lead to groundwater contamination.**
8.	**Concurrent Land Management Practices**	**Fertilizer management.**

APPENDIX IV
Review of Best Management Practices (BMP's)
(continued)

Nonvegetative Soil Stabilization: Examples of temporary soil stabilizers include mulches, nettings, chemical binders, crushed stone, and blankets or mats from textile material. Permanent soil stabilizers include coarse rock, concrete, and asphalt. The purpose of soil stabilizers is to reduce erosion from construction sites.

CRITERIA		**REMARKS**
1.	**Effectiveness**	
	a) Sediment	**Excellent.**
	b) Nitrogen (N)	**Poor.**
	c) Phosphorus (P)	**Poor.**
	d) Runoff	**Poor on steep slopes with straw mulch, otherwise good.**
2.	**Capital Costs**	**Low to high, depending on technique applied.**
3.	**Operation and Maintenance**	**Moderate.**
4.	**Longevity**	**Generally a temporary solution until a more permanent cover is developed. Excellent for permanent soil stabilizer.**
5.	**Confidence**	**Good.**
6.	**Adaptability**	**Excellent.**
7.	**Potential Treatment Side Effects**	**No effect on soluble pollutants.**
8.	**Concurrent Land Management Practices**	**Runoff detention/retention.**

Porous Pavement: Porous pavement is asphalt without fine filling particles on a gravel.

CRITERIA		**REMARKS**
1.	**Effectiveness**	
	a) Sediment	**Good.**
	b) Nitrogen (N)	**Good.**
	c) Phosphorus (P)	**Good.**
	d) Runoff	**Good to excellent.**
2.	**Capital Costs**	**Moderate, slightly more expensive than conventional surfaces.**
3.	**Operation and Maintenance**	**Potentially expensive, requires regular street maintenance program and can be destroyed in freezing climates.**
4.	**Longevity**	**Good, with regular maintenance (i.e., street cleaning), in southern climates. In cold climates, freezing and expansion can destroy.**
5.	**Confidence**	**Unknown.**
6.	**Adaptability**	**Excellent.**
7.	**Potential Treatment Side Effects**	**Groundwater contamination from infiltration of soluble pollutants.**
8.	**Concurrent Land Management Practices**	**Runoff detention/retention.**

APPENDIX IV
Review of Best Management Practices (BMP's)
(continued)

Flood Storage (Runoff Detention/Retention): Detention facilities treat or filter out pollutants or hold water until treated. Retention facilities provide no treatment. Examples of detention/retention facilities include ponds, surface basins, underground tunnels, excess sewer storage and underwater flexible or collapsible holding tanks.

CRITERIA		REMARKS
1.	Effectiveness	
	a) Sediment	Poor to excellent, design dependent.
	b) Nitrogen (N)	Very poor to excellent, design dependent.
	c) Phosphorus (P)	Very poor to excellent, design dependent.
	d) Runoff	Poor to excellent, design dependent.
2.	Capital Costs	Dependent on type and size. Range from $100 to $1,000, per acre served, depending on site. These costs include capital costs and operational costs.
3.	Operation and Maintenance	Annual cost per acre of urban area served has ranged from $10 to $125 depending on site.
4.	Longevity	Good to excellent, should last several years.
5.	Confidence	Good, if properly designed.
6.	Adaptability	Excellent.
7.	Potential Treatment Side Effects	Groundwater contamination with retention basins.
8.	Concurrent Land Management Practices	Porous pavements.

Sediment Traps: Sediment traps are temporary structures made of sandbags, straw bales, or stone. Their purpose is to detain runoff for short periods of time so heavy sediment particles will drop out. Typically, they are applied within and at the periphery of disturbed areas.

CRITERIA		REMARKS
1.	Effectiveness	
	a) Sediment	Good, coarse particles.
	b) Nitrogen (N)	Poor.
	c) Phosphorus (P)	Poor.
	d) Runoff	Fair.
2.	Capital Costs	Low.
3.	Operation and Maintenance	Low, require occasional inspection and prompt maintenance.
4.	Longevity	Poor to good.
5.	Confidence	Poor.
6.	Adaptability	Excellent.
7.	Potential Treatment Side Effects	None identified.
8.	Concurrent Land Management Practices	Agricultural, silviculture or other construction best management practices could be incorporated depending on situation.

