City of Greenville
Governor Bond Lake

Illinois Environmental Protection Agency

CLEAN LAKES PROGRAM

Phase 1 Diagnostic Feasibility Study

GOVERNOR BOND LAKE
CITY OF GREENVILLE, BOND COUNTY, ILLINOIS

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For the City of Greenville
In Cooperation with the Illinois Environmental Protection Agency

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Illinois Clean Lakes Program

Phase I Diagnostic- Feasibility Study of Governor Bond Lake, Bond County, Illinois

PART 1

DIAGNOSTIC STUDY

INTRODUCTION

Governor Bond Lake, constructed 1968-1970, is the principal drinking water supply for the City of Greenville, Bond County, Illinois. The lake is also a major recreational resource for Bond and surrounding counties. The lake provides drinking water for over 7,600 people in the City of Greenville and its service area. At 775 acres, the lake surface area receives inflow from a total watershed area of 22,080 acres. Over 80% of the watershed is cropland, with the remaining 20% composed of pasture, forest, urban and other land uses. The lake is entirely owned by the municipality of Greenville.

Historic data collected by the Illinois Environmental Protection Agency (IEPA) by way of its Ambient Lake Monitoring Program (ALMP), as well as data available from the local water treatment plant (WTP), indicated elevated levels of nutrients (nitrogen and phosphorus compounds). The lake's hypereutrophic state was of particular concern. Data also suggested that use of the lake for drinking water and recreation had been significantly impaired by heavy sedimentation within the lake. The local office of the Natural Resource Conservation Service (NRCS) and its Resource Planning Committee, as well as other local interested parties had conducted extensive planning and review of the problem. Evidence pointed to use impairment and shortened life span of the lake due to sedimentation, with as much as one-third of total lake volume lost to date.

In an effort to develop a comprehensive understanding of water quality issues and to aid in developing scientifically sound restoration measures, the City applied for a Phase I Diagnostic / Feasibility Study grant from the IEPA. In October of 1998 the City of Greenville submitted a final grant application to the IEPA to study Governor Bond Lake. The IEPA provided cost sharing for this study through their Clean Lakes Program, funded through the state-sponsored Conservation 2000 (C2K) program in Illinois.

The City of Greenville partnered with the Zahniser Institute for Environmental Studies at Greenville College and began work in April of 1999.

Table 1 Lake Identification and Location

Lake Name	**Governor Bond**
IEPA Lake Code	**ROP**
State	**Illinois**
County	**Bond (005)**
Nearest City	**Greenville**
Latitude	**38°57' 02"**
Longitude	**89°21' 56"**
USEPA Region	**5**
Major Basin	**07 Upper Mississippi**
Minor Basin	**14 Kaskaskia**
USGS Hydrologic Unit Code	**07140203**
Major Tributary	**Dry Branch**
Receiving Water Body	**Shoal Creek**
Water Quality Standards	**Title 35 Environmental Protection; Subtitle C Water Pollution; Chapter I Pollution Control Board; Part 302 Water Quality Standards**

GEOLOGICAL AND SOILS DESCRIPTION OF THE DRAINAGE BASIN

The following geological and groundwater description is taken from a 1995 report compiled by Dr. Leon Winslow, Geology professor at Greenville College (Winslow 1995).

The Greenville area is part of a belt of low ridges and hills that rise above a broad, flat, physiographic area called the Springfield Plain. Here the landscape was shaped largely by great, slow-moving continental masses of ice, called glaciers, that covered much of Illinois repeatedly during the past million years or so. Glaciers left deposits of materials on the irregular bedrock surface; these materials, generally unconsolidated, but sometimes as dense as claystone, include pebbly clay (till), water-laid sand and gravel (outwash), and wind-laid silt (loess). The glacial deposits (drift) are 150 feet thick or more in the Greenville area. The soils here, as well as in most of the rest of Illinois, are developed in the upper portion of the glacial deposits.

Evidence for pre-Illinoian glaciation has been reported. The older glacier came across this area, following about the same path as the Illinoian glaciers, from a region of snow and ice accumulation in northeastern Canada. Remains of these early deposits have been buried by younger glacial deposits left by Illinoian glaciers that slowly advanced across the state, establishing the southernmost limit of continental glaciation in North America. Glaciers of Wisconsinan age reached to within about 45 miles northeast of Greenville. Although Wisconsinan drift did not cover the Greenville area, silts and loess of Wisconsinan age do mantle the older Sangamon Soil that had developed on the Illinoian till plain.

Curious features are found on the Illinoian till plain in the Greenville and adjacent areas: elongated ridges and knolls that trend primarily north-northeast. The elongated ridges are composed largely of sand and gravel, and the knolls scattered across the landscape contain gravel, glacial till, and blocks of ice-thrusted bedrock. The origin of these features has been the object of much debate throughout this century, but the latest research indicates that they are the result of deposition from glaciers that, for the most part, were stagnant. These deposits have been of considerable interest for many years because they are one of the most important sources of building and road materials in southern Illinois.

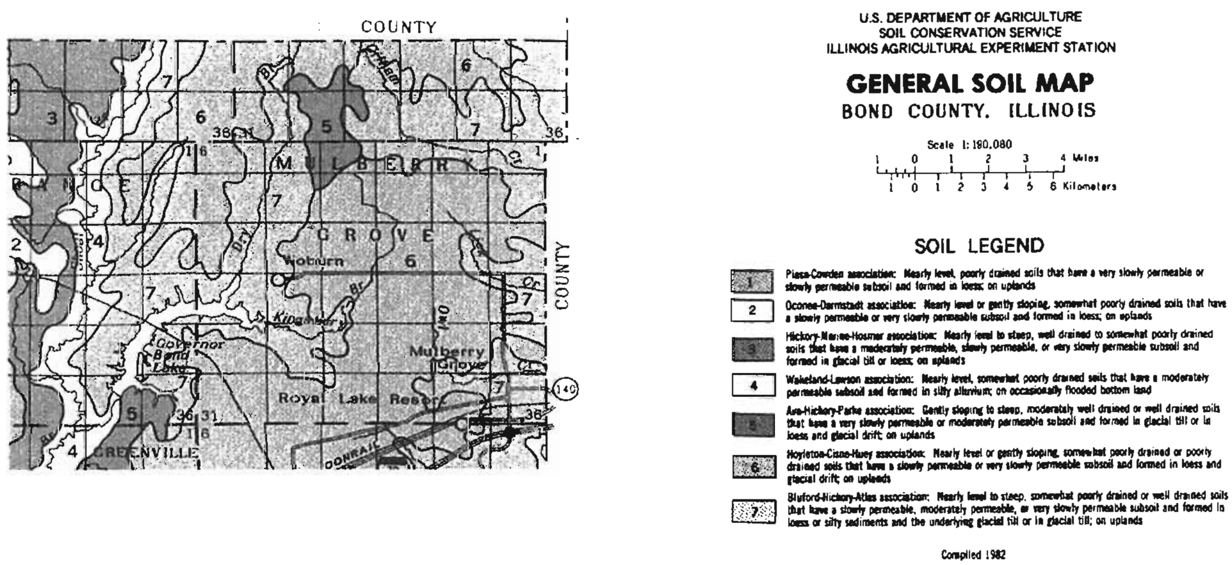
The relatively loose Quaternary deposits in the Greenville area are underlain by consolidated, layered bedrock strata of late Pennsylvanian age that were deposited in shallow seas that some 275 million years ago repeatedly covered this part of what is now the Mid-continent Region of North America. Relatively thin layers of rock, such as shale, limestone, coal, and sandstone, are exposed only at a few places along stream banks and in quarries and roadcuts. Older strata, known from water, oil and gas prospect wells, have an aggregate thickness here of between 6,000 and 7,000 feet. These strata dip down gently to the south and east into the deeper parts of the Illinois Basin forming a broad, shallow, spoon-shaped bedrock depression that underlies much of southern Illinois and adjacent portions of southwestern Indiana and western Kentucky.

Groundwater is obtained from underground reservoirs occurring in beds of saturated glacial sand and gravel or stream alluvium, or in porous or creviced bedrock layers. Groundwater is released slowly into creeks, lakes, and ponds during dry periods, replenishing water lost through evaporation, outflow, and well water and other withdraws.

The original municipal water supply for Greenville was obtained from shallow sand and gravel wells located in the southern part of the city that tapped the Hagarstown Member of the Glasford Formation. In 1923, this location was abandoned when eight new wells ranging from 45 to 60 feet deep were put into service just north of the depot between Second and Third Streets. The combined yield of these new wells was about 195 gallons per minute (gpm). In 1927, seven new wells (average depth, 62 feet) were opened north of the stockyard; they had a total yield of about 300 gpm. Additional exploration, only partially successful, for sand and gravel well sites was undertaken as water demands increased in the 1940s and 1950s. In the late 1960s, damming the Kingsbury Branch north of Greenville formed Governor Bond Lake. The lake covers 775 acres and provides drinking water for the city and surrounding communities.

The topography of the watershed is gently rolling hills, with some erosion and stream dissection development. Soils have developed under both prairie and forest vegetation, with soil types including steeply sloping timber soils (Hickory), upland timber soils (Atlas, Bluford and Wynoose), prairie soils (Cisne and Hoyleton) and sodium / natric soils (Darmstadt, Huey and Piasa). The broad, flat, alluvial valleys of Kingsbury and Dry Branches contain 30-50 feet of exposed glacial till mantled with 4 feet or more of loess. (Soil Survey of Bond County, Illinois U.S. States Department of Agriculture Soil Conservation Service 1981, Figure 1).

Figure 1 Soil Map of Governor Bond Lake Watershed



The soils in the Governor Bond Lake watershed have been extraordinarily productive for agricultural purposes, as well as for maintenance of grasslands and forest. A general description of the soils is as follows:

- Steeply Sloping Timber Soils – Steep, well-drained soil, occurring on slopes ranging from 20 to 30 percent. Often times, these are the soils that are immediately adjacent to the lake. Hickory is the typical soil type within this group. This group of soils developed on exposures of weathered glacial till with a thin loess cover less than 4 feet.
- Upland Timber Soils – Light colored, silt loam soil with moderately slow permeability. These soils occur on slopes ranging from 0 to 10 percent. They developed in loess and the underlying weathered Illinoian till. Typical soils are Atlas, Bluford, and Wyrosse.
- Prairie Soils – Nearly level, somewhat poorly drained to poorly drained soils, located in shallow depressions and on low ridges throughout the watershed. Typically, the surface layer is much darker and thicker than under the timber soils. Typical soil types are Cisne and Hoyleton.
- Sodium (Natric) Soils – Of special note in this watershed are soils that have an accumulation of sodium in their subsoils much high than "normal." These soils are poorly and somewhat poorly drained and most often are located on broad upland plains and low ridges. These soils also contain high amounts of clay in their subsoils. They have "dispersed" subsoil, due to the high sodium. This clay dispersion or "clay plugging," plus the high total clay content, causes these soils to have very slow permeability. This feature affects all use and management of these soils, from erosion to urban uses. Typical soil types are Darmstadt, Huey, and Piasa.

