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SECTION 1
INTRODUCTION

In January of 1992, the Lake Delton Lake Association and the Village of Lake Delton selected a lake study and management plan proposal prepared by Woodward-Clyde Consultants (formally EWI Engineering Associates). The proposal was submitted to the Wisconsin Department of Natural Resources' Lake Management Planning Grant Program for funding. The application was awarded a state grant for about 75% of the cost of the study. The remainder of the study was funded jointly by the Lake Association and Village.

The study, as described in the proposal set out the following objectives:

1. Conduct a water quality/quantity monitoring survey to document the water quality conditions and to help confirm the results from a watershed pollutant loading model which will be developed as part of this study.

2. Develop a nutrient budget (phosphorus) for the lake. This nutrient budget will help determine remediation measures and the potential water quality goals for the lake.

3. Conduct a complete watershed evaluation to determine the quantity and quality of runoff to the lake. The nonpoint source pollution will be quantified by land use type within the watershed.

4. Evaluate alternative watershed control measures. Develop recommendations for watershed treatment based upon applicability, implementation costs, and availability of funding.

5. Document the study in a report suitable for review by potential funding agencies. The report should also serve as a step-by-step manual for use in implementing remedial measures.

The study is documented within this report.

SECTION 2
BACKGROUND AND SETTING OF LAKE DELTON

GENERAL INFORMATION

Lake Delton is a 270 acre impoundment in Sauk County, Wisconsin (see Figure 2-1). A dam on Dell Creek just upstream of the Wisconsin River was constructed about 1928 to create the Lake Delton impoundment. The lake's original maximum depth was 16 feet. The current maximum depth is about 14 feet. The lake is considered nutrient rich (eutrophic), and has experienced algae and duckweed nuisance conditions for many years. The Lake is heavily used for recreational purposes because of it's location near the Wisconsin Dells tourist area. Commercial uses of the lake include tour boats, ski show, and aquatic recreational craft rentals.

THE WATERSHED AND LAND USE

The Lake Delton watershed encompasses approximately 75 square miles. The topography of the area consists of gentle hills with steep sandstone outcrops along the river and creek valleys. The soils are generally glacial outwash sands.

The land use of the watershed is mostly rural agricultural, however there are significant areas of development around the lake in the Village of Lake Delton. The rural land use is dominated by dairy farming operations. Public lands also make up a significant area of rural land use. Mirror Lake State Park is 2,050 acres in size and the Dell Creek State Wildlife Area encompasses 2,125 acres. Table 2-1 shows a breakdown of the land use.

The only incorporated community in the watershed is the Village of Lake Delton with a year round population of 1,650. Although the land area is not large (approximately 1,000 acres) the land use is intensive commercial development. The Lake Delton area is a very popular tourist attraction area and the summer population swells to 30,000 - 40,000. The commercially developed area includes numerous amusement attractions, a dog race track, restaurants, stores, and other establishments.

Table 2.1
Land Use Cover in the Lake Delton Watershed

Land Use Type	Acres (%)
Cropland	14,015 (29%)
Pasture	5,425 (11%)
Woodland/Open Lands	28,019 (58%)
Residential	493 (1%)
Industrial & Commercial	550 (1%)
Total:	**48,502 (100%)**

Source: Sauk County Erosion Control Plan and 1992 Aerial Photographs

WATER RESOURCES OF THE WATERSHED

Besides Lake Delton, there two other named lakes within the watershed: Mirror Lake and Blass Lake (see Figure 2-1). Mirror Lake is a 137 acre impoundment on Dell Creek, and Blass Lake is a 34 acre impoundment on Spring Brook Creek. The major tributaries to Lake Delton include Dell Creek and Spring Brook Creek. Lost Canyon Creek is an intermittent tributary on the south side of Lake Delton. In addition to these tributaries, Beaver and Camel Creeks feed Dell Creek, and Harrison Creek is a direct tributary to Mirror Lake. Dell Creek (above Mirror Lake), Camel's Creek, Harrison Creek, and Beaver are all classified as "Class II" trout streams by the Wisconsin Department of Natural Resources.

Figure 2.1: General Map of Lake Delton Watershed

SECTION 3
METHODS USED IN THE STUDY

WATER QUALITY SAMPLING

Water Quality sampling of Lake Delton, its major tributaries, and the outlet of the lake were conducted three times in 1992 by Woodward-Clyde Consultants. Table 3-1 shows the locations of the sampling sites, the dates of sampling, and the parameters sampled. All nutrient and chlorophyll-a samples were immediately placed on ice. The nutrient samples were preserved with sulfuric acid provided by the Wisconsin State Laboratory of Hygiene (SLOH) in Madison, Wisconsin. All samples were submitted to SLOH within 24 hours of sampling.

Lake measurements of dissolved oxygen and temperatures were conducted with a Yellow Springs Instrument (YSI) Model 59 dissolved oxygen meter. The probe membrane was changed, stabilized, and air calibrated before each sample trip.

All flow measurements were done with a Pygmy flow meter.

The lab reports and field notes are in Appendix B. Section 4.0, of this report presents detailed tables of the sampling results.

Table 3.1
Sampling Sites, Dates, & Parameters in 1992
(all sampling conducted by Woodward Clyde-Consultants)

Water Body	Location/ Sample Date		Nutrients[1]	Suspended Sediment	Dissolved Oxygen/ Temperature	Flow
Lost Canyon Cr.	Canyon Rd.	4/23	Yes	Yes	Yes	Yes
		7/23	Yes	Yes	Yes	No[2]
		8/20	No	No	No	No[7]
Dell Creek	Ishnala Rd.	4/23	Yes	Yes	Yes	No[3]
		7/23	Yes	Yes	Yes	No[3]
		8/20	Yes	Yes	Yes	Yes
Spring Brook	Below Biblical Garden's Spillway	4/23	Yes	Yes	Yes	Yes
		7/23	Yes	Yes	Yes	Yes
		8/20	Yes	Yes	Yes	Yes
Lake Delton Outlet	Above Co. Hwy A.	4/23	No [4]	No	No	No[4]
		7/23	Yes	Yes	No	Yes
		8/20	Yes	Yes	Yes	Yes
Lake Delton[5]	Mid-Lake (3 depths)	4/23	Yes	N/A[6]	Yes	N/A[6]
		7/23	Yes	N/A	Yes	N/A
		8/20	Yes	N/A	Yes	N/A

1 Nutrient analysis included total phosphorus and total Kjeldahl Nitrogen for the creek samples and total phosphorus for the lake samples.

2 Flow was too low to measure; estimated at less than .5 cubic feet/second

3 Flow was too high to wade stream; flow calculated with broad-crested weir formula

4 Flow was too high to access outlet stream below dam for sampling or flow measurement

5 Sampling in Lake Delton also included Secchi disk and surface Chlorophyll-a sample at each visit

6 Sediment samples and flow measurements not in lake sampling plan.

7 No flow

NONPOINT SOURCE POLLUTION INVENTORY METHODS

Rural Pollutant Sources

Phosphorus - Barnyard Runoff

Phosphorus loads to Lake Delton attributed to barnyard runoff are estimated using data collected by the Sauk County Land Conservation Department in 1990 on the "Narrows Creek/Little Baraboo River Priority Watershed Project". This project, done in cooperation with Department of Natural Resources (DNR) and Department of Agriculture, Trade, and Consumer Protection (DATCP) involved a detailed inventory of every barnyard in the Narrows Creek/Little Baraboo River watershed. The watershed is located in Sauk County and includes the lands draining to the Baraboo River between Reedsburg and Baraboo.

A barnyard is simply defined as a livestock concentration area. The prediction of pollutants from the barnyard is based on a computer model called BARNY. This model estimates the amount of pollutants (including phosphorus) that is picked up by the runoff water flowing through the barnyard area over an average year.

The Narrows/Baraboo Watershed was subdivided into smaller areas for data analysis purposes. One of these subdivisions is called Copper Creek. This is a 5,700 acre area which is adjacent, and just south of the Dell Creek watershed. Discussions with Joe Van Berkle (Sauk County Land Conservation Department) confirmed that Copper Creek has similar land use, soils, and topography to the rural portions of the Lake Delton watershed. For this reason, the conditions found from the inventory of Copper Creek as part of the Narrows Creek/Baraboo River Watershed Project were applied to the Lake Delton watershed for purposes of estimating phosphorus from barnyard runoff.

During the Copper Creek inventory it was found that there were 21 barnyard with a total annual phosphorus contribution of 1,328 pounds. This is an average of 149 pounds of phosphorus per square mile of watershed within Copper Creek. This phosphorus loading rate is applied to Dell Creek and Spring Brook Creek watersheds to estimate the barnyard contribution of phosphorus to Lake Delton.

Phosphorus - Upland Erosion

Erosion from cropland, pastures, woodlots, and other lands also contribute phosphorus to streams and lakes in a watershed. Two sources of information are used to estimate the contribution of phosphorus to Lake Delton from upland erosion.

The first data source is water quality monitoring conducted by the United States Geological Survey (USGS) on rural watersheds in Wisconsin. For this study the monitoring conducted in the Black Earth Creek watershed (Dane County) from 1985 - 1991 was used. Monitoring at four different sites over this period found that for every ton of suspended sediment in the stream there is an average of 5.82 pounds of phosphorus. This ratio is applied to the sediment loads calculated for the Lake Delton Watershed to estimate the phosphorus loads in the runoff waters. The calculation of the sediment pollutant load for Lake Delton is described below.

There is one consideration which must be taken into account when using the sediment to phosphorus ratio. The phosphorus monitored by the USGS includes phosphorus from both barnyards and upland sources. The fraction of the phosphorus coming from the barnyard based on the BARNY modeling was subtracted from the phosphorus load calculated for the Lake Delton watershed. The remaining phosphorus is then attributed to the upland sources since there were no other significant sources of phosphorus in the rural portion of the watershed.

Sediment - Upland Sources

During the Narrows Creek/Little Baraboo Watershed Project, sediment from various land uses was calculated using a detailed modeling effort called the Wisconsin Nonpoint (WIN) model. This model calculated sediment loads in tons/square mile/year for various types of land uses (such as cropland, pasture, woodlots, etc). The acres of land under the various land use categories for Dell Creek and Spring Brook Creek watersheds are based on the findings of the Sauk County Erosion Control Plan (1987). The sediment loading rates are shown below. The rates found in the Copper Creek were applied to the rural land uses in the Dell Creek and Spring Brook Creek watersheds. The results of the estimate are shown on Table 4.3.

Table 3.2
Sediment Loading Rates for Copper Creek Subwatershed

Land Use	Sediment Load (tons/sq.mile/year)
Cropland	155.0
Woodlots	4.1
Pasture	44.7

* Source: "Narrows Cr./Baraboo River Priority Watershed Plan", Sauk County LCD and WDNR

Sediment - Streambank Erosion Source

Streambank erosion is the another major source of sediment in a rural watershed. Again, the streambank erosion inventories conducted in Copper Creek as part of the Narrows Creek/Baraboo River Watershed Project were used to estimate this sediment source in the Lake Delton Watershed. Inventories conducted by Sauk County LCD found that there are 3.03 tons of sediment per year from eroding streambanks for each square mile of Copper Creek watershed. This per square mile rate is applied to Dell Creek and Spring Brook Creek watersheds to estimate the annual sediment amount from stream bank erosion to Lake Delton. The results of the estimate are shown on Table 4.3

Urban Pollutant Sources

Background

Nonpoint Pollution loadings from the urban areas of the watershed were determined using a model called "Source Load and Management Model" (SLAMM). This model is used by

the WDNR in it's Nonpoint Source Pollution Abatement Program. The model calculates, on an annual basis, the amount of sediment, phosphorus, and heavy metals, contained in the runoff waters from an urban area. The SLAMM calculates these pollutant loadings based on several factors including:

- Land use
- Street conditions
- Drainage system
- Existing drainage control practices
- Existing street sweeping program
- Climatic conditions

Procedure for Using SLAMM

The steps taken in this study to calculate the urban nonpoint source pollution loads with the SLAMM are listed below.

1. Determine Village of Lake Delton drainage basins

   Using the 1" = 2,000' (7.5 minute) USGS topographic map, the Village of Lake Delton was subdivided into nine major drainage basins. These basins are listed on Table 3.2 and shown on Figure 3.1.