APPENDIX IV
Review of Best Management Practices (BMP's)
(continued)

Surface Roughening: On construction sites, the surface of the exposed soil can be roughened with conventional construction equipment to decrease water runoff and slow the downhill movement of water. Grooves are cut along the contour of a slope to spread runoff horizontally and increase the water infiltration rate.

CRITERIA		REMARKS
1.	**Effectiveness**	
	a) Sediment	**Good.**
	b) Nitrogen (N)	**Unknown.**
	c) Phosphorus (P)	**Unknown.**
	d) Runoff	**Good.**
2.	**Capital Costs**	**Low, but requires timing and coordination.**
3.	**Operation and Maintenance**	**Low, temporary protective measure.**
4.	**Longevity**	**Short-term.**
5.	**Confidence**	**Unknown.**
6.	**Adaptability**	**Excellent.**
7.	**Potential Treatment Side Effects**	**None identified.**
8.	**Concurrent Land Management Practices**	**Nonvegetative soil stabilization.**

Riprap: A layer or loose rock or aggregate placed over a soil surface susceptible to erosion.

CRITERIA		REMARKS
1.	**Effectiveness**	
	a) Sediment	**Good, based on visual observations.**
	b) Nitrogen (N)	**Unknown.**
	c) Phosphorus (P)	**Unknown.**
	d) Runoff	**Poor.**
2.	**Capital Costs**	**Low to high, varies greatly.**
3.	**Operation and Maintenance**	**Low.**
4.	**Longevity**	**Good, with proper rock size.**
5.	**Confidence**	**Poor to good.**
6.	**Adaptability**	**Excellent.**
7.	**Potential Treatment Side Effects**	**In streams, erosion may start in a new, unprotected place.**
8.	**Concurrent Land Management Practices**	**Streamside (lake) management zone.**

APPENDIX IV
Review of Best Management Practices (BMP's)
(continued)

Interception or Diversion Practices: Designed to protect bottom land from hillside runoff, divert water from areal sources of pollution such as barnyards or to protect structures from runoff. Diversion structures are represented by any modification of the surface that intercepts or diverts runoff so that the distance of flow to a channel system is increased.

CRITERIA		**REMARKS**
1.	**Effectiveness**	
	a) Sediment	**Fair to good (30 to 60 percent reduction).**
	b) Nitrogen (N)	**Fair to good (30 to 60 percent reduction).**
	c) Phosphorus (P)	**Fair to good (30 to 60 percent reduction).**
	d) Runoff	**Poor, not designed to reduce runoff but divert runoff.**
2.	**Capital Costs**	**Moderate to high, may entail engineering design and structures.**
3.	**Operation and Maintenance**	**Fair to good.**
4.	**Longevity**	**Good.**
5.	**Confidence**	**Poor to good, largely unknown.**
6.	**Adaptability**	**Excellent.**
7.	**Potential Treatment Side Effects**	**None identified.**
8.	**Concurrent Land Management Practices**	**Since the technique can be applied under multiple situations (i.e., agriculture, silviculture, construction) appropriate best management practices associated with individual situations should also be applied.**

Grassed Waterways: A practice where broad and shallow drainage channels (natural or constructed) are planted with erosion-resistant grasses.

CRITERIA		**REMARKS**
1.	**Effectiveness**	
	a) Sediment	**Good to excellent (60 to 80 percent reduction).**
	b) Nitrogen (N)	**Unknown.**
	c) Phosphorus (P)	**Unknown.**
	d) Runoff	**Moderate to good.**
2.	**Capital Costs**	**Moderate.**
3.	**Operation and Maintenance**	**Low, but may interfere with the use of large equipment.**
4.	**Longevity**	**Excellent.**
5.	**Confidence**	**Good.**
6.	**Adaptability**	**Excellent.**
7.	**Potential Treatment Side Effects**	**None identified.**
8.	**Concurrent Land Management Practices**	**Conservative tillage, integrated pest management, fertilizer management, animal waste management.**

APPENDIX IV
Review of Best Management Practices (BMP's)
(continued)

Maintain Natural Waterways: This practice disposes of tree tops and slash in areas away from waterways. Prevents the buildup of damming debris. Stream crossings are constructed to minimize impacts on flow characteristics.