Kingsbury Branch has wide flat-bottomed valleys suitable for cultivation which attain widths of a quarter mile in some places. Where these valleys are deepest, their floodplains lie some 50 to 60 feet below the average upland levels. The last glacier (Illinoian) moved across a subdued land surface whose depressions were filled by the drift of the earlier glaciers. The glacial deposits in this area were laid down on a surface that apparently had about as much relief as that of the present average upland surface. One of the principle pre-glacial valleys, followed generally by the present valley of Kingsbury Branch, extends from northeast to southwest across Bond County. There are numerous places along the valleys in this area where as much as 40 to 50 feet of Illinoian drift is exposed, and along Dry Branch in the northern part of the watershed, 30 feet is exposed. The glacial deposits were mantled with an average thickness of four feet of loess.

The geological processes that have been active in this area since the glaciers melted from the mainland of North America include weathering, erosion, slope wash, and wind. Erosion has developed to the point where possibly only one-fourth of the upland area is ineffectively drained. Dry Branch Creek, the northern tributary, has not only widened the valley in this watershed but has also deepened it.

Governor Bond Lake is a relatively young lake, but siltation has significantly reduced the volume of the lake from a water supply standpoint. Also, recreational use and fish habitats have been negatively affected. Governor Bond Lake is bisected at two points: by a railroad causeway and trestle (mid-lake) and an elevated fill road (upper lake) (Figure 2). The railroad trestle that divides the lake tends to create two lakes with different water quality characteristics. The area east of the Woburn Road constriction acts as a silt basin for the Kingsbury Branch inflow; the railroad trestle effectively detains water at mid-lake, trapping most of the soil particles before they are transported to the lower end of the lake. The upper areas of the lake (above the mid-lake trestle and upper lake roadway), therefore, have higher levels of turbidity.

Using the 1985 Food Security Act definition, there are 1,780 acres of highly erodible soils in the Governor Bond Lake watershed in pasture, hayland, and woodland. About 1,505 acres of the highly erodible soils are in cropland and are eroding at an average of 16 tons/acre/year. There are 5,642 acres of potentially highly erodible soils in the watershed where sheet and rill erosion generates approximately 6.5 tons/acre/year. Another 10,552 acres of cropland contribute an average annual soil loss of 2.5 tons/acre/year. The remaining 2,622 acres of watershed contains pasture, woodland, urban areas, and streams, ponds and lakes. These erosion figures are based on pre-1985 Food Security Act FSA plan applications and soil losses. Housing developments and construction activities add to the soil lost and eroded into the lake, since all are close to the shoreline. Any erosion that occurs discharges directly into the lake (Table 2).

Table 2 NRCS Estimate of Sediment Delivered to the Lake Yearly

Source: GBL Lake Ecosystem Plan

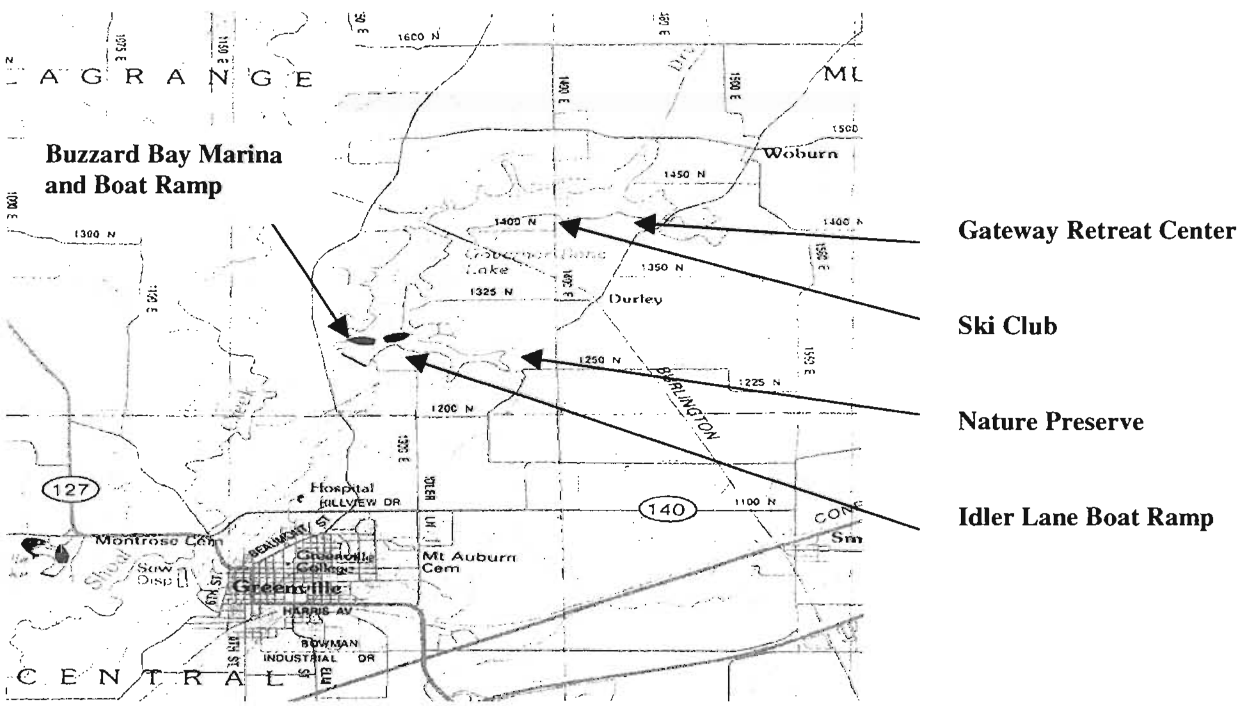
Erosion Sources	Gross Erosion (Ton/yr.)	Sediment Delivery Ration (SDR)	Gross Sedimentation (Tons/yr.)
Sheet and Rill			
Cropland	85,316	0.70	59,700
Pasture	5,400	0.75	4,050
Woodland	6,969	0.80	5,575
Other	862	0.80	690
Total Sheet & Rill	98,546		70,015
Ephemeral	11,825	0.90	10,600
Gully	11,390	0.90	10,250
Streambank	1,050	1.0	1,050
Shoreline	1,420	1.0	1,420
Total	124,231		93,320
SedimentTransportation Factor (STF)			x 0.35
Sediment delivered to the lake yearly			32,670 tons

Gully, ephemeral gully and streambank erosion has not been specifically measured at this time, but these sources of erosion could add as much at 15,768 tons of sediment to the lake each year. Although sedimentation has not yet threatened the lake as a water supply from a volume perspective, the effects of sedimentation are obvious. Boaters on Governor Bond Lake report difficulty in reaching the upper end of the lake because of sedimentation. In addition, sedimentation has caused a reduction in Governor Bond Lake's water storage capacity. The estimates from NRCS' sediment survey indicated the loss of one-third of the lake's volume and water-holding capacity (Source Gov. Bond Lake Ecosystem Plan , IEPA, NRCS, SWCD, IDNR).

PUBLIC ACCESS AND BENEFIT

The lake provides substantial benefits to the local and regional population, including a local, safe drinking water supply and a highly valued recreational resource. Governor Bond is a popular fishing location drawing people from throughout the region. Boating and skiing are also popular activities on the Lake. The ski club holds contests and maintains a slalom course for skiers. The public is allowed reasonably controlled access to the lake, including boat permits issued to both local and non-local users. City Ordinances promote recreational uses without causing undue impact on the water supply (e.g. fishing, boating/skiing allowed, but no swimming).

Figure 2 Map of Lake Access



The public has access to the lake through a variety of means (Figure 2). There are several subdivisions around the lake with homes on or near the lake. Many of these homes have boat docks providing direct access to the lake. There are also several subdivisions, which provide boat access to owners who do not own lake front property. The ski club located east of the railroad trestle provides lake access to members. Durley Camp, located at the eastern end of the lake near Woburn Road, provides lake access to campers. In addition to these private access points the city maintains two boat ramps. One ramp is located east of the spillway at the end of Idler Lane. The other is west of the spillway off of Redball Trail. Both boat ramps provide free parking for boat users. The Buzzard Bay marina off Redball Trail provides boat rental, camping, and a bait store. The Kingsbury Park District maintains an 80-acre nature preserve on the southeastern portion of the Lake. The preserve has trails which allow horseback riding, walking and mountain biking. There is also a picnic pavilion and free parking located near the entrance. Along one of the trails there is a historic log cabin. The preserve is free to the public. There is no public transportation that provides public access to the lake.

Local Interest & Resource Commitment

There is an ever-increasing level of local interest and support, which has been substantial since 1993 (with the development of the first resource planning committee). The current resource planning committee has completed its resource planning document (Appendix 1). The City of Greenville has already committed to a long-term investment of time and, ultimately, financial resources to improve/enhance Governor Bond Lake. Applications have been submitted requesting grant monies available from several federal and state sources to assist with lake improvements, although no grants have been issued to date apart from this Clean Lakes grant.

SIZE AND ECONOMIC STRUCTURE OF POTENTIAL USER POPULATION

Governor Bond Lake is used by a number of individuals from the City of Greenville and from throughout the region. The populations of Greenville and Bond County according to the most recently available census report (1990) are 4,806 and 14,991 respectively. Currently, the population for Greenville and Bond County has increased to 6,438 and 16,321 respectively.

Governor Bond Lake is located in southcentral Illinois just northeast of the city of Greenville, the county seat for Bond County. The major cities within a 30-mile radius of the city include Highland to the west, Hillsboro to the north, Vandalia to the east and Carlyle to the south (Table 3). The counties in the region with potential user population include Bond, Montgomery, Fayette and Clinton (Table 4).