2. Determine types and extent of existing land uses

   WCC met with Village of Lake Delton Public Works Director to obtain the current land use and Village zoning maps. This data was supplemented with air photos of the Village flown in the spring of 1992. The photos were used to add in any land use conditions not shown on the zoning map. The areas of each land use type were digitized from the Village zoning map and the results are shown on Table 3.3.

3. Set SLAMM conditions to Village characteristics

For each land use type, SLAMM modifies the quantity of pollutants produced based upon several physical characteristics and management conditions. For each land use the following characteristics were set, based upon WCC discussions with the Village and field observations.

- Road surface roughness
- Road drainage type (ditch, curb and gutter, undeveloped)
- Street sweeping schedule
- Present storm water control measures (basins, ponds, etc)
- Roof drainage type (direct connection to street or connection to grass areas)
- SCS hydrologic soil type
- Street parking density

Table 3.3
Urban Drainage Basin Areas Within the Lake Delton Watershed

Drainage Basin	Area (acres)
U1 Upper Lost Canyon	597.1
U2 Lower Lost Canyon	1,125.6
U3 East Lake Side	304.8
U4 Dell Creek	365.8
U5 Spring Brook Creek	409.4
U6 West Lake Side	178.3
U7 North West Lake Side	223.8
U8 North Lake Side	62.3
U9 South Lake Side	26.8
TOTAL:	**3,293.9**

Table 3.4
Urban Land Use Acreages

Land Use	Acres by Drainage Basin									
	U1	U2	U3	U4	U5	U6	U7	U8	U9	Total
Cemetery	0	0	0	0	12	0	0	0	0	12
Commercial	0	125	0	21	142	68	168	0	0	525
Industrial	18	7	0	0	0	0	0	0	0	25
Park/Open	579	974	220	221	190	0	24	16	14	2,238
Residential	0	19	84	93	65	89	32	46	13	442
Mobile Homes	0	0	0	30	0	21	0	0	0	51
Total	597	1,126	305	366	409	178	224	62	27	3,294

4. Run the SLAMM for pollutant loads

The model was then run for each of the nine urban drainage basins. The pollutants selected for calculation were sediment, total phosphorus, and lead. The model reports a result for each pollutant in pounds (or tons) per year. This means that in an average year, the runoff waters from a land use, or a drainage basin of interest, contains the calculated quantity of the selected pollutant. This quantity is delivered to Lake Delton during periods of rainfall runoff or snowmelt.

Calculating Sediment Runoff from Construction Erosion

Construction sites are particularly vulnerable to sediment washoff. The combination of exposed soil in the setting of an urban drainage system means that almost all of the sediment leaving a construction site through runoff will be delivered to the lake. There is little opportunity for the sediment to settle out before reaching the lake. The WDNR's Nonpoint Source Pollution Abatement Program generally uses a figure of 30 tons/acre/year of sediment eroding from construction sites. This rate was used to estimate the quantity of sediment from construction sites in the Lake Delton watershed.

The aerial photographs of 1992 showed that about 10.4 acres of land were under construction at the time of the photographs. Assuming that this is a representative condition, about 312 tons of sediment were in the runoff from these sites.

Adjustment Made to Calculated Rural and Urban Pollutant Loads

Mirror Lake and Blass Lake Affects

Almost all of the rural runoff from the Lake Delton watershed enters Mirror or Blass Lakes before entering Lake Delton. Mirror and Blass Lakes act as large "settling ponds". The sediment and nutrients in the runoff water enters these lakes and the heavier materials (sand and silt size particles) may drop to the bottom of the lakes and remain at the bottom of the Mirror or Blass Lake. How much of the sediment falls to the bottom of the lake's is called the "trapping efficiency" of the lake.

Because the trapping efficiencies of Mirror and Blass Lakes have not been directly measured, estimates were made based on the physical characteristics of the lakes, literature values, and discussions with Roger Bannerman of WDNR's Bureau of Water Resources. One factor in determining how much material will settle out in a lake is the lake's residence time. A lake's residence time is a measure of the amount of time it takes to completely replace the water within a lake. The longer the lake's residence time, the more material will drop out of the water before the material reaches the outlet of the lake. There are other variables such as the physical location of a lake's inlet and outlet which must also be considered. The table below shows the residence time for the lakes both on a annual basis and for the spring period, when stream flows are higher (and thus residence times lower). Using this information, it can be estimated that 75% of the sediment settles out in the lake before reaching the outlet. The phosphorus trapping efficiency is estimated to be approximately 40% on an average annual basis. These figures are an approximation consistent with measured values in other lake or constructed settling pond situations. The phosphorus trapping is not as effective because during certain times of the year lakes will produce plant material (algae) from the nutrients, and the algae can contribute nutrients to the downstream water bodies. Also, phosphorus is attached to the smallest size sediment particles (clay size). These are the particles which are lightest and have the greatest chance to flow through the lake and exit before settling out.

These figures (75% reduction for sediment and 40% reduction for phosphorus) were applied when calculating the pollutant loads to Lake Delton shown in Tables 4.3 and 4.4.

Table 3.5
Calculated Residence Times for Mirror and Blass Lakes
(Annual and Spring Periods)

Parameter	Mirror Lake	Blass Lake
Area (acres)	137	34
Mean Depth (feet)	8	8
Lake Volume (acre feet)	1,096	272
Average Annual Inflow (cu.ft./sec)	30	3.9
Avg. Annual Runoff Volume (ac. ft.)	21,719	2,823
Average Spring Inflow (cu.ft./sec)*	56	5.1
Avg. Spring Runoff Volume (ac. ft.)	6,776	617
Avg. Annual Residence Time (days)	18.4	35.2
Avg. Spring Residence Time (days)	9.9	26.9

* Spring flows based on average flow of March and April from 1978, 1979, and 1980 (USGS Gauge Station)

Phosphorus Removal from Duckweed Harvesting

The Village of Lake Delton funds a duckweed harvesting operation on Mirror Lake during the late spring and summer months. Floating duckweed has been a nuisance in Lake Delton. In 1990 a Masters Thesis by L. Gardner (UW-Madison) the effects of the duckweed harvesting on reducing the phosphorus to Dell Creek (and Lake Delton downstream) was calculated. The study concluded that the current harvesting removes up to 20% of the summer phosphorus loading to Mirror Lake. The annual phosphorus loading to Mirror Lake is calculated to be 21,067 pounds. The summer flow (mid-May through August) accounts

for about 30% of the annual flow (based on USGS records at Dell Creek station). Thus, the summer phosphorus loading can be estimated at 30% of 21,067 pounds or 6,320 pounds. If the duckweed harvesting program is 20% effective, this would account for a removal of 1,264 pounds of phosphorus during the period of mid-May through August. This figure was applied to reduce the phosphorus load received by Lake Delton and is reflected in Table 4.4.

Animal Phosphorus Sources in Lost Canyon and Lake Delton Direct Drainage Areas

The Lost Canyon and Lake Delton drainage areas each have horse riding stables located within their boundaries. Livestock wastes are a source of phosphorus not considered in the SLAMM urban modeling program which was conducted for these drainage areas. Because of this, phosphorus loading from these two sites were estimated and added to the urban model results. The phosphorus loading was estimated using the BARNY model previously described. The model takes into account:

- # and type of livestock
- physical characteristics of the area contributing runoff to the lot
- size of the animal lot
- physical characteristics of the area between the lot and a channel or stream
- annual rainfall intensities and quantities for the location

The results of the livestock waste modelling showed that the two stables within Lost Canyon contributed an estimated total of 24.5 pounds of phosphorus per year. The stable within the Direct Drainage Area (on the southeast side of the lake) contributed an estimated 12.2 pounds of phosphorus per year. These values were added to the phosphorus loading from Lost Canyon and the Direct Drainage Areas and are shown in Table 4.4.

ESTIMATING OTHER PHOSPHORUS SOURCES TO LAKE DELTON

Atmospheric Sources

Dust and precipitation falling through the atmosphere, carry with it phosphorus (along with other compounds). This atmospheric source from dust and/or precipitation falling directly on the lake's surface is another source of nutrients to the lake.

No direct measurements of this source were conducted as part of this study. Values from other research efforts in similar conditions were used to estimate the significance of this source of phosphorus. A United States EPA publication (Reckhow, et al, 1980) provides information on the phosphorus loading from atmospheric sources for Madison, Wisconsin. Measurements averaged 1.00 kilogram/hectare/year. This converts to an annual average of 0.89 pounds/acre (of lake surface). Since Lake Delton is 267 acres in size, the estimated phosphorus loading to the lake from atmospheric deposition is 237 pounds/year. This value is not shown on Table 4.4, however it is used in the trophic status modeling.

Lake Sediment Phosphorus Source

The muck and sediment at the bottom of Lake Delton is also a potential source of phosphorus to the water, and thus to the algae and aquatic weeds in the lake. Phosphorus, that is contained in the sediment can become soluble and be released into the water under certain conditions. It is commonly believed that phosphorus release from sediments in oxygenated water is less than in water with no or low dissolved oxygen levels (Holdren 1977). This assumption, however has been challenged by other studies (Lee 1976) that have found similar phosphorus release rates from sediments regardless of the water's dissolved oxygen levels.

Because of this uncertainty, this potential source is not included in the Lake Delton phosphorus budget. Additional sampling of the lake's sediment could be conducted to determine of phosphorus from sediment is a significant source.

LAKE TROPHIC STATUS MODELING

Background Information

One measure of a lake's water quality is by the classification of it's "trophic status". The trophic status is a general description of the nutrient level in a lake. Delton Lake is considered eutrophic based upon past monitoring results. This eutrophic condition is characterized by frequent blooms of blue-green algae and dense growths of macrophytes (lake weeds).

Three measurements of a lake's trophic status are water clarity, (measured with a Secchi disk), Chlorophyll-a concentrations, and total phosphorus concentrations.

Water Clarity Measuring water clarity with a Secchi disk is an easily understood indication of "how green" a lake is perceived to be. Classification of clarity depths is shown on Table 3.6 on the next page.

Chlorophyll-a Chlorophyll-a is a photosynthetic pigment found in algae. This parameter is a direct measure of the algal biomass. This measurement varies widely throughout the summer depending on the algal bloom cycle. Table 3.6 shows the classification of Chlorophyll-a concentrations relative to perceived water quality.

Phosphorus Concentrations Phosphorus is generally the nutrient most responsible for supporting the excessive algae and/or macrophyte growths. When a lake's surface layer of water is high in phosphorus, high algae production can be expected. Classification of total phosphorus concentrations are shown in Table 3.6.

The trophic status model predicts the lake's future water quality in terms of these parameters based on projected reductions in nutrient (phosphorus) pollution from the watershed. For example: "The average summer Secchi disk is currently 'X' feet. With a reduction of phosphorus pollution of 'Y %' (through nonpoint source control practices), the summer Secchi disk measurements can be expected to be 'Z' feet."

TABLE 3.6

WATER QUALITY INDEX FOR WISCONSIN LAKES
BASED ON TOTAL PHOSPHORUS, CHLOROPHYLL a
CONCENTRATIONS, AND WATER CLARITY

Water Quality	Approximate Total Phosphorus (mg/L)	Secchi disk Depth (ft)	Approximate Chlorophyll a (μg/L)	Approximate Trophic Status Index*
Excellent	<.001	>20	<1	<34
V. Good	.001-.01	10-20	1-5	34-44
Good	.01-.03	6-10	5-10	44-50
Fair	.03-.05	5-6	10-15	50-54
Poor	.05-.15	3-5	15-30	54-60
V. Poor	>.15	<3	>30	>60

*After Carlson (1977)
Source: WDNR Technical Bulletin 138 (1983)

"<" means "less than"
">"means "greater than"

Model Selection

The trophic status modeling was conducted using software available from the WDNR for common lake situations in Wisconsin. There are several models to chose from to compare to the actual monitored conditions within Lake Delton. Table 4.6 compares the trophic models' results with the monitored conditions. All of the models tested produced reasonable predicted results using the input data shown on Table 3.7 (next page). The Vollenweider model was selected to predict future changes in the lake's trophic condition with phosphorus control measures. These predicted changes are shown on Table 4.7 for various phosphorus reduction levels.