CRITERIA		REMARKS
1.	**Effectiveness**	
	a) Sediment	**Fair to good, prevents acceleration of bank and channel erosion.**
	b) Nitrogen (N)	**Unknown, contribution would be from decaying debris.**
	c) Phosphorus (P)	**Unknown, contribution would be from decaying debris.**
	d) Runoff	**Fair to good, prevents deflections or constrictions of stream water flow which may accelerate bank and channel erosion.**
2.	**Capital Costs**	**Low, supervision required to ensure proper disposal of debris.**
3.	**Operation and Maintenance**	**Low, if proper supervision during logging is maintained, otherwise $160-$800 per 100 ft stream.**
4.	**Longevity**	**Good.**
5.	**Confidence**	**Good.**
6.	**Adaptability**	**Excellent.**
7.	**Potential Treatment Side Effects**	**None identified.**
8.	**Concurrent Land Management Practices**	**Proper design and location of haul and skid trails; Streamside management zones.**

Haul Roads and Skid Trails: This practice is implemented prior to logging operations. It involves the appropriate site selection and design of haul road and skid trails. Haul roads and skid trails should be located away from streams and lakes. Recommended guidelines for gradient, drainage, soil stabilization, and filter strips should be followed. Routes should be situated across slopes rather than up or down slopes. If the natural drainage is disrupted, then artificial drainage should be provided. Logging operations should be restricted during adverse weather periods. Other goods practices include ground covers (rock or grass) closing roads when not in use, closing roadways during wet periods, and returning main haul roads to prelogging conditions when logging ceases.

CRITERIA		REMARKS
1.	**Effectiveness**	
	a) Sediment	**Good if grass cover is used on haul roads (45 percent reduction); Excellent if crushed rock is used as ground cover (92 percent reduction).**
	b) Nitrogen (N)	**Unknown.**
	c) Phosphorus (P)	**Unknown.**
	d) Runoff	**Unknown.**
2.	**Capital Costs**	**High, grass cover plus fertilizer $5.37/100 ft roadbed, crushed rock (6 in) $179.01/100ft roadbed.**
3.	**Operation and Maintenance**	**High, particularly with grass which may have to be replenished routinely and may not be effective on highly traveled roads.**
4.	**Longevity**	**Unknown.**
5.	**Confidence**	**Good for ground cover, poor for nutrients.**
6.	**Adaptability**	**Good.**
7.	**Potential Treatment Side Effects**	**Potential increase in nutrients to water course if excess fertilizers are applied.**
8.	**Concurrent Land Management Practices**	**Maintain natural waterways.**

APPENDIX V
SOURCES OF INFORMATION AND ASSISTANCE (15)
Cary Millpond, Waupaca County

Department of Natural Resources:

Waupaca Area Office
N2490 Hartman Creek Road
Waupaca, WI 54981
715-258-2372 or

Lake Michigan District Office
Tim Rasman
Lakes-LMD
1125 N. Military Road, Box 10448
Green Bay, WI 54307-0448
414-497-6034

Can answer questions on lake management, groundwater, water quality, fisheries, regulations, zoning and wildlife or direct you to someone that can be of help.

East Central Wisconsin Planning Commission:

Ken Theine
RP, ECWRPC
132 N. Main Street
Menasha, WI 54952
414-729-4770

Has information regarding zoning and building planning information as well as information on land use.

Environmental Task Force:

Environmental Task Force
College of Natural Resources
UW-Stevens Point
Stevens Point, WI 54481

Will test soils, lake water or well water.

APPENDIX V
(Continued)

IPS Environmental and Analytical Services

IPS Environmental and Analytical Services
ATTN: Lake Management Program
P.O. Box 446
Appleton, WI 54912-0446
(414) 749-3040 (Business Phone)
(414) 749-3046 (FAX)

Has specific information on the Cary Millpond management plan and development of other management plans in the area.

State Laboratory of Hygiene:

University of Wisconsin
Center for Health Sciences
465 Henry Mall
Madison, WI 53706
608-262-3458

Can give information on costs or testing of water and soils.

Waupaca County Lakes Association:

Greg Peterson
LCC, Courthouse
811 Harding Street
Waupaca, WI 54981
715-258-6245

Can furnish information on lakes in Waupaca County.