Table 3 Census Data for Major Cities within 30 Miles of Governor Bond Lake

	Greenville	Carlyle	Highland	Hillsboro	Vandalia
Population 1998	6,438				
Population (1990 census)	4,806	3,474	7,525	4,400	6,114
Total Housing Units	2,015	1,391	3,047	1,943	2,341
Median household income	21,124	24,944	32,009	25,151	21,683
Percent below poverty level	15.2%	12.1%	4.5%	16.3%	13.1%
SOURCES OF WATER					
Public system or private company	1,990	1,391	3,034	1,923	2,307
Individual drilled well	21	0	13	20	15

Table 3 (Cont.)	Greenville	Carlyle	Highland	Hillsboro	Vandalia
Individual dug well	4	0	0	0	11
Some other source	0	0	0	0	0
SEWAGE DISPOSAL					
Public sewer	1,917	1,381	3,015	1,834	2,253
Septic tank or cesspool	94	10	32	109	80
Other means	4	0	0	0	8
EDUCATIONAL LEVEL					
Percent high school graduate or higher	78.8%	66.5%	72.1%	76.2%	71.4%
Percent bachelor's degree or higher	23.9%	10.3%	13.1%	13.3%	10.3%

Bureau of Census 1990

Table 4 Census Data for Counties in the Region with Potential User Populations

	Bond County	Montgomery County	Fayette County	Clinton County	Illinois
Population (1990 census)	14,491	30,728	20,893	33,944	11,430,602
Total Housing Units	6,136	12,456	8,551	12,746	4,506,275
Median household income	23,756	23,879	22,029	29,890	32,252
Percent below poverty level	12.1%	14.0%	13.6%	10.2%	11.9%
SOURCE OF WATER					
Public system or private company	3,942	9,789	4,502	10,131	4,044,971
Individual drilled well	1,133	1,133	1,714	1,524	366,146
Individual dug well	968	1,402	1,948	1,000	74,026
Some other source	93	132	387	91	21,132
SEWAGE DISPOSAL					
Public sewer	3,100	8,493	4,067	8,448	3,885,689
Septic tank or cesspool	2,878	3,796	4,249	4,047	598,125
Other means	158	167	235	251	22,461
EDUCATIONAL LEVEL					
Percent high school graduate or higher	69.2%	72.2%	68.8%	67.2%	76.2%
Percent bachelor's degree or higher	12.7%	8.1%	8.5%	9.2%	21.0%
1980 Population Estimate	16,224	31,686	22,167	32,617	11,427,409
1997 Population Estimate	17,070	30,992	21,604	35,367	11,895,849
Percent change between 1980-1990	-7.6%	-3.0%	-5.7%	4.1%	0.0%
Percent change between 1990-1997	14%	0.9%	3.4%	4.2%	4.7%

Bureau of Census 1990

SUMMARY OF HISTORICAL LAKE USES

The lake has been a premiere recreational resource since its construction in 1970. Fishing and boating are the two major activities that occur on the lake. Other activities include educational activities, camping, skiing, horseback riding, hiking and picnicking.

There is very little data regarding past lake usage, but information was obtained from boat permit data, fishing license data and estimates were made based on interviews and personal observations (Tables 5 and 6).

Table 5 Governor Bond Lake Boat Permit Breakdown, 1996-1999

	Class A (Non Motored)	Class B (Trolling)	Class C (51-135)	Class C1 (136-200/210)	Class D (Dealers)	Class E Tournament	Class F (Rental)	P.W. (51-120)	P.W. (51-120)	Total Permits
In County										
1996	56	169	150	0	1	6	3	16	16	417
1997	50	161	141	0	1	7	5	12	23	400
1998	30	175	144	17	1	9	7	11	29	423
1999	28	186	141	24	1	8	8	10	33	439
Out-of County										
1996	9	110	60	0	0	1	0	19	15	214
1997	10	127	76	0	0	1	0	12	7	233
1998	9	156	88	0	0	1	0	11	12	280
1999	12	170	77	0	0	2	0	11	11	303
Total 1996	65	279	210	0	1	7	3	35	31	631
Total 1997	60	288	217	0	1	8	5	24	30	633
Total 1998	39	331	232	20	1	10	7	22	41	703
Total 1999	40	356	218	44	1	10	8	21	44	742

Source: City of Greenville

Table 6 1999-2000 Lake Usage Estimates

Estimated number of people using the lake annually	
Ski Club	150
Nature Preserve	2,000-4,000
Durely Camp	1,200-1,500
Boating Permits	742
Fishing License	2,500
Estimated Usage Hours from GBL Resource plan	59,615

POPULATION SEGMENTS AFFECTED BY LAKE DEGRADATION

Governor Bond Lake serves the two main functions of public drinking water supply and recreational resource. It is clear that both of these main functions are negatively affected by hypereutrophication of the lake. Pollution sources such as sedimentation and nutrient loading are diminishing lake water quality, which in turn increases water treatment costs. Low visibility, caused by sediments and high nutrient-related algal blooms, negatively affect recreational uses such as boating, skiing as well as fishing.

One significant effect has been the need, because of the poor water quality, for the City to upgrade its water treatment plant disinfection process. The current system of chlorine gas infusion is becoming progressively less desirable as EPA regulations, pursuant to the Safe Drinking Water Act, call for tighter limits on tri-halomethanes (THMs) and residual chlorine in drinking water. Hypereutrophic water supplies, like Governor Bond Lake, are particularly vulnerable to such regulatory changes because increasing amounts of chlorine are required, while the amount of permitted chlorine decreases. The City is currently considering an upgrade of the disinfection process, which may include a tri-ox system to replace the current chlorination process. This upgrade could cost in excess of $250,000.00, a significant expenditure for a small, rural community. Several specific population segments suffering adverse effects are described below.

Elderly and Low Income

Poorer water quality has resulted in needs for more sophisticated treatment processes, which in turn has resulted in higher water bills. This is particularly hard on the elderly who have fixed incomes, and low income families.

General Public - City Services

High treatment plant costs and expensive processes reduce the amount of discretionary funds available for other City functions and programs. Currently, the City is considering disinfection alternatives which could cost the City more than $250,000.00.

General Public - Drinking Water Quality

It has become commonplace for City water users to experience brief periods of poor taste and color in their drinking water. In addition, there are periods of high chlorine content in the finished water which can cause skin irritation and other problems.

Recreational Fisherman

The low visibility and dissolved oxygen levels can have serious consequences for game fish. Low body weight, fecundity (birth rates) and periodic fish kills dramatically reduce the average age and body mass of standing stock.

Lake Residents and Property Owners

Aesthetic effects are common, but are hard to quantify economically. Water discoloration, algal blooms, and odors, related to high nutrient loading, all have aesthetic as well as use-related effects. Shoreline erosion and property damage are direct effects associated with maintenance related needs at the lake. Finally, sedimentation has dramatically reduced or impaired access to boat docks and shoreline areas, which historically were available for boat and canoe access.

COMPARISON OF LAKE USAGE TO OTHER LAKES WITHIN 80 KM

Most of the lakes within 80 kilometers of Governor Bond Lake are found in the Middle Kaskaskia River/Shoal Creek Watershed (Figure 3). The only exception to this is Highland Silver Lake (ROZA) which is found in the Lower Kaskaskia River Watershed. At 775 acres, Governor Bond Lake is the largest lake found entirely in Bond County.

The only other lakes 10 acres or greater located entirely in the county are Greenville Old City Lake (ROY) at 25.1 acres and Sorento (ROZH) at 11 acres. One of the unique aspects of Governor Bond Lake is the Nature Preserve with its horse and hiking trails, which provide wonderful overlooks of the Lake. The nature preserve also hosts numerous school groups. Governor Bond Lake is one of the few lakes in the area which also provides camping. The Buzzard Bay marina provides camp sites which overlook the lake. Durley Camp, on the north end of the lake, hosts numerous summer camping groups. Finally, fishing and boating are two popular activities for which the lake is in high demand by area wide residents.

Table 7 Lakes within 80 Kilometers of Governor Bond Lake

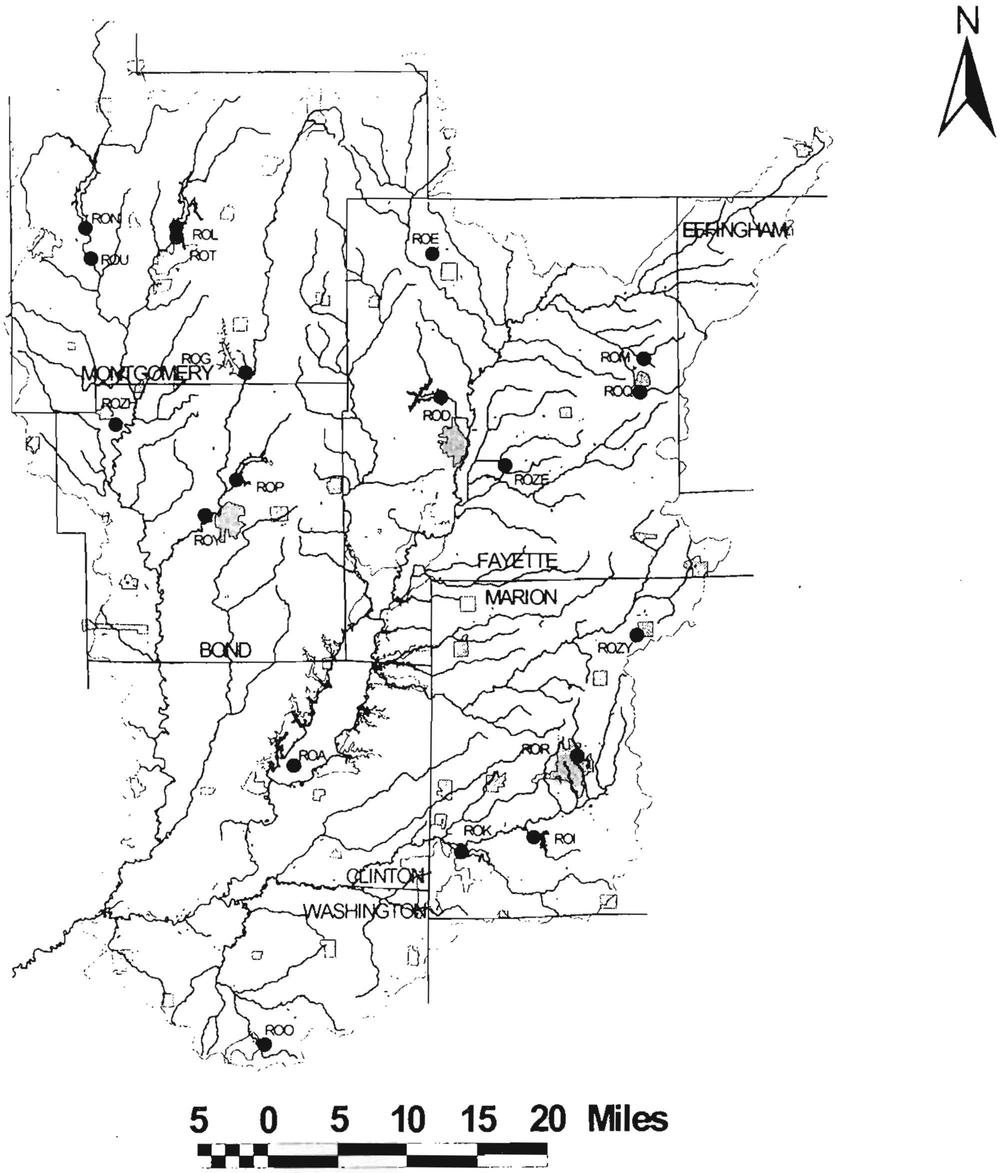
	Code	Acres	Fishing	Boating	Hiking	Hunting	Camping	Horseback Riding
Governor Bond	ROP	775	X	X	X		X	X
Carlyle	ROA	24580	X	X	X	X	X	
Centralia	ROI	450	X	X	X			
Coffeen	ROG	1038	X	X	X			
Glen Shoals	ROL	1350	X	X	X		X	
Greenville Old	ROY	25.1	X	X	X			
Highland Silver	ROZA	550	X	X	X			
Kinmundy	ROZY	20	X	X	X		X	
Lou Yaeger	RON	1205	X	X	X		X	
Nashville City	ROO	37.2	X					
Raccoon	ROK	925	X	X	X			
Ramsey	ROE	46.6	X	X	X			
Salem	ROR	74.2		X	X			
Sorento	ROZH	11						
St. Elmo New	ROM	68	X	X	X			
St. Elmo Old	ROQ	25.3		X				
Stanberry	ROZE	12						
Vandalia	ROD	660	X	X	X			
Walton Park	ROU	25		X				