Table 3.7, below, shows the input data used to run the trophic status models.

Table 3.7

Parameters Used for Input to the Lake Delton Trophic Status Modeling

Parameter	Value
Water Surface Area (acres)	267
Maximum Depth (feet)	16
Mean Depth (feet)	8
Lake Volume (acre feet)	2,136
Average Annual Inflow Rate (cfs)	50
Average Annual Flow Volume (acre feet)	36,198
Average Annual Residence Time (days)	22
Average Annual Phosphorus Load (lbs/yr.)*	13,936

* Average Annual Phosphorus Load = Nonpoint Source Load (13,399 lbs) + Atmospheric Load (237 lbs)

WATER QUALITY MONITORING

Table 4.1

1992 Lake Delton Sampling Results: Lake Sampling

Date	Depth (ft)	Total Phosphorus (mg/l)	Total Kjeldahl Nitrogen (mg/l)	Chlorophyll a (ug/l)	Dissolved Oxygen (mg/l)	Temp. (C)
4/23/92	Surface	0.07	1.0	78	14.1	9.3
	3	--	--	--	13.7	9.0
	6	0.07	1.0	--	12.7	8.9
	9	--	--	--	12.7	8.8
	12	--	--	--	12.3	8.8
	14	0.07	1.0	--	12.0	8.8
7/23/92	Surface	0.13	1.0	80.6	6.9	21.1
	2	--	--	--	6.9	21.1
	4	--	--	--	6.8	21.1
	6	0.13	1.0	--	6.7	21.1
	8	--	--	--	6.6	21.1
	10	--	--	--	6.4	21.0
	12	--	--	--	4.9	21.0
	13.5	0.14	1.1	--	4.7	21.0
8/20/92	Surface	0.11	0.8	54.7	8.6	22.3
	2	--	--	--	8.3	22.2
	4	--	--	--	8.2	22.1
	6	0.12	1.0	--	7.9	22.1
	8	--	--	--	7.4	22.1
	10	--	--	--	6.7	21.8
	12	--	--	--	5.8	21.7
	14	0.13	0.9	--	5.6	21.7

Table 4.2
1992 Lake Delton Sampling Results: Stream Sampling

Lost Canyon Site	(above Lost Canyon Rd.)					
Date	Total Phosphorus (mg/l)	Total Kel. Nitrogen (mg/l)	Suspended Solids (mg/l)	Dissolved Oxygen (mg/l)	Temp. (C)	Flow (cfs)
4/23/92	0.13	0.7	37	11.3	5.3	0.04
7/23/92	0.43	1.5	7	8.2	14.0	<.02
8/20/92	NO FLOW; NO SAMPLING					0

Spring Brook	(above Shady Lane)					
Date	Total Phosphorus (mg/l)	Total Kel. Nitrogen (mg/l)	Suspended Solids (mg/l)	Dissolved Oxygen (mg/l)	Temp. (C)	Flow (cfs)
4/23/92	0.05	0.8	6	9.9	8.4	4.08
7/23/92	0.14	0.8	11	7.1	13.4	0.26
8/20/92	0.16	1.0	56	7.8	13.1	0.55

Dell Creek	(below Mirror Lake Dam)					
Date	Total Phosphorus (mg/l)	Total Kel. Nitrogen (mg/l)	Suspended Solids (mg/l)	Dissolved Oxygen (mg/l)	Temp. (C)	Flow (cfs)
4/23/92	0.08	0.8	8	8.1	9.7	56 *
7/23/92	0.09	1.2	12	7.6	18.7	29 *
8/20/92	0.04	0.4	6	8.8	19.3	19.22

Lake Delton Outlet	(above Co. Highway A)					
Date	Total Phosphorus (mg/l)	Total Kel. Nitrogen (mg/l)	Suspended Solids (mg/l)	Dissolved Oxygen (mg/l)	Temp. (C)	Flow (cfs)
4/23/92	--	--	--	--	--	?
7/23/92	0.15	1.4	28	--	--	?
8/20/92	0.13	0.9	19	7.9	20.5	29.25

Lake Delton Urban Runoff	(parking lot channel)				
Date	Total Phosphorus (mg/l)	Total Kel. Nitrogen (mg/l)	Suspended Solids (mg/l)	Dissolved Oxygen (mg/l)	Temp. (C)
8/20/92	--	--	67	--	--

* flow calculated based broad crested weir flow equation

Table 4.3
Nonpoint Sources of Sediment to Lake Delton

	LAND USE										Streambanks & Construction			
Subwatershed	Crop–land	(%)	Pasture	(%)	Woodland/ Open	(%)	Resi–dential		Industrial and Commercial	(%)	Erosion	(%)	Total	(%)
Direct Drainage acres	0	0%	0	0%	697	44%	474	30%	400	25%	0	0%	1,571	3%
sediment load *	0	0%	0	0%	4	4%	15	15%	79	81%	0	0%	98	7%
Lost Canyon acres	0	0%	0	0%	1,543	90%	19	1%	151	9%	10	0%	1,723	4%
sediment load	0	0%	0	0%	10	3%	1	0%	30	8%	312	89%	352	24%
Dell Creek ** acres	12,862	31%	4,978	12%	23,647	57%	0	0%	0	0%			41,488	86%
sediment load	780	82%	86	9%	37	4%	0	0%	0	0%	49	5%	953	64%
Spring Brook ** acres	1,153	31%	446	12%	2,121	57%	0	0%	0	0%			3,721	8%
sediment load	70	82%	8	9%	3	4%	0	0%	0	0%	4	0%	86	6%
Total Watershed acres	**14,015**	**29%**	**5,425**	**11%**	**28,008**	**58%**	**493**	**1%**	**550**	**1%**	**10**	**0%**	**48,502**	**100%**
sediment load	**850**	**57%**	**94**	**6%**	**55**	**4%**	**15**	**1%**	**109**	**7%**	**365**	**25%**	**1,489**	**100%**

* Sediment load is expressed in tons/year

** Dell Creek and Spring Brook watershed sediment loads reduced by 75% for settling affects

Basis for Table:

Total acres for each subwatershed based on planimetered areas from USGS 7.5' topographic map

Land Use areas for Mirror Lake and Glass Lake watersheds based on % cover for Dell Creek Watershed from Sauk County Soil Erosion Plan

Rural Sediment load based on unit area load calculated for Copper Creek Subwatershed in the "Narrows\Baraboo Priority Watershed, Sauk County; Sediment load calculated using WIN sediment model (unit area load = Cropland: 155 tns/sq.mi; Woodlots: 4.1 tns/sq.mi.; Pasture: 44.7 tns/sq. mi.) Modeling done by Sauk Co. LCD and DNR.

Urban sediment and phosphorus loads based on Source Load and Management Model (SLAMM) run by Woodward–Clyde Consultants using 1992 land use and street conditions determined from aerial photographs, Village zoning map, and site visits.

Streambank erosion sediment based on 3.03 tns/sq. mi/yr., Copper Cr. Subwtrshed; "Narrows Cr./Baraboo R." Project, Sauk Co.

Sediment loads from Mirror Lake and Blass lake watersheds were reduced 50% to account for lake sedimentation.

Table 4.4
Nonpoint Sources of Phosphorus to Lake Delton

	LAND USE														Animal			
Subwatershed	Cropland	(%)	Pasture	(%)	Woodland/ Open	(%)	Residential	(%)	Industrial and Commerical	(%)	Lot Runoff	(%)	Total	(%)
Direct Drainage acres	0	0%	0	0%	697	44%	474	30%	400	3%			1,571	3%
phosphorus load *	0	0%	0	0%	14	2%	212	24%	645	73%	12	1%	883	6%
Lost Canyon acres	0	0%	0	0%	1553	90%	19	1%	150	9%		0%	1,722	4%
phosphorus load	0	0%	0	0%	31	2%	8	0%	243	14%	24	1%	306	2%
Dell Creek acres	12,862	31%	4,978	12%	23,647	57%	0	0%	0	0%		0%	41,488	86%
phosphorus load	5,314	47%	592	5%	255	2%	0	0%	0	0%	5,216	46%	11,377	83%
Spring Brook acres	1,153	2%	446	1%	2,121	4%	0	0%	0	0%			3,721	8%
phosphorus load	529	47%	59	5%	25	2%	0	0%	0	0%	520	46%	1,133	8%
Total Watershed acres	**14,015**	**29%**	**5,425**	**11%**	**28,018**	**53%**	**493**	**0%**	**550**	**7%**	**0**		**48,501**	**100%**
phosphorus loa	**5,843**	**43%**	**651**	**5%**	**326**	**2%**	**220**	**2%**	**888**	**6%**	**5,771**	**42%**	**13,699**	**100%**

* Phosphorus load is expressed in pounds/year

** Dell Creek watershed phosphorus load reduced by 6% for summer duckweed harvesting and 40% for settling afffects

*** Spring Brook watershed phosphorus load reduced by 40% for settling affects

Basis for table:

Total acres for each subwatershed based on planimetered areas from USGS 7.5' topographic map

Land Use areas based on % cover for Dell Creek Watershed from Sauk County Soil Erosion Plan

Rural Phosphorus load based on suspended solids to total phosphorus ratio from 1985–1991 USGS monitoring in Black Earth Creek, Brewery Creek, and Garfoot Creek, Dane County (average ratio = 5.82 lbs. phosphorus/1 ton sediment)

Barnyard phosphorus load based on unit area load calculated from barnyard in the Copper Creek Subwatershed in the "Narrows Creek/Baraboo River" Priority Watershed, Sauk County. Phosphorus load based on "BARNY" barnyard runoff model conducted by Sauk Co. LCD and DNR. (barnyard unit area phosphorus load = 149 lbs/sq. mi.)

Urban sediment and phosphorus loads based on Source Load and Management Model (SLAMM) run by Woodward–Clyde Consultants using 1992 land use and street conditions

Table 4.5
Urban Nonpoint Sources of Total Lead to Lake Delton

Urban Subwatershed		LAND USE Commercial	(%)	Residential	(%)	Industrial	(%)	Open Space	(%)	Total	(%)
U1	acres	0	0%	0	0%	18	3%	579	97%	597	18%
	lead load *	0	0%	0	0%	8	32%	17	68%	25	3%
U2	acres	126	11%	19	2%	7	1%	974	87%	1,126	34%
	lead load	180	85%	0	0%	3	1%	29	14%	212	25%
U3	acres	0	0%	85	28%	0	0%	220	72%	305	9%
	lead load	0	0%	4	40%	0	0%	7	60%	11	1%
U4	acres	22	6%	123	34%	0	0%	221	60%	366	11%
	lead load	31	71%	6	13%	0	0%	7	15%	43	5%
U5	acres	142	35%	65	16%	0	0%	202	49%	409	12%
	lead load	204	96%	3	1%	0	0%	6	3%	213	25%
U6	acres	68	38%	110	62%	0	0%	0	0%	178	5%
	lead load	98	95%	5	5%	0	0%	0	0%	103	12%
U7	acres	168	75%	32	14%	0	0%	24	11%	224	7%
	lead load	241	99%	1	0%	0	0%	1	0%	243	28%
U8	acres	0	0%	46	74%	0	0%	16	26%	62	2%
	lead load	0	0%	3	84%	0	0%	0	16%	3	0%
U9	acres	0	0%	13	49%	0	0%	14	51%	27	1%
	lead load	0	0%	1	68%	0	0%	0	32%	1	0%
Total Watershed	**acres**	525	16%	493	15%	25	1%	2,250	68%	3,294	100%
	lead load	754	88%	23	3%	11	1%	67	8%	855	100%

* Lead load expressed in pounds/year

Source: 1992 WCC SLAMM modeling for Lake Delton Urban Area

LAKE TROPHIC STATUS MODELING RESULTS

Table 4.6
Comparison of Lake Trophic Model Results With Monitored Conditions

Model	Total Phosphorus (mg/l)	Secchi Disk (ft)	Chlorophyll a (ug/l)
Monitored Conditions *	0.08	2.5	68.2
Dillon Rigler 1974B	0.08	2.8	46.7
Vollenweider, 1976 **	**0.11**	**2.3**	**69.4**
Bachman & Canfield, 1979 (natural lakes)	0.10	2.5	62.4
Bachman & Canfield, 1979 (artificial lakes)	0.08	2.8	45.7
Reckhow, et.al., 1980	0.09	2.6	53.9