Waupaca County Land Conservation Department:

Bruce Bushweiler
LCC, Courthouse
811 Harding Street
Waupaca, WI 54981
715-258-6245

Can provide soil erosion prevention measures and water quality problems related to your area.

APPENDIX V
(Continued)

Waupaca County Soil Conservation Service (USDA):

Gary Elmer
SCS, Courthouse
811 Harding Street
Waupaca, WI 54981
715-258-6245

Can provide information on soil types and limitations, depths to groundwater and bedrock and related information.

Waupaca County University of Wisconsin Extension:

Tom Wilson
UWEX, Courthouse
811 Harding Street
Waupaca, WI 54981
715-258-6230

Has information of agricultural practices, waste disposal and conservation practices.

Waupaca County Zoning Administration:

Dave Rosenfeldt
ZA, Courthouse
811 Harding Street
Waupaca, WI 54981
715-258-6255

May have information on development, land uses, floodplain and regulations regarding land parcels in your area.

APPENDIX VI
SUMMARY OF PERTINENT WAUPACA COUNTY ORDINANCES AND PLANS

Waupaca County Zoning Ordinance

Included in this ordinance are regulations for floodplain zoning, general shoreland provisions, and land subdivisions.

- Floodplain Zoning: Section 87.30 Wis. Stats. requires all counties to adopt floodplain zoning as part of their local zoning ordinance. This type of zoning is used to minimize flood damage in areas subject to flooding.

  Waupaca County's floodplain ordinance regulates all lands that would be inundated by a "regional flood" or a flood the magnitude that could be expected on the average of once per hundred years. Floodplain districts include a floodway and flood fringe area. The floodway is the channel of a stream and that portion of the floodplain adjoining the channel that would carry and discharge the floodwaters of the stream. Only open space uses that have a low flood damage potential and will not obstruct flood flows are permitted within the floodway.

  The flood fringe is that portion of the floodplain between the outer limits of the general floodplain and the floodway that would be covered by flood waters during a regional flood. The flood fringe is generally associated with standing water rather than rapidly flowing water. A number of structural land uses are permitted in the flood fringe, provided they meet certain floodproofing standards.

  Shoreland Provisions: As required under Section 59.971 Wis. Stats., Waupaca County was required to adopt shoreland zoning. This type of zoning provides the means to protect valuable natural resources that are common along lakes and rivers. The ordinance can prevent development of land and certain land use activities from adversely affecting the waterbody.

Soil Erosion Control Plan

In 1988, Waupaca County adopted a Soil Erosion Control Plan based on guidelines contained in Chapter AG 160 of the Wisconsin

APPENDIX VI
(Continued)

Administrative Code. The purpose of the plan is to "... determine where the most serious erosion is occurring and to establish a strategy to address the problem." (Waupaca County, 1988). Specifically, the plan provides educational programs, technical assistance, and seeks cost sharing funds to reduce soil erosion to acceptable limits and reduce the amount of sediment being carried to surface waters. Based on maintaining a tolerable soil loss level (expressed as "T"), the plan delineates areas in the county that should receive priority assistance in reducing soil loss. Although the plan looks at soil loss in relation to maintaining agricultural productivity, it can also have a significant impact in reducing nutrient loadings to rivers and lakes.

Animal Waste Water Pollution Control Plan

In 1986, Waupaca County adopted an Animal Waste Management Plan. The purpose of this plan is to "...identify those areas within the county that have the greatest potential for water pollution caused by animal waste." As with the Soil Erosion Control Plan, these priority areas will be eligible to receive technical and cost share assistance, as available.

APPENDIX VII
POTENTIAL FUNDING SOURCES FOR PLAN IMPLEMENTATION

Potential sources of funds to assist plan implementation include:

County:

- Conservation funds from the state to be used for natural resources projects (old predator fund). Erosion control cost share funds through Land Conservation Committee.
- Waupaca County Water Quality Maintenance Program. Over $20,000 is available annually for the upkeep and protection of Waupaca County surface waters in the areas of lake management planning, Adopt-a-waterway, soil erosion abatement and watershed enhancement (i.e. rock rip-rapping).