POINT SOURCE DISCHARGES

There is one minor point source discharger in the Governor Bond Lake watershed, the Gateway Retreat Center, which discharges into a roadway ditch leading to the lake. Flow rate for this discharger is 0.0160 MGD for 2 to 3 months each year. This discharger has no permitted limits and is only required to report quantities discharged.

Reported total potential point source load per year to Governor Bond Lake is 7.5lbs of BOD (3.4 Kg), 5.4 lbs of total suspended solids (2.5 kg), and 1.6 lbs of Ammonia (0.7 kg) (Discharge Monitoring Reports 1998 to 2000, IEPA, TMDL Report).

Figure 3 Middle Kaskaskia River/Shoal Creek River Watersheds



LAKE CODES	
CARLYLE	ROA
CENTRALIA	ROI
COFFEEN	ROG
GLEN SHOALS	ROL
GOV BOND (GREENVILLE)	ROP
GREENVILLE OLD	ROY
HILLSBORO OLD	ROT
KINMUNDY	ROZY
LOU YAEGER	RON
NASHVILLE CITY	ROO
RACCOON	ROK
RAMSEY	ROE
SALEM	ROR
SORENTO	ROZH
ST ELMO NEW (NELLIE)	ROM
ST ELMO OLD	ROQ
STANBERRY	ROZE
VANDALIA	ROD
WALTON PARK	ROU

- Lake
- Watershed Boundary
- County Boundaries
- Rivers and Streams
- Reference Communities

Illinois Environmental Protection Agency
Bureau of Water
Surface Water Section

LAND USES AND NONPOINT POLLUTION LOADING

Bond County Tillage Practices

According to the Illinois Soil Conservation Transect Survey Summary, 28% of the cropland in Bond County is farmed using conservation tillage. Conservation tillage can greatly reduce the amount of soil erosion and help reduce the amount of sedimentation that collects in lakes. Conservation tillage also helps reduce nutrient loading from agriculture runoff.

Table 8 Bond County Tillage Practices

	Corn/acres	Soybeans/acres	Small grains/ acres	Total
Conventional	72538	36481	11453	120472
Reduced	0	0	0	0
Mulch	424	2121	3818	6363
No-Till	1697	18240	20786	40723
N/A/Unknown	0	0	0	0
Total	**74658**	**56842**	**36057**	**167558**
Percent Conservation Tillage	**3%**	**36%**	**68%**	**28%**

Source: 2000 Illinois Soil Conservation Transect Survey Summary

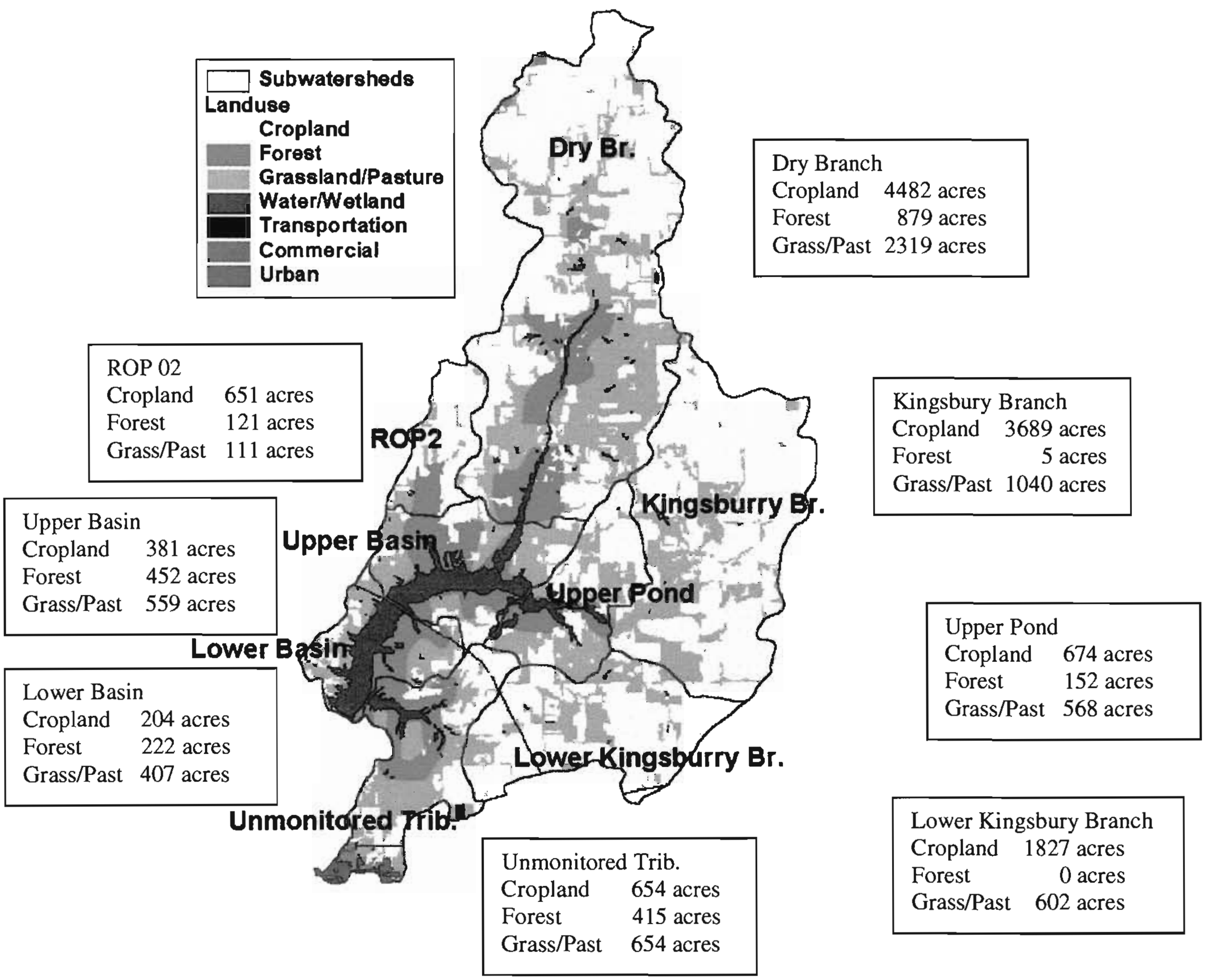
Governor Bond Lake Watershed Land Use

The watershed surrounding Governor Bond Lake is dominated by agriculture. Eighty percent of the land is cropland with fifteen percent of this land under the Conservation Reserve Program. Eight percent is forest. Two percent is urban and four percent is water or wetland area (GBL Resource Plan 1999). Runoff from agricultural land can contribute significantly to the sediment and nutrient loads for a lake. The NRCS estimates that more than 38,025 tons of sediment is delivered to the lake on an annual basis. This sediment brings with it fertilizers and pesticides that are deposited into the lake. High amounts of phosphorus and nitrogen run off contribute to the eutrophication of the lake by increasing algae growth. This algae growth also contributes to the turbidity and lack of water clarity. Residential use contributes significantly, as well, to both sedimentation and nutrient loading of the lake. In recent years there has been an increase in development around the lake. Homes on or near the lake can contribute to the nutrient and sediment load in the lake. Fertilizer run off from home fertilizers as well as nutrients from the septic systems used around the lake can contribute to the nutrient loading of the lake. New construction around the lake contributes to the sedimentation of the lake as well. If proper erosion control measures are not taken during construction, significant amounts of sediment can enter the lake. Lake front property that is not properly protected with rip-rap or other erosion control material can contribute significant amounts of sedimentation to the Lake.

Subwatershed Delineation

In an effort to develop a better understanding of the non-point pollution contribution of different areas around the watershed the overall watershed was further divided into 8 subwatersheds (Figure 4). The subwatersheds include: Dry Branch, Kingsbury Branch, Upper Pond, Lower Kingsbury Branch, Unmonitored Tributaries, Lower Basin, Upper Basin and ROP2. Dry Branch, ROP2 and the Kingsbury Branches had sampling sites located on their tributaries. Land use and acres were determined for each of the subwatershed areas using land use information and Arcview software. This information was gathered and produced with help from Tetra Tech who is working on Total Maximum Daily Load (TMDL) modeling for Governor Bond Lake (Appendix 2).