Model Input Used Phosphorus Loading From 1992 WCC Watershed Investigation

* Spring total P from 4/13/76 (DNR) & 4/23/92 (WCC) data
Secchi Disk from summer 1989 - 1992 (Self Help & WCC) data
Chlorophyll a from 8/30/76, 8/7/91 (DNR), and 7/23/92, 8/20/92 (WCC) data

** Model selected for predictive use in Table 4.7 below

Table 4.7
Predicted Changes in Trophic Status with
Various Levels of Phosphorus Reductions

% Phosphorus Reduction	Predicted Conditions *		
	Total Phosphorus (mg/l)	Secchi Disk (ft)	Chlorophyll a (ug/l)
0%	0.11	2.3	69.5
10%	0.11	2.4	67.2
15%	0.10	2.5	61.9
20%	0.10	2.6	56.7
25%	0.09	2.6	51.6
30%	0.09	2.8	46.7
35%	0.08	3.0	41.9
40%	0.07	3.1	37.9

* Predictions based on Vollenweider 1976 trophic status model
Total Phosphorus is steady state concentration

SECTION 5
DISCUSSION OF RESULTS

WATER QUALITY CONDITIONS

Lake Delton has historically been a eutrophic lake (that is, a lake high in nutrients with occasional nuisance levels of algae and/or aquatic weeds). WDNR sampling in 1975 - 1977 showed that the lake was high in total phosphorus, and chlorophyll a, and with low summer Secchi disk readings. These conditions have not measurably changed compared with the 1992 sampling. This does not mean that the lake's aesthetic qualities are unchanged. The lake has had a history of nuisance levels of floating duckweed and other macrophytes. Also, dense blue-green algae blooms have been noted in the past. Summer applications of herbicides to the lake (for both the duckweed and algae) have routinely been done since the 1970's. Based on discussions with lake property owners, these conditions have not been as intense, or for as long of a duration in the past five to seven years. Since 1987 the Village of Lake Delton has coordinated a duckweed harvesting operation on Mirror Lake. This effort has had a positive impact on the lake's aesthetics, and may be removing a significant portion of the nutrients entering Lake Delton in the Summer (Gardner, 1990).

The 1992 lake monitoring showed high levels of chlorophyll a; although no nuisance levels of algae growth were noted. In fact, this was the first year that no application of algaecide was made for more than a decade. Relatively cool summer temperatures may be one reason for the reduced algae conditions in 1992.

Monitoring of Lake Delton in the 1970's and in 1992 showed that the lake does not stratify during the summer months. This means that the water stays mixed from surface to the bottom. Also, the dissolved oxygen levels remained adequate for fish and other aquatic life throughout the monitored period.

The water quality conditions of the tributaries to Lake Delton are indicative of waters from nutrient rich, agricultural lands or developed areas. No high flow samples were obtained. However, based on storm event monitoring from other similar areas, these tributaries likely contain high bacteria, sediment, and nutrient concentrations during these runoff periods. (Field, 1986)

LAKE TROPHIC STATUS AND FUTURE CONDITIONS

The lake's trophic status (nutrient condition) is generally indicated by the Secchi disk depths, the surface water's phosphorus concentrations, and the surface water's chlorophyll a concentration. The table below shows how Lake Delton compares to 26 other lakes in southwestern Wisconsin for these parameters. The information on the 26 lakes was obtained from a 1983 WDNR publication by Dick Lillie and Jack Mason.

Table 5.1
Comparison of Lake Delton 1992 Trophic Conditions with Other Lakes in Southwestern Wisconsin

	Secchi disk (ft)	% of SW Wis. Lakes in Each Category	Chlorophyll a (ug/l)	% of SW Wis. Lakes in Each Category	Total Phosphorus (mg/l)	% of SW Wis. Lakes in Each Category
Best	> 19.7	0%	0-5	0%	<.010	0%
	9.8-19.7	0%	5-10	13%	.010-.020	23%
	6.6-9.8	7%	10-15	17%	.020-.030	7%
	3.3-6.6	32%	15-30	30%	.030-.050	20%
	>3.3	61%	>30	40%	.050-.100	20%
Worst					.100-.150	23%
					>.150	7%

* Data Source for SW Wisconsin Lakes: D. Lillie, J. Mason; 1983; WDNR

** Shaded values show Lake Delton condition based on average of 1992 sampling

Table 4.7 shows the changes that are predicted to the lake's trophic status with various levels of phosphorus control. The highest level of control used is 40%. This level of control could only be attained through a very aggressive and comprehensive management program throughout the watershed. With this type of effort the model shows a change of average summer Secchi depth readings from 2.3 to 3.2 feet. This is about a 40% improvement in water clarity. This is a significant change in water clarity, and would result in a noticeable difference in the lake's aesthetics by the lake users.

The predicted changes in water quality from various levels of phosphorus control will not put Lake Delton into a "good" trophic status category. Perhaps the best that can be expected is that the lake would be classified in the "fair" category. The lake cannot reasonably be rehabilitated to match the conditions found in many of Wisconsin's clear deep lakes. There are several reasons for this. First, many of the soils in the watershed are naturally rich in nutrients and even under "natural" land cover conditions, the runoff contains some level of nutrients. Second, the large size of the watershed (relative to the lake size) means that a lot of runoff waters are funnels to the lake and thus a large volume of nutrients are also carried to the lake.

It should be noted, however, that although improvements in the lake's condition may not be as dramatic as some would hope for; a decline in the lake's condition will likely occur unless measures are taken to control the current and new sources of nutrients.

POLLUTION SOURCES

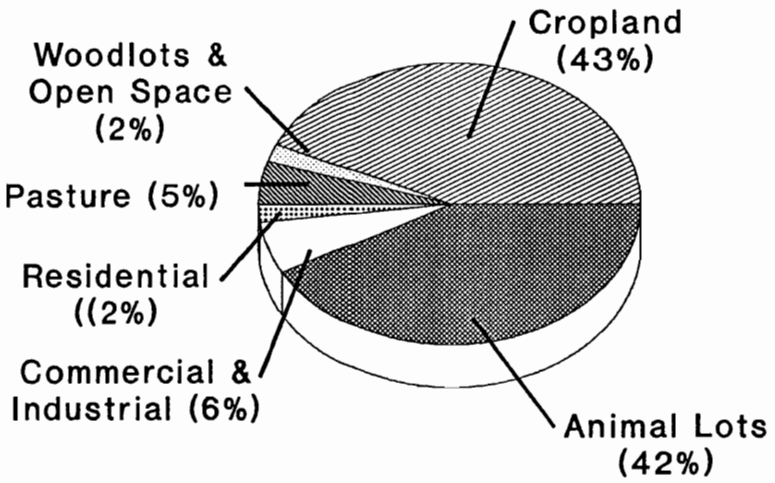
The figures on the following pages show the sources of pollution to Lake Delton from the various geographical areas, and from the various land use activities.

Phosphorus

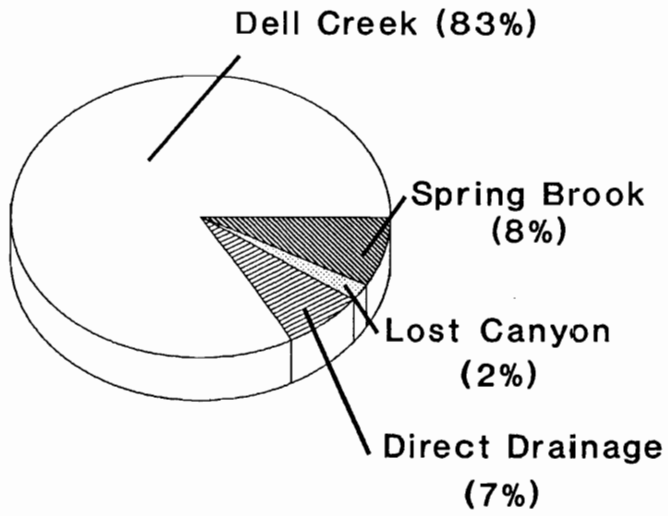
Clearly, the rural portions of the watershed contribute the most significant amounts of phosphorus to Lake Delton. This is not unusual for the type of land use and the size of the watershed contributing runoff waters to the lake. Studies have shown that on a "per acre" basis as much phosphorus comes off from residential properties (from lawn fertilizers, leaves, etc) as comes off from agricultural fields. For Lake Delton, there are so much more

Figure 5.1
NPS Phosphorus Sources to Lake Delton

Land Use Activities



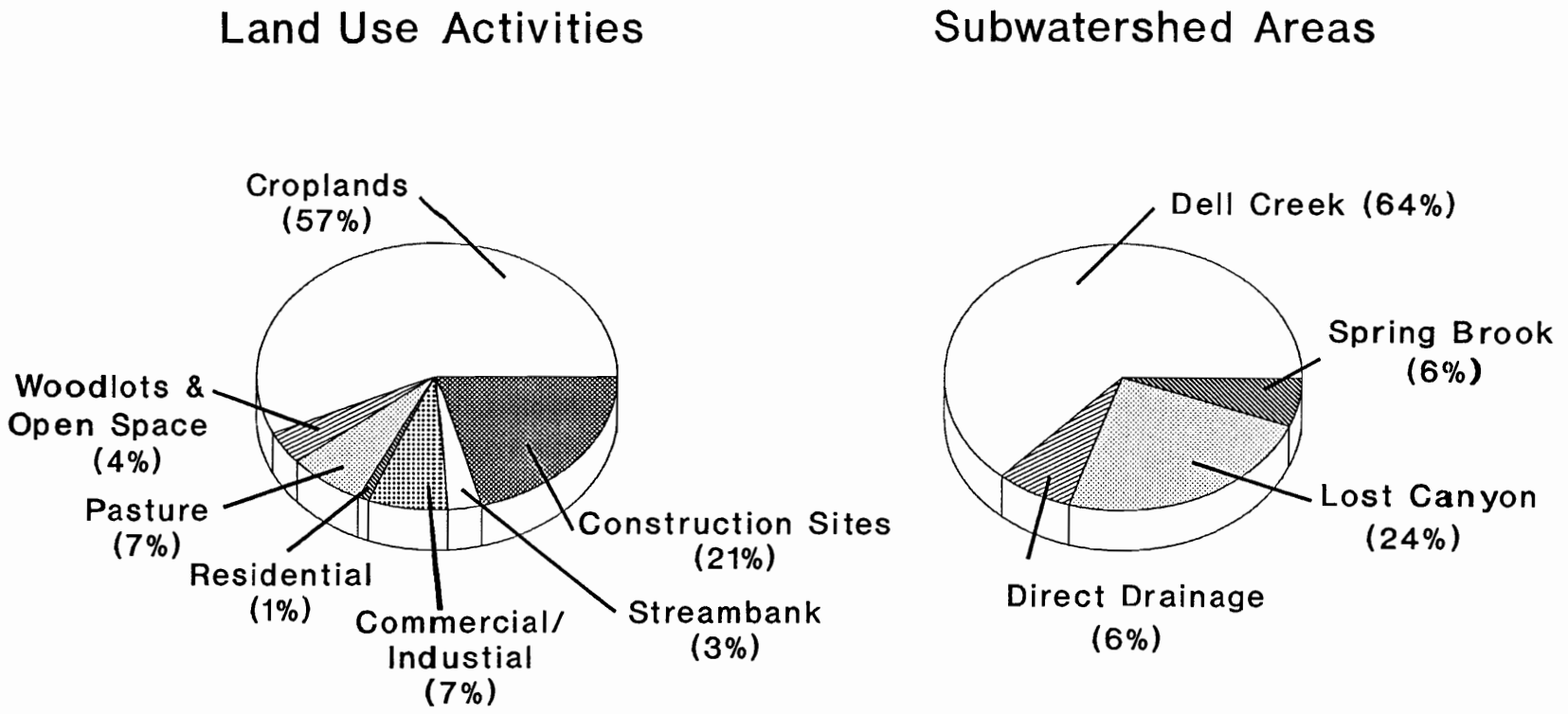
Subwatershed Areas



Source: WCC 1992 Watershed Inventory

Woodward-Clyde Consultants

Figure 5.2
NPS Sediment Sources to Lake Delton



Woodward-Clyde Consultants

agricultural lands (compared to the developed areas) that the agricultural lands become the most significant sources of phosphorus to the lake.