State:

- WDNR Priority Watershed Program. This program has been modified to include priority lakes. The program provides 50-80% cost share for installing "best management practices" to combat nonpoint source water pollutants. Projects are selected by the WDNR and administered by the County Land Conservation Committee.
- WDNR Lake Management Grants. Funding is available to local governments and lake management organizations for the collection and analysis of information needed to manage lakes. The state may pay for 75% of the cost and up to $10,000 for any one project. The remaining 25% must be provided by the local organization or cash contributions from other sources. Projects may include: gathering and analysis of physical, chemical and biological information, describing present and potential land uses within lake watersheds, reviewing jurisdictional boundaries and evaluating ordinances that relate to zoning, sanitation or pollution control, gathering and analyzing information from lake property owners, community residents and lake users, developing alternative courses of action and recommendations.
- WDNR Lake Protection Grants. Another 75% cost share program which allows lake management organizations to obtain funds to protect or

restore lakes and their ecosystems. Activities

APPENDIX VII
(Continued)

eligible for funding include: the purchase of property which will contribute to the protection or improvement of the natural ecosystem and water quality of a lake, the restoration of wetlands, the development of regulations and ordinances, and any lake improvement projects recommended in a DNR approved plan including lake restoration, watershed management, pollution prevention and control projects.

- WDNR's Recreational Boating Facilities Program (NR 7). Program has been expanded to include qualified lake associations as applicants. This program is administered by the WDNR and supervised by the Wisconsin Waterways Commission. Forty percent of funds are allocated to the Great Lakes, 40% to inland lakes and 20% is discretionary. Financial assistance is available for safe recreational boating projects including: "...dredging of channels of waterways for recreational boating purposes, acquisition of capital equipment necessary to cut and remove aquatic plants, and acquisition of aids to navigate and regulatory markers." A 50% cost share is provided.

- Dam Repairs. Counties, cities, villages, towns and public inland lake protection and rehabilitation districts are eligible for 50% cost sharing of dam maintenance, repair, modification or abandonment. Three million dollars is allocated annually and dams must be inspected by the WDNR and be under directives to be repaired.

- DATCP Farmers' Fund (AG 165). Assists farmers with construction of animal waste management installations (county sets design standards). Soil Erosion Control (AG 160) funds targeted to areas that counties have identified as priorities in the County Erosion Control Plan (the watershed including Weyauwega Lake is not currently identified as a priority soil erosion area).

- Stewardship Program. Ten year $250,000 to protect environmentally sensitive areas and acquire or maintain recreational areas. The funds are raised by state sale of bonds. Potential lake applications include:

APPENDIX VII
(Continued)

Habitat Restoration Areas - $1.5M annually to encourage private landowners and non-profit organizations to adopt management practices favorable to wildlife.

Urban Green Space - $750,000 annually for 50% grants to municipalities to protect scenic or ecological sites from development.

Streambank Protection - $1M annually to WDNR to purchase streambank easements of at least 66 feet and to provide fencing.

Federal:

- EPA Clean Lakes Program (appropriations pending). Limited amount of cost share funding for planning and implementing public lake protection and restoration projects. WDNR must apply for the funds on behalf of lake organization. Requires EPA feasibility study.

- US Army Corps of Engineers. Can provide limited cost share funds to states to support selected aquatic plant management projects. Must be identified by WDNR as high priority and have an in-depth aquatic plant management plan.

- USDA (1985 Federal Farm Bill). Program to take land out of agricultural production. While these funds go to individual farmers, lake leaders may want to encourage farmers to use these programs. Conservation Reserve Program is purchasing the right to keep some Wisconsin farmland out of cultivation for 10 years. County office administers the program.

- FmHA Loan program to farmers in exchange for Conservation Easements. Long-term easements take land adjacent to wetlands, lakes and streams out of production. Annual multi-year set-aside programs.

- SCS. Beginning in 1983, SCS has provided large grants to selected areas to enhance water quality.

APPENDIX VII
(Continued)

Miscellaneous:

Programs that might be useful in certain situations include: Trout Stamp land purchase program (WDNR), Water Bank Program (ASCS), water safety patrol aids (WDNR), Land and Water Conservation Fund (US Dept. of Interior and WDNR), Forest Incentive Program (ASCS), Mining Investment and Local Impact Fund (Wis. Dept. of Revenue) and Septic Tank Replacement Program (WDNR).

PHASE I
LAKE MANAGEMENT PLAN
CARY MILLPOND
WAUPACA COUNTY, WISCONSIN

Prepared for

the City of Waupaca

by

December, 1995