Figure 4 Subwatershed Delineation



Source Tetra Tech

HYDROLOGIC, SEDIMENT AND NUTRIENT BUDGETS

An annual water budget was calculated for Governor Bond Lake. This is a best estimate of the amount of water coming into, and going out of, the lake. To determine the amount of water entering the lake stream staff gauges were placed in the major tributaries as close to the lake as possible. ZIES staff on a daily basis recorded the stream height as a staff gauge reading. Cross-sections of the streams were measured at each of the gauge sites. A relationship was established for the area of the cross-section in relationship to staff gauge height. Next, flow measurements in feet-per-second were measured by floating a lemon a given distance and timing its progress. A coefficient of .85 was used to convert surface velocity to mean velocity (NALMS 1990). Next, flow and area measurements were combined to establish a relationship between staff height and cubic feet-per-second of water passing the cross-section. Calculations were then used to determine the acre-feet per day of water entering the lake for each of the measured tributaries. For the unmonitored tributaries and for one of the subwatersheds where problems were experienced establishing accurate flow data, rainfall, land use and standard runoff coefficients were used to determine the amount of water entering the lake (Haan 1994). In addition to the water flowing in from the watershed, rain which fell directly onto the lake surface was calculated from daily rain amounts recorded at the water treatment plant by city workers.

An additional staff gauge was placed near the spillway of the lake. It was used to determine the height of water above the spillway. This information was used to calculate the amount of water flowing out of the lake over the spillway. These calculations were made using theoretical equations for a broad-crested weir: $Q = CLH^{(3/2)}$, where Q is the water discharged in cubic feet-per-second, C is a coefficient based on H, L is the length of the spillway in feet and H is the height of the water above the spillway (Brater 1976). Water treatment plant staff took daily staff gauge readings in this location. This information was used to determine the acre-feet flowing over the spillway. Problems with ice during the winter months made this method impractical during January and February. Calculations for these months were estimated from similar rain in-flow and out-flow during other months. Evaporation was calculated using 50 years of historical evaporation rates in Illinois (Roberts 1967). Water withdraws by the water treatment plant were also considered as part of the lake out-flow. All of the in-flow and out-flow data is presented in Table 9.

Table 9 **Hydrologic Budget for Governor Bond Lake 1999-2000**

Month	In Flow			Out Flow			
	Tributaries in acre feet	Rainfall in acre feet	Total In	Drinking water withdraws in acre feet	Flow over spillway in acre feet	Evaporation in acre feet	Total Out
Jul	1752.6	346.5	2099.1	126.0	1378.1	407.5	1911.6
Aug	1033.5	138.6	1172.1	128.2	0	332.4	460.6
Sep	1137.8	84.7	1222.5	124.1	0	235.5	359.6
Oct	1667.2	169.4	1836.6	128.2	0	149.5	277.7
Nov	802.8	107.8	910.6	129.3	0	68.7	197.9
Dec	883.5	146.3	1029.8	110.9	0	30.8	141.7
Jan	1902.1	392.7	2294.8	110.7	2666.5	30.8	2808.0
Feb	1612.6	269.5	1882.1	113.6	1257.8	50.1	1421.5
Mar	1098.9	138.6	1237.5	102.2	167.3	116.1	385.7
Apr	991.4	169.4	1160.8	99.6	29.8	200.2	329.6
May	1898.9	354.2	2253.1	111.6	2797.0	302.2	3210.8
Jun	1858.9	562.1	2421.0	108.7	2536.6	365.1	3010.4
Total	16640.0	2872.1	19520.0	1393.1	10833.1	2288.8	14515.0

Estimated Sediment and Nutrient Loading from the Tributaries
Nutrients and sediment can enter the tributaries from a variety of different sources: fertilizers, livestock waste, septic systems, lake sediments, atmospheric sources, wildlife, etc. Nutrients from atmospheric sources, lake sediments, and wildlife (Table 10) are described below.

Nutrients and sediments coming from the tributaries were measured during rain events and concentrations were averaged monthly. Using monthly water volumes from the hydrologic budget in Table 9, the nutrients and sediments in kilograms were calculated for each tributary (Table 11). The highest concentration of nutrients entered the lake from Dry Branch, which is to be expected since it represents the largest subwatershed.

Estimated Atmospheric Nutrient Loading
Nutrients in the atmosphere should be considered non-point sources of pollution. These nutrients can enter the lake indirectly by washing in from the watershed or by directly depositing on the water surface. Of the principle nutrients, phosphorus and nitrogen, nitrogen is found in higher concentrations in the atmosphere. Nitrogen is deposited into the atmosphere primarily from burning fossil fuels. Automobiles and power plants are the two main sources of nitrogen. In the area around Governor Bond Lake, deposits of nitrogen can be expected in the range of 1.3 – 1.8 tons per square mile or an average of 1.55 tons per square mile (Pucket 1994).

Phosphorus is found in much lower concentrations than nitrogen. Phosphorus concentrations in the rural area surrounding Governor Bond Lake would be found at .03 milligrams of phosphorus per liter of rainwater (Litke 1999). Using these estimates, 1705.2 Kg of nitrogen and 106.2 Kg of phosphorus are deposited directly onto the Lake surface every year (Table 11).

Estimated Nutrient Loads from Lake Sediment
The lake itself can be a major contributor of nutrient loading. Nutrients bound in the sediments on the bottom of the lake, as well as nutrients in dying plant material, contribute to the nutrient loading of the lake. When the dissolved oxygen level near the bottom of the lake is depleted, phosphorus trapped in the sediments is released. During fall turnover phosphorus , along with nitrogen, is released back into the epilimnion of the lake where it can be used by algae and other plants. This process is referred to as internal loading. The stratification necessary to promote this process occurs in the south end of the lake. The surface area of the lake bottom that would experience anaerobic conditions was determined from the bathymetric map to be 791,682 m^2. Assuming a phosphorus release rate of 15mg/m^2/day (Nurnberg 1984) and a nitrogen release rate of 120 mg/m^2/day (Fillos 1975), approximately 1,452 kg of phosphorus and 11,590 kg of nitrogen were released from the sediments (Table 11). This nutrient release would generally occur during the four months when oxygen was depleted near the bottom of the lake.

Estimated Nutrient Loads from Birds
Birds can contribute significant amounts of nutrients to the lake when found in large numbers. A bird survey was conducted on Governor Bond Lake to estimate the number and types of birds using the lake (Table 24).

The daily phosphorus and nitrogen loading from a Canada goose was used to develop a ratio of daily loading to body weight. In this way, the daily loading from other birds could be estimated by comparing their body weight to that of the Canada goose (Manny 1994). This daily loading was used along with the number of days each type of bird used the lake, to determine both the monthly and yearly nitrogen and phosphorus loading attributable to birds (Table 10).

Table 10 Estimated Daily and Yearly Phosphorus and Nitrogen Loads from Birds

Common Name	Scientific Name	Daily P Load In grams	Yearly P Load in grams	Daily N Load in grams	Yearly N Load in grams
Canada Goose	*Branta canadensis*	0.49	957.5	1.57	3067.8
Blue Winged Teal	*Anas discors*	0.08	31.2	0.27	105.3
Mallard	*Anas platyrhynchus*	0.23	1154.6	0.74	3714.8
Northern Shoveler	*Anas elypeata*	0.12	82.8	0.38	262.2
Wood Duck	*Aix sponsa*	0.13	4.03	0.42	13
American Coot	*Fulica americana*	0.1	210.6	0.31	652.9
Common Merganser	*Mergus merganser*	0.28	313.6	0.89	996.8
Cattle Egret	*Bubulcus ibis*	0.06	1.8	0.2	6
Great Blue Heron	*Ardea herodias*	0.56	1747.8	1.81	5649
Great Egret	*Casmerodius albus*	0.17	88.1	0.55	284.9
Bonaparte's Gull	*Larus philadelphia*	0.04	43.2	0.13	140.4
Caspian Tern	*Hydroprogne caspia*	0.12	7.2	0.38	22.8
Ring Billed Gull	*Larus delawarensis*	0.09	732.1	0.3	2440.2
Double Crested Cormarant	*Phalacrocorax Auritus*	0.37	1733.5	1.18	5528.3
Osprey	*Pandion haliaetus*	0.26	15.9	0.83	50.6
		Total P	**7123.9**	**Total N**	**22935.0**

Estimated Sediment from Shoreline Erosion
Using information from the shoreline erosion study (Figure 37), calculations were made to estimate the amount of sediment delivered to the lake from shoreline erosion. Using estimates of 40lbs of soil per linear foot entering the lake from areas with severe erosion, 30lbs per linear foot for areas with moderate erosion, and 20lbs per linear foot for areas that are undercut, approximately 411,948 kg per year of soil enters the lake from shoreline erosion (Hill 1994). This amounts to 26% of the total sediment entering the Lake (Table 11).

TABLE 11 **NUTRIENT AND SEDIMENT BUDGET FOR GOVERNOR BOND LAKE**

INFLOW	TOTAL PHOSPHORUS		TOTAL NITROGEN		TOTAL SUSPENDED SOLIDS	
	Kg/yr	%	Kg/yr	%	Kg/yr	%
TRIBUTARIES						
DRY BRANCH	2433.1	32.0%	18122.2	36.0%	327612	21.0%
KINGSBURY BRANCHES	1971.6	25.9%	8788.1	17.4%	467782	30.0%
ROP02	166.6	2.2%	2435.3	4.8%	34926	2.2%
UNMONITORED	1473.6	19.4%	7700.6	15.3%	301845	19.4%
ATMOSPHERIC	106.2	1.4%	1705.2	3.4%	15695	1.0%
WATERFOWL	4.9	0%	22.9	0%		
INTERNAL	1451.8	19.1%	11590.0	23.0%		
SHORELINE					411948	26.4%
Total Inflow	**7,607.8**	**100%**	**50,364.3**	**99.9%**	**1,559,808**	**100%**

NOTE: NOT ALL TOTALS EQUAL 100% DUE TO ROUNDING

OUTFLOW	TOTAL PHOSPHORUS		TOTAL NITROGEN		TOTAL SUSPENDED SOLIDS	
	Kg/yr	%	Kg/yr	%	Kg/yr	%
SPILLWAY	668.1	9%	9751.9	19%	446514	29%
DRINKING WATER	114.2	2%	1462.1	3%	55475	4%
Total Outflow	**782.3**	**11%**	**11,214.0**	**21%**		**33%**

NET LOADING	TOTAL PHOSPHORUS		TOTAL NITROGEN		TOTAL SUSPENDED SOLIDS	
	Kg/yr	% RETAINED	Kg/yr	% RETAINED	Kg/yr	% RETAINED
	6,827.7	**89%**	**39,150.0**	**78%**	**1,057,818**	**67%**

BASELINE LIMNOLOGICAL DATA

Morphometric Data

The physical characteristics of Governor Bond lake can be summed up as morphometric date for the lake. This is existing data on size, depth, retention time, etc. (Table 12).