Sediment

The figures showing the sediment sources to the lake do not tell the whole story. Although Dell Creek subwatershed contributes about half of the total amount of sediment to Lake Delton, it is important to note the types of sediment being transported from each source. The term "sediment" includes any organic or inorganic material varying in size from the very small (clay) size particles to the larger (sand) size particles. The small size particles are the lightest, and thus are more likely to stay suspended in the water the longest. This means that these size particles do not settle out and a high per cent of them will travel through the lake (and out the dam) or settle out only in the very deepest portions of the lake. The larger, sand size, particles will more readily settle out and form deposits near the mouths of channels or tributaries to Lake Delton.

Because the Dell Creek sediment has traveled through Mirror Lake, only the smallest size particles make it over the Mirror Lake Dam and into Lake Delton. These sediment particles will more likely stay suspended in Lake Delton and exit through the dam or settle out in the deepest portion of the lake. Sediment from the direct drainage area or Lost Canyon includes a high percentage of the sand size particles. These sediments will be the most visible and cause the most interference with recreational uses of the lake by settling out near the shores of the lake. The bottom line is that the source of the most visible sediment problems in Lake Delton are probably coming from the developed and developing (under construction) areas of the watershed.

Metals

Metals, such as lead, zinc, and copper are commonly found in urban runoff water (Bannerman et al, 1983). Metals in urban runoff come from deterioration of vehicles, metal roofs and gutters, and lawn pesticides among other things. There is no information that the metals in the runoff to Lake Delton have caused harm to the lake. However, based on lake sediment monitoring in other urban areas, it is likely that there are elevated levels of lead and other metals in the sediments near the urban storm sewer outfalls.

Other Pollution Sources

The Village of Lake Delton has a high concentration of swimming pools at motels and other resorts along with several large water theme parks. A concern has been expressed by several village residents about the potential impacts on Lake Delton water quality when these pools are drained or the filters are back flushed. The pool water often drains to the lake.

The WDNR regulates the quality of the water allowed to be drained to lakes and streams from the larger theme parks. Each park has a "permit" which requires minimum standards to be met on suspended solids (sediment), Ph (acid-base levels) and chlorine. With these requirements in place, the impacts upon Lake Delton from this source appears to be minimal.

The Village of Lake Delton is on sanitary sewer service, with treated discharge to the Wisconsin River. There are not a high number of septic systems in the direct drainage area to Lake Delton so septic systems are not be expected to be a significant source of pollution to the lake.

SECTION 6
RECOMMENDATIONS

MAINTAIN THE DUCKWEED HARVESTING OPERATION

This operation results in two benefits to Lake Delton: 1) it directly removes the floating macrophytes that cause nuisance conditions in Lake Delton, and 2) the removal of this plant material is an effective way of reducing the amount nutrients entering Lake Delton during the summer months. The reduction in plant material will help to reduce the deposition of dead plants (and the nutrients in the plant material) on the lake bed following plant die-offs. This reduction, in turn, will help reduce the intensity and duration of summer algae blooms.

REDUCE THE NONPOINT SOURCES OF POLLUTION TO LAKE DELTON

The calculations made in this study clearly show that the major sources of phosphorus, sediment, and heavy metals to the lake are from rural and urban runoff. Below is listed a combination of programs and approaches that can be employed to carry out this recommendation.

Rural Nonpoint Source Pollution

Because of the large watershed above Lake Delton, and the diffuse nature of the sources, the local government (Village of Lake Delton) does not have significant authority alone to address this source. However the Village along with the towns, area lake associations, and other citizen groups can do much to promote the Lake Delton watershed for inclusion in Wisconsin's Nonpoint Source Pollution Abatement Program (commonly called "priority watershed program"). This program provides funding and administrative resources to allow for a comprehensive approach to control the rural (and urban) nonpoint sources of pollution. The program has been used successfully in two other watershed projects within Sauk County.

It is recommended that the Village of Lake Delton, along with the other local groups contact the WDNR's Southern District Nonpoint Source Coordinator to initiate the selection process for the Lake Delton watershed. In addition to the WDNR, the Sauk County Land Conservation Department, UW-Extension, and USDA Soil Conservation Service should be contacted to ask for their support and assistance in the selection process.

Based on estimates used for rural nonpoint source control measures to Copper Creek (in the Narrows Creek/Baraboo River Watershed Project) the rural control needs in Dell Creek and Spring Brook Creek may range in cost from $750,000 to $1,000,000. The state will fund 60% - 75% of these costs under the Nonpoint Source Control Program.

Urban Nonpoint Sources of Pollution

Wisconsin's Nonpoint Source Pollution Abatement Program (the same program mentioned above) also addresses the urban nonpoint pollution control needs within a selected watershed. The program provides a mechanism to cost share, with state funding, the construction of urban nonpoint source control practices and the development of non-structural approaches to controlling urban runoff. Some of these non-structural approaches are discussed below. Although this program will go a long way toward the long term reduction of urban nonpoint source pollution, there are several other steps that can be taken immediately. These are listed below.

- Initiate a citizen's information/education program
  Many of the pollutants that come from urban areas can be controlled by property owners changing some common habits. Reducing lawn fertilizers, properly disposing waste automobile oil, keeping leaves and grass out of the street gutters, and redirecting roof downspouts away from driveways or other impervious areas are all examples of low cost approaches that can help reduce the urban pollution problem. The Village or other local groups could develop posters, newsletters, mailings, or other approaches to informing citizens of ways to reduce runoff from their property.

- Continue enforcement of the local construction erosion control ordinance

  The Village has passed a construction erosion control ordinance. The ordinance was based on the model ordinance developed jointly by the League of Municipalities and WDNR. Passage of the ordinance is only the first step. The effectiveness of the ordinance will depend on the enforcement procedures implemented. Because of the nature of the pollution source, the water quality is impacted after a single intense rainfall. This means that enforcement of the ordinance is critical and must be in a timely manner for it to be effective.

- Develop a street and parking lot sweeping schedule to maximize water quality benefits

  Studies have shown that the most significant portion of urban nonpoint pollution comes during spring rainfall events. This is when the streets have the most debris, sand, and dirt on them from the winter period. An intense street sweeping schedule for the village streets in the early spring and late fall periods are the most effective time for reducing pollution from urban runoff.

- Develop a fall leaf pick up program

  Runoff from leaves placed in the street gutters or roadside ditch can carry a high level of nutrients to the lake. To minimize this potential, leaves should be composted or used for mulch by the property owners. An alternative is for the municipality to remove the leaves to a compost pile. The leaves should not be raked into the streets or roadside ditches, but left in piles on the grass for pickup.

- Continue management of horse stable areas

  The three stables in the direct drainage to Lake Delton are potential sources of nutrients to the lake. The management of these areas to minimize runoff during rainstorms or snow melt periods will help to reduce the pollution from the stables. The Sauk County Land Conservation Department and USDA Soil Conservation Service have the technical expertise to recommend measures for the control of runoff from these sites.

CONTINUE WATER QUALITY MONITORING EFFORTS

The Lake Delton Association has been a cooperator with WDNR's Self Help Monitoring Program since 1989. The Association has recently applied to increase the monitoring efforts by becoming involved in the "Expanded" Self Help Monitoring Program. In addition to the regular Secchi disk sampling, the expanded program includes nutrients and chlorophyll a sampling on the lake by a citizen volunteer. The long term continuation of this monitoring will help to show trends in the lake's condition.

MONITOR APPLICATION RATES AND NEEDS FOR AQUATIC HERBICIDES

In 1992 a system was initiated to determine the needs and extent of aquatic herbicide application to control nuisance conditions. A Secchi disk was used to measure transparency (clarity) of the water to objectively measure lake conditions. This process resulted in an aquatic herbicide application policy based on need, rather than a regular schedule. This policy should be continued. The approach should result in a reduction of the quantity of herbicide applied while still controlling the nuisance conditions. If phosphorus control measures are implemented, the need for the herbicide application should decrease in the future.

AESTHETICS/NAVIGATION CLEAN UP OF LOWER DELL CREEK

Concerns have been raised about the water access to Dell Creek between Lake Delton and the Mirror Lake Dam from boaters on Lake Delton. Tree falls have obstructed the channel and caused debris to build up in the channel. Although this is not directly a water quality issue, the condition does interfere with the public use of this water body. The Village, along with local groups (sports clubs, lake associations, scouts, etc) could organize clean up days to use volunteer help in removing the obstructions. WDNR should be contacted to ensure that there are no problems with navigation and "Chapter 30" regulations. Also, some of the trees may require professional equipment for their removal.

SECTION 7
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APPENDIX A: PRE–1992 WATER QUALITY DATA

Table A–1
Pre–1992 Lake Delton Sampling Results:
Secchi Depths, Cholophyll a, & Nutrient Levels

(WDNR Bureau of Research File Data & Lake Delton Self–Help Monitoring)

Date	Data Source	Total Phosphorus (mg/l)	Chlorophyll a (ug/l)	Secchi disk (ft)	Total Kel. Nitrogen (mg/l)
7/10/75	DNR	0.14		2.0	1.35
10/21/75	DNR	0.08		2.0	0.08
2/24/76	DNR	0.22		2.0	2.60
4/13/76	DNR	0.08		2.5	0.08
8/30/76	DNR	0.12	53.47	2.5	0.86
2/2/77	DNR	0.05		5.0	>1.24
8/89	Self–Help			4.5	
4/20/90	Self–Help			2.5	
6/1/90	Self–Help			2.0	
6/23/90	Self–Help			2.0	
7/20/90	Self–Help			2.0	
8/7/91	DNR	0.11	84	2.0	0.95
6/30/92	Self–Help *			3.5	
7/7/92	Self–Help *			3.2	
7/14/92	Self–Help *			2.0	
7/21/92	Self–Help *			2.0	
7/28/92	Self–Help *			2.0	
8/3/92	Self–Help *			2.0	
8/20/92	Self–Help *			2.0	
8/25/92	Self–Help *			2.0	
9/3/92	Self–Help *			2.0	

* Secchi disk based on average of two mid–lake location samples

Table A–2
Pre–1992 Lake Delton Sampling Results: Dissolved Oxygen & Temperature

(WDNR Bureau of Research File Data)

Date	Depth (ft)	Dissolved Oxygen (mg/l)	Temp. (F)
7/10/75	Surface	9.2	74.0
	7	9.2	74.0
	14	8.5	74.0
	Inlet	7.5	66.0
10/21/75	Surface	9.8	55.0
	14	9.1	54.0
	Inlet	8.5	47.5
2/24/76	Surface	10.7	34.0
	3		35.0
	7	9.0	36.0
	10		36.5
	14	8.6	37.5
	Inlet	12.0	34.5
4/13/76	Surface	13.2	51.0
	14	12.3	51.0
	Inlet	11.2	46.0
8/30/76	Surface	9.7	76.0
	14	7.0	74.5
	Inlet	--	--
2/2/77	Surface	8.3	33.0
	7	8.2	34.0
	13	8.0	34.5
	Inlet	--	--

APPENDIX B: 1992 FIELD SAMPLING NOTES & LAB SLIBS

FIELD NOTES: LAKE DELTON SAMPLING APRIL 23, 1992

1. Lost Canyon Creek at Canyon Road
   Time: 08:30
   Weather: cloudy; 45° F; calm
   Stream Conditions: Total sand bottom, some leaves & sticks; few stones; stream is channelized about 150 yards above Canyon Road.

   Water Quality Sample obtained 20' upstream from culverts on Canyon Road; nutrient and residue samples obtained
   DO: 11.3 mg/l Temp: 5.3° C

   Flow Flow measured about 200 yards upstream from Canyon Road; Pygmy Meter used. Water Level was just above the upstream lip of the culverts on Canyon Road. 90% of the flow was through the east culvert, 10% through the west culvert, none in the middle culvert. Flow measurements on back page.