Table 12 Morphometric Data

Watershed Area	22,080 acres	8,934 hectares
Surface Area	775 acres	314 hectares
Shoreline Length	19 miles	30.65 Kilometers
Mean Depth	13 feet	3.96 meters
Maximum Depth	25 feet	7.62 meters
Volume	6,839 acre-feet	8,432,487 cubic meters
Retention Time	0.608 years	
Lake Type	Reservoir / Dam / Spillway	
Year Constructed / Opened	1970	

Bathymetric Map

A bathymetric map was made by ZIES using a Trimble GPS unit and sonar depth finding equipment. GPS points were collected throughout the lake in a zigzag pattern. The GPS technology allowed staff to collect points with an exact knowledge of the location of these points. Along with the GPS points, depth points were taken. All depths were corrected for height of water above or below the spillway. All depths are in relation to the surveyed spillway elevation of 524.71 feet above sea level. The data from the GPS unit and depth gage were sent to Crawford Murphy & Tilly (CMT) an engineering firm in Springfield, Illinois. CMT produced a contour map and calculated volumes and areas for the current lake (Figure 5).

Figure 5 Governor Bond Lake Bathymetric Map 1999

ZAHNISER INSTITUTE FOR ENVIRONMENTAL STUDIES

Lake Monitoring

Historically, Governor Bond Lake has been sampled at three sites (Table 13): ROP-1t (top sample) and ROP-1b (bottom sample) near the spillway; ROP-2 just south of the railroad trestle; and ROP-3 on the north end of the lake close to the ski club. In addition to the traditional sampling sites, ZIES staff sampled for a variety of parameters at four additional sites throughout the lake: ROP-5, ROP-6 and ROP-7 on the north end of the lake and ROP-4 on the south end of the lake (Figure 6). For comparison purposes, most data are reported only for Sites ROP-1 (t & b), ROP-2 and ROP-3 since these sites have been historically sampled under the ALMP.

Water samples were collected and shipped according to IEPA protocol to IEPA laboratories for analyses. Samples were analyzed for total suspended solids, volatile suspended solids, total phosphorus, dissolved phosphorus, kjeldahl nitrogen, nitrate + nitrite nitrogen and ammonia nitrogen. ZIES staff tested for pH, turbidity, conductivity, temperature and dissolved oxygen on-site using a Hydrolab probe during collection of the other water samples.

Figure 6 Lake Sampling Sites

Historical Data for Governor Bond Lake

The IEPA has sampled Governor Bond Lake since 1977 under their Ambient Lake Monitoring Program (ALMP) and this historical data is presented in Table 13 for comparison purposes to 1999-2000 data.

Table 13 Governor Bond Lake Historical Data 1977-1993

	ROP-1	**ROP-2**	**ROP-3**
	Value (Year)	**Value (Year)**	**Value (Year)**
Ammonia Nitrogen			
Peak	3 mg/L (1993)	0.3 mg/L (1993)	0.3 mg/L (1982)
Average	0.5 mg/L	0.1 mg/L	0.1 mg/L
Kjeldahl Nitrogen			
Peak	2.8 mg/L (1992)	2.1 mg/L (1989)	2.2 mg/L (1989)
Average	1.2 mg/L	1.2 mg/L	1.3 mg/L
pH			
Peak	9.5 (1993)	9.3 (1993)	9.4 (1993)
Average	7.9	8.5	8.4
Secchi			
Peak	40 inches (1982)	34 inches (1977)	16 inches (1989)
Average	24.4 inches	20.4 inches	11.4 inches
Chlorophyll a			
Peak	151.3 µg/L (1989)	199.4 µg/L (1989)	209.2 µg/L (1989)
Average	63.2 µg/L	93.7 µg/L	106.7 µg/L
Nitrate + Nitrite Nitrogen			
Peak	0.96 mg/L (1993)	1 mg/L (1993)	1.2 mg/L (1993)
Average	0.32 mg/L	0.3 mg/L	0.3 mg/L
Phosphorus			
Peak	0.78 mg/L (1993)	0.18 mg/L (1993)	0.36 mg/L (1993)
Average	0.18 mg/L	0.1 mg/L	0.18 mg/L

Source: EPA STORET data

CURRENT LIMNOLOGICAL DATA

Suspended Materials

High concentrations of suspended materials in the water can have adverse effects on a lake's health. Suspended materials in the water can have a significant impact on the plant and animal species in a lake environment. Highly turbid waters will decrease the amount of available sunlight, which will reduce the amount of plant material and limit the depth at which plant life will be found. Turbid waters will affect reproduction, eggs and larva and can irritate fish gills and reduce the growth rate of fish and other species.

There are several ways that suspended materials in Governor Bond Lake were measured. The components measured included: total suspended solids (TSS), volatile suspended solids (VSS), non-volatile suspended solids (NVSS), turbidity and secchi depth. Water samples were collected by ZIES staff and analyzed for TSS and VSS at IEPA laboratories. NVSS was determined by comparing TSS to VSS. Turbidity was measured using a Hydrolab water probe and was recorded by ZIES at the same time water samples were collected. Secchi depth was measured and recorded by ZIES staff when water samples were collected.

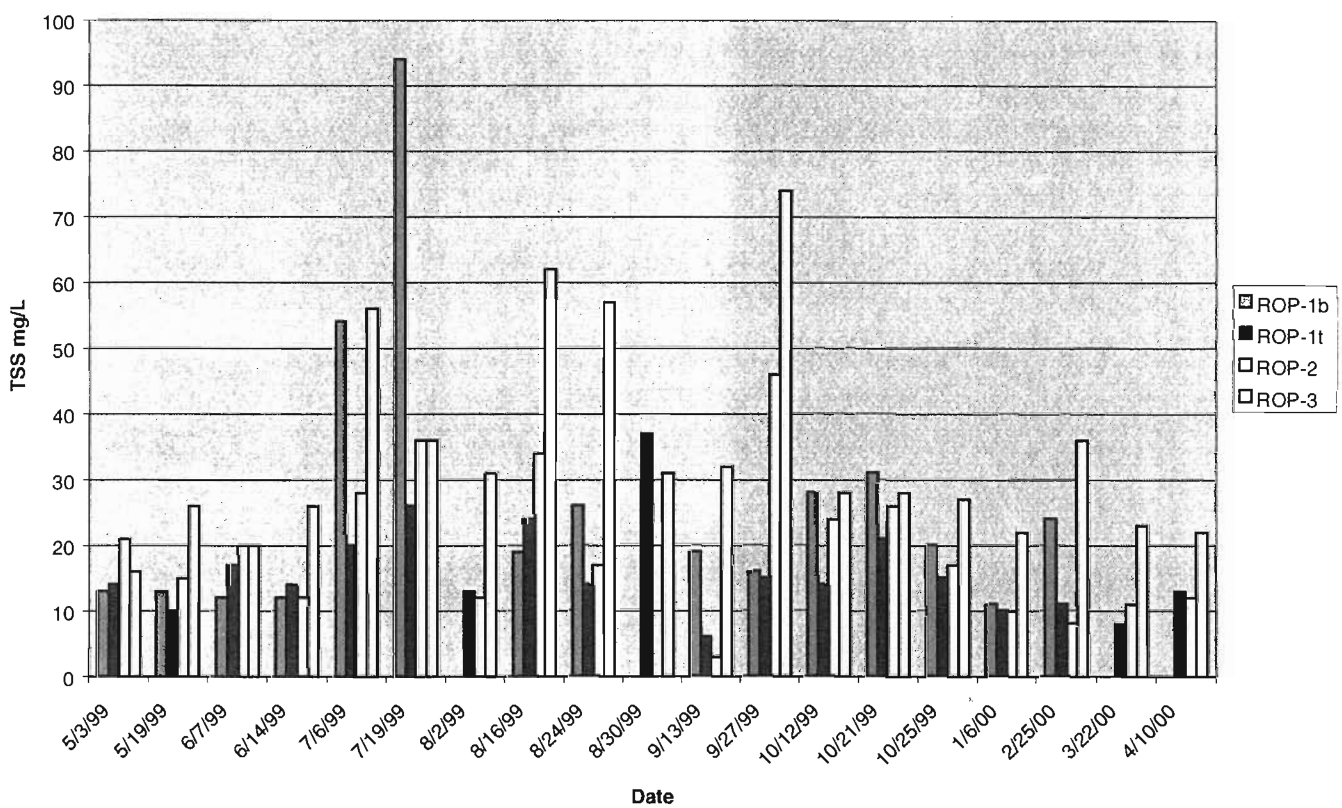
Peak concentrations of TSS, VSS and NVSS corresponded with rain events on several dates (Figures 7, 8, 9). However, this was not always the case. Sources other than rainfall runoff must account for some of the suspended materials and turbidity in the lake water. VSS peaks corresponded with several high chlorophyll a peaks (Figures 8, 39, 40, 41). VSS and chlorophyll a would indicate that algae are a further reason for the highly turbid waters in the lake. Another factor to consider are powerboats, which particularly in the shallower end of the lake would stir up bottom sediments and increase shoreline erosion, adding to the turbidity of the water. Fish, especially carp, can also stir the sediments near the bottom of the lake adding to the turbidity. ROP-3 had more turbid waters than the other sites in the lake (Figure 6). This site is located on the north end of the lake, near the mouth to both major tributaries, in five feet of water near the ski club. Such an area would experience highly turbid waters after a rain, would be more susceptible to alga blooms from nutrient runoff, and its shallow depth would make it susceptible to motor boat activities.

The relationship between TSS and VSS gives an indication of the source of suspended solids in the water. The upper/north end of the lake had a larger percentage of NVSS (68%) than VSS (32%). This indicates that there is a large amount of non-organic material in this part of the lake. This distribution is likely an indication that soil washing in from the tributaries or bottom sediments being stirred up are more significant contributors of the turbidity than algae. The lower/south end of the lake had almost an even distribution with 49% VSS and 51% NVSS. This distribution indicates an equal distribution of organic and non-organic material suspended in the water, and so both soil erosion and algae play an equal role in the turbidity in this end of the lake.

Total Suspended Solids

Total suspended solids (TSS) is a measurement of all of the suspended material in the water including both organic and inorganic materials. Total suspended solids would include materials such as algae, decaying plant materials, minerals, and soil particles (Figure 7).

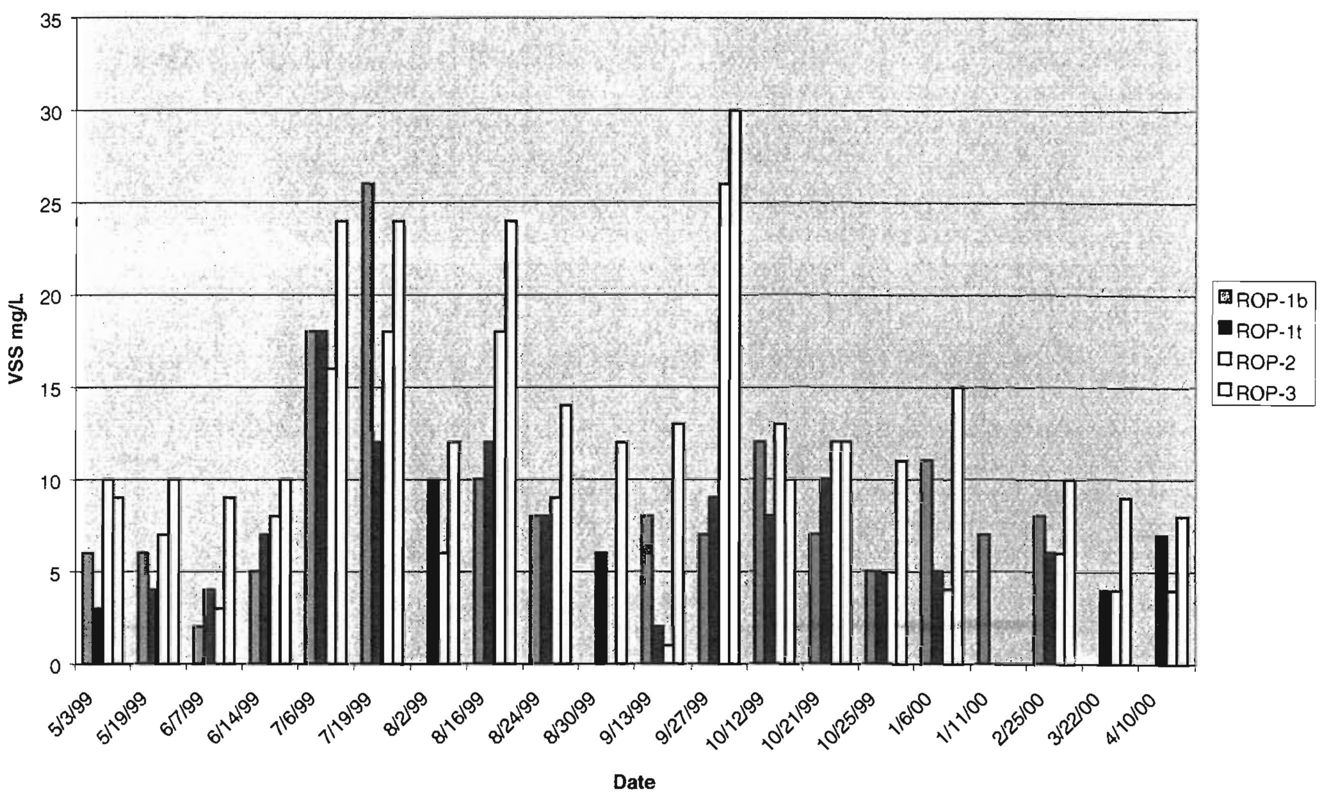
Figure 7 **Total Suspended Solids (TSS) 1999-2000**



Volatile Suspended Solids

Volatile suspended solids (VSS) is a measurement of only the organic material suspended in the water. This material would include algae, decaying plant material and all other organic material suspended in the water (Figure 8). VSS peaked on the same dates as TSS and NVSS and corresponded with high turbidity readings, low secchi depths and high chlorophyll a data (Figures 7, 9, 10, 11, 39, 40, 41).

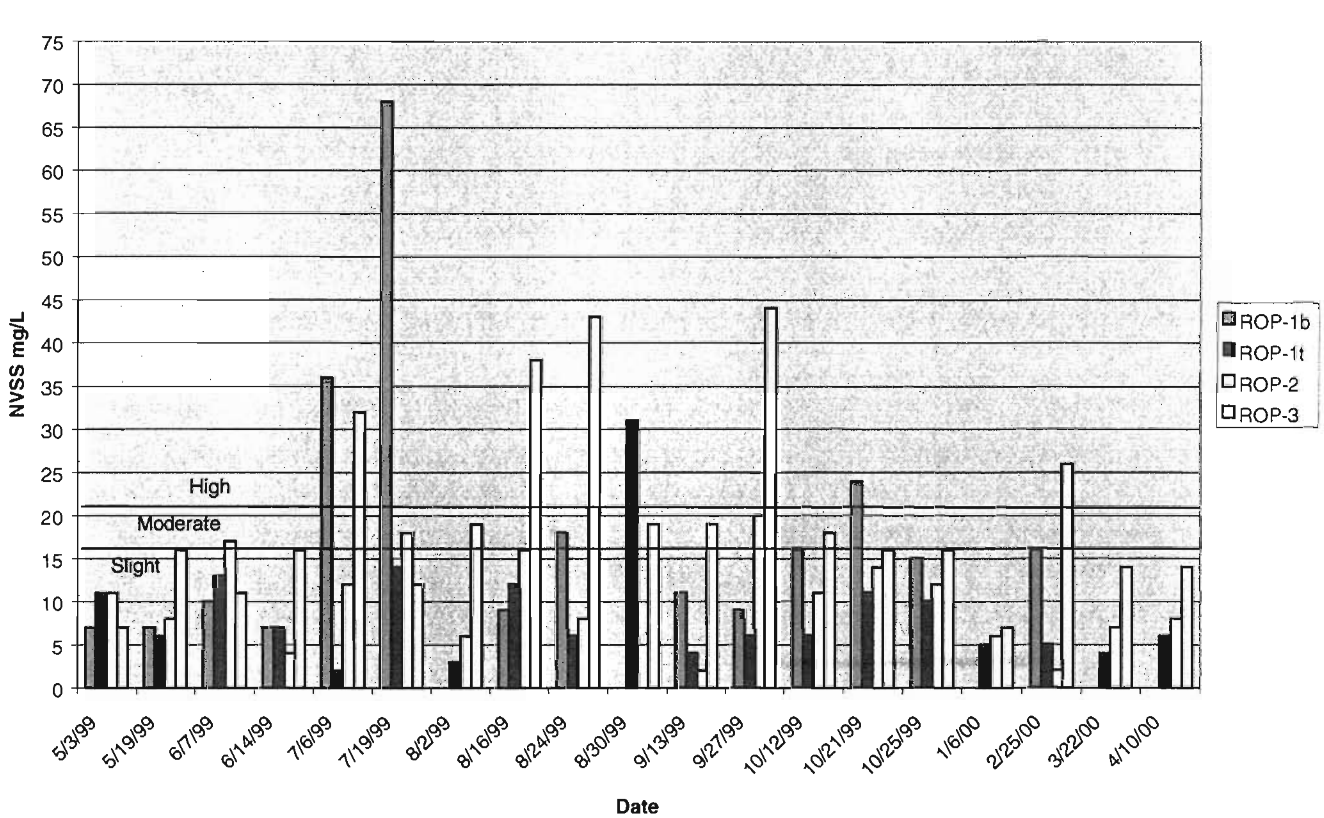
Figure 8 **Volatile Suspended Solids (VSS) 1999-2000**



Non-Volatile Suspended Solids

Non-Volatile Suspended Solids (NVSS) is the portion of TSS that is not VSS. NVSS is the non-organic portion of TSS. NVSS is used by the IEPA as a parameter in their Aquatic Life Use Impairment Index (ALI). The 305(b) report's weighted criteria states that NVSS found in concentrations of < 12 mg/L is minimal, ≥ 12mg/L < 15mg/L as slight, ≥ 15mg/L < 20mg/L as moderate and values ≥ 20mgL as substantial. NVSS for Governor Bond Lake at ROP-1b were found in the range of moderate to high on several dates. ROP-1t was found on most dates in the slight range and only on one date to be high. ROP-2 fluctuated between slight to moderate, never reading high. ROP-3 fluctuated between all three ranges (Figure 9).