2. Spring Brook at Shady Lane
   Time: 09:45
   Weather: cloudy; 45° F; calm
   Stream Conditions: Stony/Rock bottom, some leaves & sticks; clear water

   Water Quality Sample obtained 100 yards upstream from bridge on Shady Lane; about 100 yards below small spillway; nutrient and residue samples obtained
   DO: 9.9 mg/l Temp.: 8.4° C

   Flow Flow measured about 200 yards upstream from Shady Lane; Pygmy Meter used. Bench Mark established on tree leaning over the creek about 50 yards below the spillway. An "+" was carved into tree on the downstream side. Water level was 5.20' below the "+". Flow measurements on back page.

3. Dell Creek at Ishnala Road bridge (below Mirror Lake Dam)
   Time: 10:45
   Weather: cloudy; 45° F; calm
   Stream Conditions: Stony/Rock bottom, some leaves & sticks; dark stained water color; high flow, flow from spillway and side race.

   Water Quality Sample obtained 15 feet out from north bridge piling; about 50 yards below Mirror Lake spillway; nutrient and residue samples obtained
   DO: 8.1 mg/l T: 9.7° C

   Flow Flow was not measured; stream could not be waded. Bench marks and water

levels measured above and below the dam. Above the dam, marks set in dam abutment, concrete slab over the side race, and on the north wing wall below the dam. (see photographs for locations).

Water Level Measurements:

Mirror Lake Pool:	2.60' below north dam abutment
Side Race:	width of race: 6.5'
Pool Depth at Race:	4.90' below BM on top middle of concrete slab over race
Below Dam:	7.30' below BM on north wing wall (see photographs)

4. Lake Delton

Time: 12:30 - 14:00
Weather: cloudy; 45° F; calm; intermittent sprinkles

Water Quality Samples obtained in 14' of water. Near outlet between Sandy Hook Resort and "TV Dish" point.

Secchi Disk: 2.1' (dark stain water)

Dissolved Oxygen:

Depth	DO	Temp
(mg/l)	(C°)	
Surface	14.1	9.3
3.0'	13.7	9.0
6.0'	12.7	8.9
9.0'	12.7	8.8
12.0	12.3	8.8
14.0	12.0	8.8

Nutrient (TP & TKN) samples obtained at depths of 1.0', 7.0' and 13.5'
Chlorophyll a obtained at 1.0' depth

5. Lake Delton Outlet

Time: 14:30
Weather: cloudy; 45° F; calm; intermittent sprinkles

Water Quality No samples obtained. Very high flow and could not wade river

Flow Flow was not measured; stream could not be waded. Bench marks and water levels measured above and below the dam. Above the dam, used the base plate of middle yellow post over the spillway as a bench mark. Bench Mark also chiseled into top of south wing wall about 8' up from bottom. (see photographs for locations).

Water Level Measurements:

Lake Delton Lake Pool:	3.85' below base plate of middle yellow post
Side Race:	no measurement possible
Below Dam:	2.85' below BM on south wing wall (see photographs)

Woodward-Clyde Consultants

24-Apr-92

Lake Delton Tributaries Flow Measurements

Lost Canyon 08:30; 4/23/92

Station	Depth (ft)	Rev.	Time (sec.)	Velocity (ft/sec)	Width (ft)	Area (ft)	Flow (cu.ft./sec)
0.5	0.05	10	19.0	0.53	0.50	0.03	0.01
1.0	0.05	10	19.5	0.51	0.50	0.03	0.01
1.5	0.03	10	21.0	0.48	0.50	0.02	0.01
2.0	0.03	10	19.0	0.53	0.50	0.02	0.01
2.5	0.02	5	18.0	0.28	0.50	0.01	0.00
3.0	0.02	0	0.0	0.00	0.50	0.01	0.00

Total Flow: 0.04

Spring Brook 09:45; 4/23/92

Station	Depth (ft)	Rev.	Time (sec.)	Velocity (ft/sec)	Width (ft)	Area (ft)	Flow (cu.ft./sec)
1.0	0.40	10	24.5	0.41	1.00	0.40	0.16
2.0	0.40	10	14.6	0.68	1.00	0.40	0.27
3.0	0.50	10	15.8	0.63	1.00	0.50	0.32
4.0	0.50	10	17.6	0.57	1.00	0.50	0.28
5.0	0.55	10	16.2	0.62	1.00	0.55	0.34
6.0	0.52	10	11.6	0.86	1.00	0.52	0.45
7.0	0.50	10	11.2	0.89	1.00	0.50	0.45
8.0	0.40	10	9.4	1.06	1.00	0.40	0.43
9.0	0.38	10	8.2	1.22	1.00	0.38	0.46
10.0	0.35	10	9.0	1.11	1.00	0.35	0.39
11.0	0.35	10	10.3	0.97	1.00	0.35	0.34
12.0	0.32	10	17.1	0.58	1.00	0.32	0.19

Total Flow: 4.08

09/17/92

Woodward-Clyde Consultants

Lake Delton Tributaries Flow Measurements

Lost Canyon 08:30; 4/23/92

Station	Depth (ft)	Rev.	Time (sec.)	Velocity (ft/sec)	Width (ft)	Area (ft)	Flow (cu.ft./sec)
0.5	0.05	10	19.0	0.53	0.50	0.03	0.01
1.0	0.05	10	19.5	0.51	0.50	0.03	0.01
1.5	0.03	10	21.0	0.48	0.50	0.02	0.01
2.0	0.03	10	19.0	0.53	0.50	0.02	0.01
2.5	0.02	5	18.0	0.28	0.50	0.01	0.00
3.0	0.02	0	0.0	0.00	0.50	0.01	0.00
						Total Flow:	0.04

Spring Brook 09:45; 4/23/92

Station	Depth (ft)	Rev.	Time (sec.)	Velocity (ft/sec)	Width (ft)	Area (ft)	Flow (cu.ft./sec)
1.0	0.40	10	24.5	0.41	1.00	0.40	0.16
2.0	0.40	10	14.6	0.68	1.00	0.40	0.27
3.0	0.50	10	15.8	0.63	1.00	0.50	0.32
4.0	0.50	10	17.6	0.57	1.00	0.50	0.28
5.0	0.55	10	16.2	0.62	1.00	0.55	0.34
6.0	0.52	10	11.6	0.86	1.00	0.52	0.45
7.0	0.50	10	11.2	0.89	1.00	0.50	0.45
8.0	0.40	10	9.4	1.06	1.00	0.40	0.43
9.0	0.38	10	8.2	1.22	1.00	0.38	0.46
10.0	0.35	10	9.0	1.11	1.00	0.35	0.39
11.0	0.35	10	10.3	0.97	1.00	0.35	0.34
12.0	0.32	10	17.1	0.58	1.00	0.32	0.19
						Total Flow:	4.08

Dell Creek 10:45; 4/23/92

NO FLOW MEASUREMENT – FLOW TOO HIGH

Lake Delton Outlet 14:30; 4/23/92

NO FLOW MEASUREMENT – FLOW TOO HIGH

Lost Canyon Creek 09:30; 7/23/92
at Lost Canyon Drive

NO FLOW MEASUREMENT; Q < .5 cfs

FIELD NOTES: LAKE DELTON SAMPLING
JULY 23, 1992

Weather: Overcast, some drizzle, Temps lower 60^0's F in morning to lower 70^0's F. in afternoon

Sample Site #1: Lost Canyon Creek at Lost Canyon Rd.

Time: 09:30
Flow: measurement not taken; flow too low for meter; estimated less than 20 gpm
Water T: 14.0^0 C
DO: 8.2 mg/l
% sat.: 79%
Nutrient and Sediment Sample obtained

Sample Site #2: Lake Delton Outlet; above Co. Hwy A bridge

Time: 10:00
Flow: Measurement of lake level at dam:
lake stage below plate at base of middle yellow post on dam catwalk: 3.83'

water stage below dam at left wing wall mark: 4.81'

Flow measured with pygmy meter above Co. Hwy A. bridge:

Water T and DO not taken
Nutrient and Sediment Sample obtained

Sample Site #3: Spring Brook, below Biblical Gardens dam

Time: 11:40
Flow: measurement taken with pygmy meter and "float method"

Float: X-Section area = 4.4 sq. ft.
Velocity = .20 ft/sec
Q = 4.4 x .20 x .6
.53 cfs

Water T: 13.4^0 C
DO: 7.12 mg/l
% sat.: 68.6%
Nutrient and Sediment Sample obtained

Sample Site #4: Dell Creek, below Mirror Lake Dam

Time: 12:23
Flow: Measurement of lake level at dam:
lake stage below WCC mark to the right of catwalk gate: -2.76'
lake stage below WCC mark on concrete slab over side race: -4.94'
water stage below dam at right wing wall WCC mark: -7.35'

Water T: 18.7° C
DO: 7.62 mg/l
% sat.: 81.9%

Nutrient and Sediment Sample obtained
Water T: and DO not taken

Nutrient and Sediment Sample obtained

Sample Site #5: Lake Delton,

Time: 14:00
Secchi disk: 1.5' (dark stain water, no algae bloom)

Nutrient samples obtained at surface, 7' and 13' depths
Chlorophyll*a* sample obtained at 1'depth

Depth (ft)	DO (mg/l)	Temp (C°)	% Sat
surface	6.93	21.1	78.2
2	6.93	21.1	78.2
4	6.81	21.1	76.6
6	6.71	21.1	75.8
8	6.58	21.1	74.6
10	6.35	21.0	71.7
12	4.90	21.0	55.2
13.5	4.67	21.0	52.1

09/17/92

Woodward-Clyde Consultants

Lake Delton Tributaries Flow Measurements

Lake Delton Outlet 10:20 7/23/92

Station	Depth (ft)	Rev.	Time (sec.)	Velocity (ft/sec)	Width (ft)	Area (ft)	Flow (cu.ft./sec)
0.0	0.00	0	0.0	0.00	2.00	0.00	0.00
2.0	0.30	20	11.1	1.80	2.00	0.60	1.08
4.0	0.32	20	29.5	0.68	2.00	0.64	0.43
6.0	0.90	20	12.0	1.67	2.00	1.80	3.00
8.0	0.95	20	12.5	1.60	2.00	1.90	3.04
10.0	1.20	20	11.0	1.82	2.00	2.40	4.36
12.0	0.95	20	12.0	1.67	2.00	1.90	3.17
14.0	1.30	20	9.8	2.04	2.00	2.60	5.31
16.0	1.30	20	11.4	1.75	2.00	2.60	4.56
18.0	1.10	20	20.8	0.96	2.00	2.20	2.12
20.0	1.20	20	11.1	1.80	2.00	2.40	4.32
22.0	1.20	20	10.1	1.98	2.00	2.40	4.75
24.0	1.20	20	10.5	1.90	2.00	2.40	4.57
26.0	0.95	20	11.6	1.72	2.00	1.90	3.28
28.0	0.95	20	15.8	1.27	2.00	1.90	2.41
30.0	0.80	20	15.8	1.27	2.00	1.60	2.03
32.0	0.65	20	15.4	1.30	2.00	1.30	1.69
34.0	0.65	20	14.1	1.42	2.00	1.30	1.84
36.0	0.50	20	14.0	1.43	2.00	1.00	1.43
38.0	0.40	20	11.1	1.80	2.00	0.80	1.44
40.0	0.20	20	50.0	0.40	2.00	0.40	0.16
41.0	0.00	20	0.0	0.00	1.00	0.00	0.00
						Total Flow:	**54.98**

Spring Brook 11:40 7/23/92

Station	Depth (ft)	Rev.	Time (sec.)	Velocity (ft/sec)	Width (ft)	Area (ft)	Flow (cu.ft./sec)
0.0	0.60	0	24.5	0.00	1.00	0.60	0.00
1.0	0.80	5	45.0	0.11	1.00	0.80	0.09
2.0	0.80	1	60.0	0.02	1.00	0.80	0.01
3.0	0.75	5	40.0	0.13	1.00	0.75	0.09
4.0	0.60	5	48.0	0.10	1.00	0.60	0.06
5.0	0.50	0	60.0	0.00	1.00	0.50	0.00
6.0	0.40	0	60.0	0.00	1.00	0.40	0.00
7.0	0.25	0	60.0	0.00	1.00	0.25	0.00
8.0	0.00	0	60.0	0.00	1.00	0.00	0.00
						Total Flow:	**0.26**

FIELD NOTES: LAKE DELTON SAMPLING
AUGUST 20, 1992

Weather: Clear, light breeze, Temps lower 60^0's F in morning to lower 80^0's F. in afternoon

Sample Site #1: Lost Canyon Creek at Lost Canyon Rd.

Time: 09:00
Flow: No Flow;
Water T:
DO:
% sat.:
No Nutrient or Sediment Sample obtained

Sample Site #2: Lake Delton Outlet; above Co. Hwy A bridge

Time: 9:30
Flow: Measurement of lake level at dam:
lake stage below plate at base of middle yellow post on dam catwalk: -3.77'

water stage below dam at left wing wall mark: -4.75'

Flow measured with pygmy meter above Co. Hwy A. bridge (see page 3)

Water T: 20.5^{0}C
DO: 7.9 mg/l
% sat.: 88%
Nutrient and Sediment Sample obtained

Sample Site #3: Spring Brook, below Biblical Gardens dam

Time: 10:30
Flow: measurement taken with pygmy meter

Water T: 13.1^0 C
DO: 7.8 mg/l
% sat.: 83%
Nutrient and Sediment Sample obtained

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Lost Canyon 09:00; 8/20/92
at Lost Canyon Drive

Station	Depth (ft)	Rev.	Time (sec.)	Velocity (ft/sec)	Width (ft)	Area (ft)	Flow (cu.ft./sec)
0.0	0.00	0	0.0	0.00	0.50	0.00	0.00
			NO FLOW, DRY CREEK BED				
0.0	0.00	0	0.0	0.00	0.50	0.00	0.00
						Total Flow:	0.00

Spring Brook 10:30; 8/20/92
at Biblical Gardens (just below spillway)

Station	Depth (ft)	Rev.	Time (sec.)	Velocity (ft./sec.)	Width (ft.)	Area (sq. ft.)	Flow (cu.ft./sec)
108.5	0.25	0	30.0	0.00	0.50	0.13	0.00
109.0	0.40	0	30.0	0.00	0.50	0.20	0.00
110.0	0.40	5	36.0	0.14	0.50	0.20	0.03
110.5	0.45	5	32.0	0.16	0.50	0.23	0.04
111.0	0.50	0	30.0	0.00	0.50	0.25	0.00
111.5	0.40	5	24.2	0.21	0.50	0.20	0.04
112.0	0.30	5	11.1	0.45	0.50	0.15	0.07
112.5	0.30	10	14.5	0.69	0.50	0.15	0.10
113.0	0.25	10	16.9	0.59	0.50	0.13	0.07
113.5	0.28	10	13.4	0.75	0.50	0.14	0.10
114.0	0.22	10	11.4	0.88	0.50	0.11	0.10
						Total Flow:	0.55

Lake Delton Outlet 09:30 8/20/92
above Co. Hwy. A

Station	Depth (ft)	Rev.	Time (sec.)	Velocity (ft/sec)	Width (ft)	Area (ft)	Flow (cu.ft./sec)
112.0	0.10	0	20.0	0.00	2.00	0.20	0.00
114.0	0.20	0	20.0	0.00	2.00	0.40	0.00
116.0	0.65	20	33.0	0.61	2.00	1.30	0.79
118.0	0.90	10	32.0	0.31	2.00	1.80	0.56
120.0	0.90	10	7.0	1.43	2.00	1.80	2.57
122.0	1.10	10	3.3	3.03	2.00	2.20	6.67
124.0	1.00	10	4.8	2.08	2.00	2.00	4.17
126.0	0.90	10	4.0	2.50	2.00	1.80	4.50
128.0	0.70	10	4.0	2.50	2.00	1.40	3.50
130.0	0.60	10	4.3	2.33	2.00	1.20	2.79
132.0	0.40	10	5.6	1.79	2.00	0.80	1.43
134.0	0.50	10	9.6	1.04	2.00	1.00	1.04
136.0	0.20	10	6.4	1.56	2.00	0.40	0.63
138.0	0.20	10	6.6	1.52	2.00	0.40	0.61
140.0	0.00	0	0.0	0.00	2.00	0.00	0.00
						Total Flow:	29.25

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11/24/92

Mirror Lake Dam **11:00 8/20/92**

Station	Depth (ft)	Rev.	Time (sec.)	Velocity (ft/sec)	Width (ft)	Area (ft)	Flow (cu.ft./sec)
103	0.20	20	12.2	1.64	3.00	0.60	0.98
106	0.20	10	9.2	1.08	3.00	0.60	0.65
109	0.20	10	6.3	1.59	3.00	0.60	0.96
112	0.20	10	7.2	1.39	3.00	0.60	0.83
115	0.20	10	5.2	1.91	3.00	0.60	1.15
118	0.20	10	5.5	1.82	3.00	0.60	1.09
121	0.20	10	5.4	1.85	3.00	0.60	1.11
124	0.20	10	7.1	1.40	3.00	0.60	0.84
127	0.20	10	6.9	1.46	3.00	0.60	0.88
130	0.20	10	6.7	1.50	3.00	0.60	0.90
133	0.20	10	8.1	1.23	3.00	0.60	0.74
136	0.20	10	7.5	1.34	3.00	0.60	0.81
139	0.20	10	8.0	1.25	3.00	0.60	0.75
142	0.20	10	9.0	1.11	3.00	0.60	0.67
145	0.20	10	11.0	0.91	3.00	0.60	0.55
148	0.20	10	10.7	0.94	3.00	0.60	0.56
151	0.10	10	11.1	0.90	3.00	0.30	0.27
154	0.10	10	10.3	0.97	3.00	0.30	0.29
157	0.10	10	15.7	0.64	3.00	0.30	0.19
160	0.10	10	12.5	0.80	3.00	0.30	0.24
165	0.10	10	10.6	0.95	3.00	0.30	0.28
170	0.10	10	11.3	0.88	5.00	0.50	0.44
175	0.10	10	12.5	0.80	5.00	0.50	0.40
180	0.10	10	11.0	0.91	5.00	0.50	0.45
185	0.10	10	17.0	0.59	5.00	0.50	0.29
190	0.10	10	16.0	0.63	5.00	0.50	0.31
195	0.05	10	24.0	0.42	5.00	0.50	0.21
200	0.10	10	10.0	1.00	5.00	0.25	0.25
205	0.10	10	12.0	0.83	5.00	0.50	0.42
210	0.10	10	17.5	0.57	5.00	0.50	0.29
215	0.10	10	12.0	0.83	5.00	0.50	0.42
220	0.10	10	10.0	1.00	5.00	0.50	0.50
221.5	0.10	10	10.0	1.00	5.00	0.50	0.50
						Total Flow:	19.22

Woodward-Clyde Consultants

State Laboratory of Hygiene
University of Wisconsin Center for Health Sciences
465 Henry Mall, Madison, WI 53706
R.H. Laessig, Ph.D., Director S.L. Inhorn, M.D., Medical Director

Environmental Science Section (608) 262-3458 DNR LAB ID 113133790
Inorganic chemistry (#13 of 15 on 05/21/92, unseen)

Id: 573055 Point/Well/..: 173 Field #: 6 Route: WR12
Collection Date: 04/23/92 Time: 13:10 County: 57 (Sauk)
From: LAKE DELTON - BOTTOM
To: LEVERANCE
DNR
FITCHBURG
Source: Surface Water
Account number: WR133 Collected by: LEVERANCE
Date Received: 04/23/92 Labslip #: IC090156 Reported: 05/20/92

TOTAL KJELDAHL NITROGEN	1.0	MG/L
TOTAL PHOSPHORUS	0.07	MG/L

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Environmental Science Section (608) 262-3458 DNR LAB ID 113133790
Inorganic chemistry (#1 of 2 on 05/27/92, unseen)

Id: 573055 Point/Well/..: 173 Field #: 4 Route: WR12
Collection Date: 04/23/92 Time: 13:00 County: 57 (Sauk)
From: LAKE DELTON - SURFACE
To: LEVERANCE
DNR
FITCHBURG
Source: Surface Water
Account number: WR133 Collected by: LEVERANCE
Date Received: 04/23/92 Labslip #: IC090154 Reported: 05/26/92

CHLOROPHYLL A UNCORRECTED	78	UG/L
TOTAL KJELDAHL NITROGEN	1.0	MG/L
TOTAL PHOSPHORUS	0.07	MG/L

Woodward-Clyde Consultants

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Environmental Science Section (608) 262-3458 DNR LAB ID 113133790
Inorganic chemistry (#9 of 15 on 05/21/92, unseen)

Id: Point/Well/..: 173 Field #: 1 Route: WR12
Collection Date: 04/23/92 Time: 08:30 County: 57 (Sauk)
From: LOST CANYON RD. LOST CANYON CR. (TRIB. TO L. DELTON)
To: LEVERANCE
DNR Source: Surface Water
FITCHBURG
Account number: WR133 Collected by: LEVERANCE
Date Received: 04/23/92 Labslip #: IC090151 Reported: 05/20/92

TOTAL KJELDAHL NITROGEN	0.7	MG/L
TOTAL PHOSPHORUS	0.13	MG/L
SUSPENDED SOLIDS	37.	MG/L

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Environmental Science Section (608) 262-3458 DNR LAB ID 113133790
Inorganic chemistry (#10 of 15 on 05/21/92, unseen)

Id: Point/Well/..: 173 Field #: 2 Route: WR12
Collection Date: 04/23/92 Time: 10:45 County: 57 (Sauk)
From: SPRING BROOK - ABOVE (TRIB. TO L. DELTON)
To: LEVERANCE
DNR Source: Surface Water
FITCHBURG
Account number: WR133 Collected by: LEVERANCE
Date Received: 04/23/92 Labslip #: IC090152 Reported: 05/20/92

TOTAL KJELDAHL NITROGEN	0.8	MG/L
TOTAL PHOSPHORUS	0.05	MG/L
SUSPENDED SOLIDS	6.	MG/L

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Environmental Science Section (608) 262-3458 DNR LAB ID 113133790
Inorganic chemistry (#11 of 15 on 05/21/92, unseen)

Id: Point/Well/..: 173 Field #: 3 Route: WR12
Collection Date: 04/23/92 Time: 11:30 County: 57 (Sauk)
From: DELL CREEK BELOW MIRROR LAKE (TRIB. TO L. DELTON)
To: LEVERANCE
DNR
FITCHBURG
Source: Surface Water
Account number: WR133 Collected by: LEVERANCE
Date Received: 04/23/92 Labslip #: IC090153 Reported: 05/20/92

TOTAL KJELDAHL NITROGEN	0.8	MG/L
TOTAL PHOSPHORUS	0.08	MG/L
SUSPENDED SOLIDS	8.	MG/L

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Inorganic chemistry (#12 of 15 on 05/21/92, unseen)

Id: 573055 Point/Well/..: 173 Field #: 5 Route: WR12
Collection Date: 04/23/92 Time: 13:05 County: 57 (Sauk)
From: LAKE DELTON - 7 FT. DEPTH
To: LEVERANCE
DNR
FITCHBURG
Source: Surface Water
Account number: WR133 Collected by: LEVERANCE
Date Received: 04/23/92 Labslip #: IC090155 Reported: 05/20/92

TOTAL KJELDAHL NITROGEN	1.0	MG/L
TOTAL PHOSPHORUS	0.07	MG/L

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Inorganic chemistry (#23 of 24 on 08/18/92, unseen)

Id: 573055 Point/Well/..: 173 Field #: 5C Route: WR12
Collection Date: 7/23/92 Time: County: 57 (Sauk)
From: BOTTOM BACHHUBER LAKE DELTON
To: LEVERANCE
DNR Source: Surface Water
PITCHBURG
Account number: WR133 Collected by: LEVERANCE
Date Received: 07/24/92 Labslip #: ID009344 Reported: 08/17/92

TOTAL KJELDAHL NITROGEN	1.1	MG/L
TOTAL PHOSPHORUS	0.14	MG/L

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Inorganic chemistry (#21 of 24 on 08/18/92, unseen)

Id: 573055 Point/Well/..: 173 Field #: 5A Route: WR12
Collection Date: 07/23/92 Time: 14:00 County: 57 (Sauk)
From: SURFACE BACHHUBER LAKE DELTON
To: LEVERANCE
DNR Source: Surface Water
FITCHBURG
Account number: WR133 Collected by: LEVERANCE
Date Received: 07/24/92 Labslip #: ID009342 Reported: 08/17/92

CHLOROPHYLL A UNCORRECTED	80.6	UG/L
TOTAL KJELDAHL NITROGEN	1.0	MG/L
TOTAL PHOSPHORUS	0.13	MG/L

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Inorganic chemistry (#22 of 24 on 08/18/92, unseen)

Id: 573055 Point/Well/..: 173 Field #: 5B Route: WR12
Collection Date: Time: County: 57 (Sauk)
From: MIDDLE LAKE DELTON
To: LEVERANCE
DNR Source: Surface Water
FITCHBURG
Account number: WR133 Collected by: LEVERANCE
Date Received: 07/24/92 Labslip #: ID009343 Reported: 08/17/92

TOTAL KJELDAHL NITROGEN	1.0	MG/L
TOTAL PHOSPHORUS	0.13	MG/L

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Inorganic chemistry (#19 of 24 on 08/18/92, unseen)

Id: Point/Well/..: 173 Field #: 3 Route: WR12
Collection Date: 07/23/92 Time: 11:00 County: 57 (Sauk)
From: SPRINGBROOK BACHHUBER L. DELTON TRIB TO L. DELTON
To: LEVERANCE
DNR Source: Surface Water
FITCHBURG
Account number: WR133 Collected by: LEVERANCE
Date Received: 07/24/92 Labslip #: ID009340 Reported: 08/17/92

TOTAL KJELDAHL NITROGEN	0.8	MG/L
TOTAL PHOSPHORUS	0.14	MG/L
SUSPENDED SOLIDS	11.	MG/L

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Inorganic chemistry (#20 of 24 on 08/18/92, unseen)

Id: Point/Well/..: 173 Field #: 4 Route: WR12
Collection Date: 07/23/92 Time: 12:00 County: 57 (Sauk)
From: DELL CR BACHHUBER TRIB TO L. DELTON
To: LEVERANCE
DNR Source: Surface Water
FITCHBURG
Account number: WR133 Collected by: LEVERANCE
Date Received: 07/24/92 Labslip #: ID009341 Reported: 08/17/92

TOTAL KJELDAHL NITROGEN	1.2	MG/L
TOTAL PHOSPHORUS	0.09	MG/L
SUSPENDED SOLIDS	12.	MG/L

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Inorganic chemistry (#17 of 24 on 08/18/92, unseen)

Id: Point/Well/..: 173 Field #: 1 Route: WR12
Collection Date: 07/23/92 Time: 09:30 County: 57 (Sauk)
From: LOST CANYON BACHHUBER TRIB TO L DELTON
To: LEVERANCE
DNR Source: Surface Water
FITCHBURG
Account number: WR133 Collected by: LEVERANCE
Date Received: 07/24/92 Labslip #: ID009338 Reported: 08/17/92

TOTAL KJELDAHL NITROGEN	1.5	MG/L
TOTAL PHOSPHORUS	0.43	MG/L
SUSPENDED SOLIDS	7.	MG/L

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Inorganic chemistry (#18 of 24 on 08/18/92, unseen)

Id: Point/Well/..: 173 Field #: 2 Route: WR12
Collection Date: 07/23/92 Time: 10:00 County: 57 (Sauk)
From: L DELTON OUTLET BACHHUBER COUNTY A TRIB TO L. DELTON
To: LEVERANCE
DNR Source: Surface Water
FITCHBURG
Account number: WR133 Collected by: LEVERANCE
Date Received: 07/24/92 Labslip #: ID009339 Reported: 08/17/92

TOTAL KJELDAHL NITROGEN	1.4	MG/L
TOTAL PHOSPHORUS	0.15	MG/L
SUSPENDED SOLIDS	28.	MG/L

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Inorganic chemistry (#58 of 77 on 09/21/92, unseen)

Id: 573055 Point/Well/..: 173 Field #: 5 Route: WR12
Collection Date: 08/20/92 Time: 13:00 County: 57 (Sauk)
From: LAKE DELTON MIDDLE
To: LEVERANCE
DNR
FITCHBURG
Source: Surface Water
Account number: WR133 Collected by: LEVERANCE
Date Received: 08/21/92 Labslip #: ID019972 Reported: 09/18/92

TOTAL KJELDAHL NITROGEN	1.0	MG/L
TOTAL PHOSPHORUS	0.12	MG/L

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Inorganic chemistry (#59 of 77 on 09/21/92, unseen)

Id: 573055 Point/Well/..: 173 Field #: 6 Route: WR12
Collection Date: 08/20/92 Time: 13:00 County: 57 (Sauk)
From: LAKE DELTON BOTTOM
To: LEVERANCE
DNR
FITCHBURG
Source: Surface Water
Account number: WR133 Collected by: LEVERANCE
Date Received: 08/21/92 Labslip #: ID019973 Reported: 09/18/92

TOTAL KJELDAHL NITROGEN	0.9	MG/L
TOTAL PHOSPHORUS	0.13	MG/L

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Inorganic chemistry (#56 of 77 on 09/21/92, unseen)

Id: Point/Well/..: 173 Field #: 3 Route: WR12
Collection Date: 08/20/92 Time: 11:00 County: 57 (Sauk)
From: DELL CR. (TRIB. TO L. DELTON)
To: LEVERANCE
DNR Source: Surface Water
FITCHBURG
Account number: WR133 Collected by: LEVERANCE
Date Received: 08/21/92 Labslip #: ID019970 Reported: 09/18/92

TOTAL KJELDAHL NITROGEN	0.4	MG/L
TOTAL PHOSPHORUS	0.04	MG/L
SUSPENDED SOLIDS	6.	MG/L

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Inorganic chemistry (#57 of 77 on 09/21/92, unseen)

Id: 573055 Point/Well/..: 173 Field #: 4 Route: WR12
Collection Date: 08/20/92 Time: 13:00 County: 57 (Sauk)
From: LAKE DELTON SURFACE
TO: LEVERANCE
DNR Source: Surface Water
FITCHBURG
Account number: WR133 Collected by: LEVERANCE
Date Received: 08/21/92 Labslip #: ID019971 Reported: 09/18/92

CHLOROPHYLL A UNCORRECTED	54.7	UG/L
TOTAL KJELDAHL NITROGEN	0.8	MG/L
TOTAL PHOSPHORUS	0.11	MG/L

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Inorganic chemistry (#54 of 77 on 09/21/92, unseen)

Id: Point/Well/..: 173 Field #: 1 Route: WR12
Collection Date: 08/20/92 Time: 09:50 County: 57 (Sauk)
From: OUTLET ABOVE CO. HWY A OUTLET (TRIB. TO L. DELTON)
To: LEVERANCE
DNR Source: Surface Water
FITCHBURG
Account number: WR133 Collected by: LEVERANCE
Date Received: 08/21/92 Labslip #: ID019968 Reported: 09/18/92

TOTAL KJELDAHL NITROGEN	0.9	MG/L
TOTAL PHOSPHORUS	0.13	MG/L
SUSPENDED SOLIDS	19.	MG/L

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Inorganic chemistry (#55 of 77 on 09/21/92, unseen)

Id: Point/Well/..: 173 Field #: 2 Route: WR12
Collection Date: 08/20/92 Time: 10:30 County: 57 (Sauk)
From: SPRING BROOK (TRIB. TO L. DENTON)
To: LEVERANCE
DNR Source: Surface Water
FITCHBURG
Account number: WR133 Collected by: LEVERANCE
Date Received: 08/21/92 Labslip #: ID019969 Reported: 09/18/92

TOTAL KJELDAHL NITROGEN	1.0	MG/L
TOTAL PHOSPHORUS	0.16	MG/L
SUSPENDED SOLIDS	56.	MG/L

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Inorganic chemistry (#51 of 97 on 08/28/92, unseen)

Id: Point/Well/..: 173 Field #: 7 Route: WR12
Collection Date: 08/20/92 Time: 12:00 County: 57 (Sauk)
From: URBAN RUNOFF (TRIB. TO L. DELTON)
To: LEVERANCE
DNR Source: Surface Water
FITCHBURG
Account number: WR133 Collected by: LEVERANCE
Date Received: 08/21/92 Labslip #: ID019974 Reported: 08/27/92

SUSPENDED SOLIDS	67.	MG/L

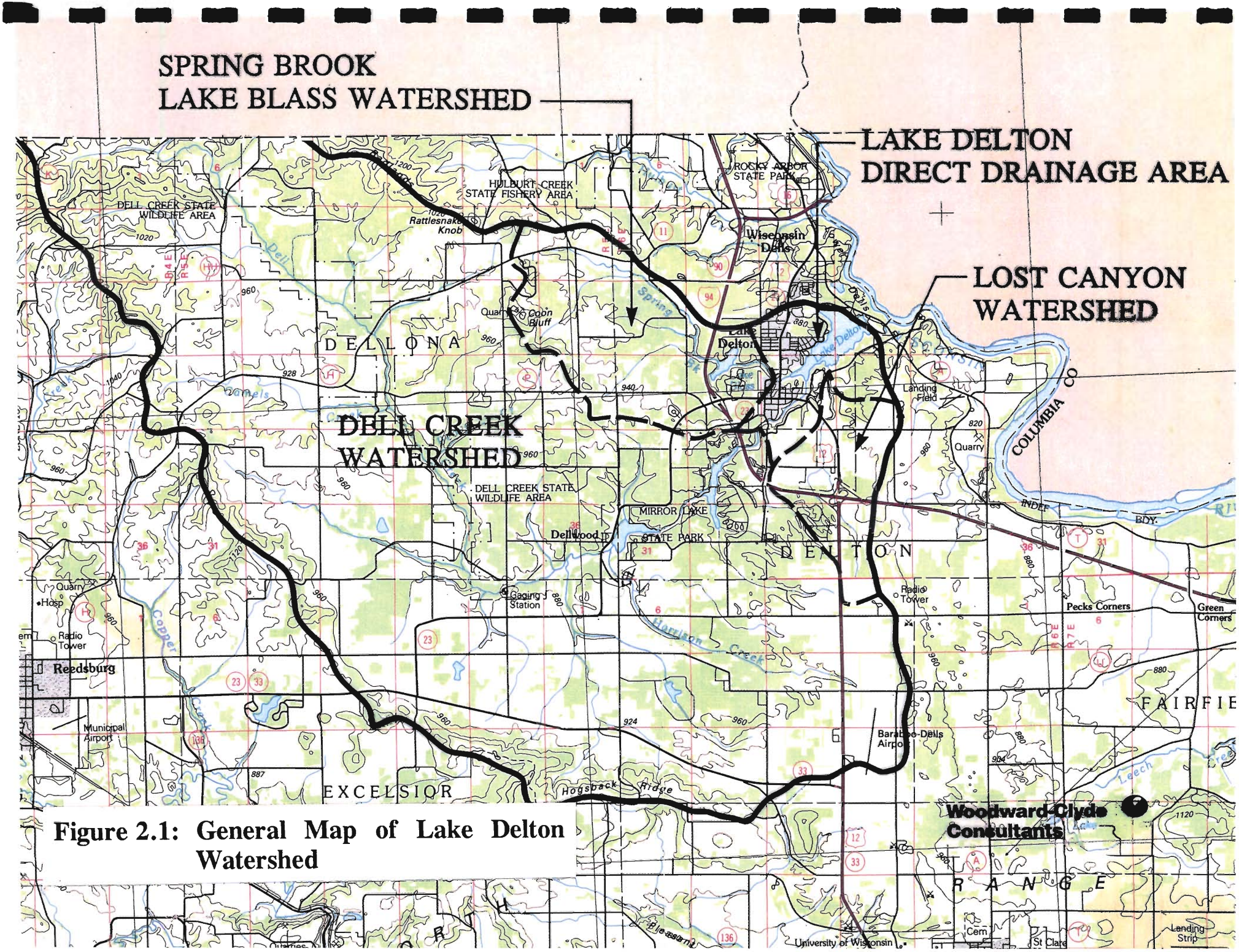

Figure 2.1: General Map of Lake Delton Watershed