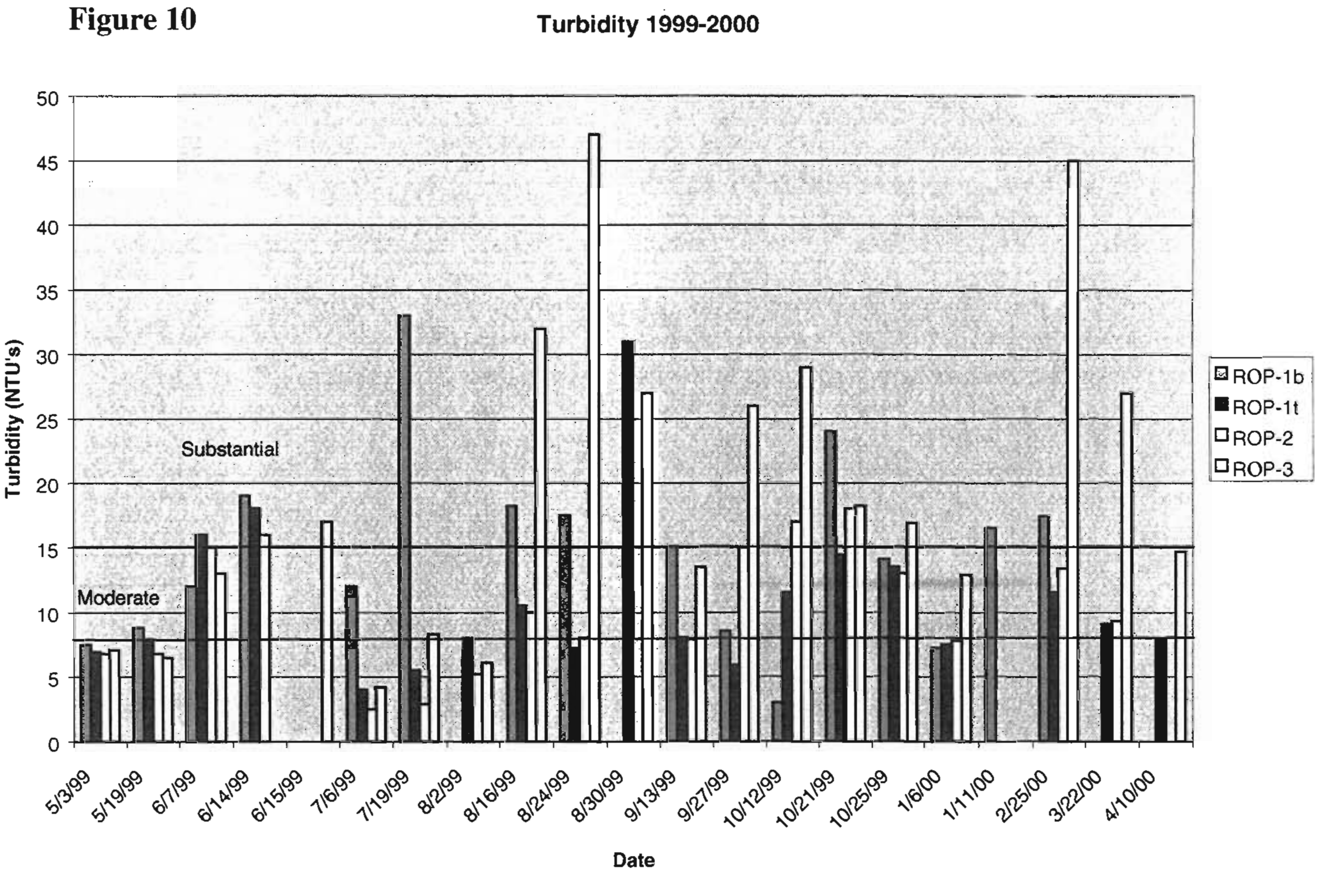
Figure 9



Turbidity

Turbidity is another measure of suspended materials in the water. Turbidity was measured using a Hydrolab water measurement instrument calibrated to a known turbidity test standard, NTU (Nephelometric turbidity units). Turbidity is a measure of material in the water causing light to scatter. Turbidity levels between 7 and 15 NTUs indicate a moderate amount of suspended material and turbidity measurements in excess of 15 NTUs indicate substantial sediment. Factors that contribute to the turbidity of a lake include soil erosion, algae material and suspension of sediment by watercraft, fish and wind (Hill 1994). Turbidity fell within the moderate to substantial range on several dates throughout the study (Figure 10). Turbidity levels corresponded with TSS, VSS, NVSS and secchi readings on several dates during the study (Figures 7, 8, 9, 11) .

Figure 10

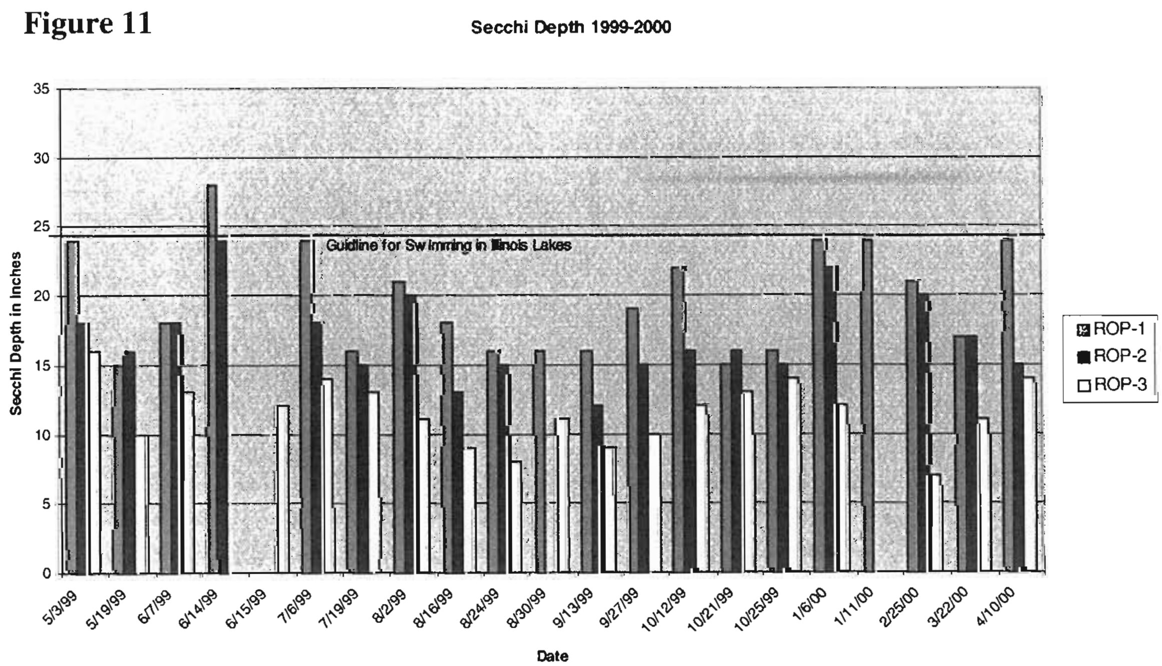


Secchi

The secchi disk is one of the most widely used tools to measure water clarity. Secchi transparency and color are used to determine criteria for lake water quality. The secchi disk is a simple circular disk divided into alternate black and white quadrants. The disk is lowered into the water and the depth at which it can no longer be seen is the secchi depth. It is one of the criteria in Carlson's Trophic State Index, which is used to determine the trophic status (Carlson 1977). Photosynthesis can generally occur at 2-3 times the Secchi depth (Kirschner 1995).

Secchi readings are a parameter used in calculating the Trophic status of a lake. The IEPA uses the trophic status as a parameter in both their guidelines for Aquatic Life Use Impairment (ALI) and their Recreation Use Impairment (RUI). The IEPA also uses secchi readings as a parameter in their swimming guidelines. All the secchi readings must be greater than 24 inches to gain full support for swimming (Illinois 305(b) Report). For Governor Bond Lake there was only one date in the entire year that the Secchi reading at any of the sites was greater than 24 inches (Figure 11). This secchi reading of 27 inches at site ROP-1 corresponded with low NVSS, VSS and TSS readings (Figures 7, 8, 9). ROP-3 had consistently shallower secchi readings throughout the study than sites ROP-1 and ROP-2. Historically the water clarity in Governor Bond Lake has been clearer. The 1999 average secchi depths are shallower than historical averages: ROP-1 averaged 19.5 inches in 1999-2000 and historically 24.4 inches; ROP-2 averaged 17.3 inches in 1999-2000 and historically 20.4 inches; ROP-3 is the only site with 1999-2000 secchi readings consistent with historical data. 1999-2000 averaged 11.2 inches and historical data averaged 11.4 inches (Table 13). For all three sites, these readings indicate a trend in decreasing water clarity in deeper portions of the lake (shallow portions have historically had poor clarity).

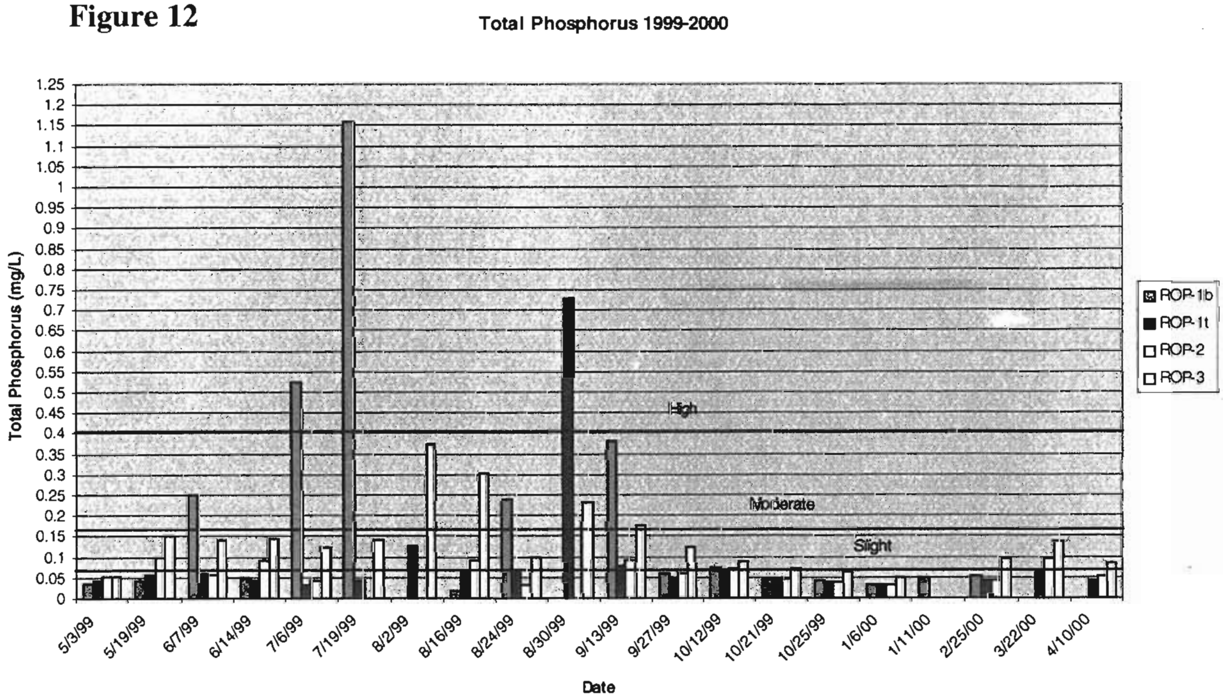
Figure 11



Phosphorus

Phosphorus is a required nutrient for plant growth. The over- or under-abundance of phosphorus is a likely factor in determining the amount of macrophyte and algae growth in a lake. High phosphorus concentrations can lead to lake eutrophication. Phosphorus is not always readily available for plant consumption. Most phosphorus in runoff is tightly bound to soil particles and therefore not available to plants. This phosphorus is considered to be in an insoluble form. If dissolved oxygen levels near the bottom of the lake become low, anaerobic decomposition of organic materials will release phosphorus in a soluble form readily available for plant use (Hill 1994). Phosphorus control is a key component to good lake management and restoration. The Illinois standard for phosphorus states that phosphorus as P shall not exceed 0.05 mg/L in any reservoir or lake with a surface area of 8.1 hectares or more. The IEPA 305(b) report establishes total phosphorus guideline levels $> 0.05 \leq 0.140$ mg/L as slight, levels $> 0.140 \leq 0.400$ mg/L as moderate and levels $> .400$ mg/L as high. Phosphorus levels in Governor Bond Lake at the bottom of ROP-1 were moderate to high during the summer months when the lake was stratified. This would indicate the likelihood that anaerobic conditions are releasing phosphorus. As the dissolved oxygen levels become lower at the bottom at ROP-1b during June and July the phosphorus concentrations increased (Figures 12, 18) Phosphorus levels at ROP-1t were found in the slight range except August 30th, which corresponded to a significant rain event. Levels at ROP-2 were at the slight level on all dates, and levels at ROP-3 were at moderate levels in the summer months (Figure 12). Historical data indicates that phosphorus levels have averaged in the moderately elevated levels at lake sites ROP-1 and ROP-3. This would indicate that phosphorus is perhaps washing into the lake at ROP-3 and remaining in the lake at ROP-1.

Figure 12



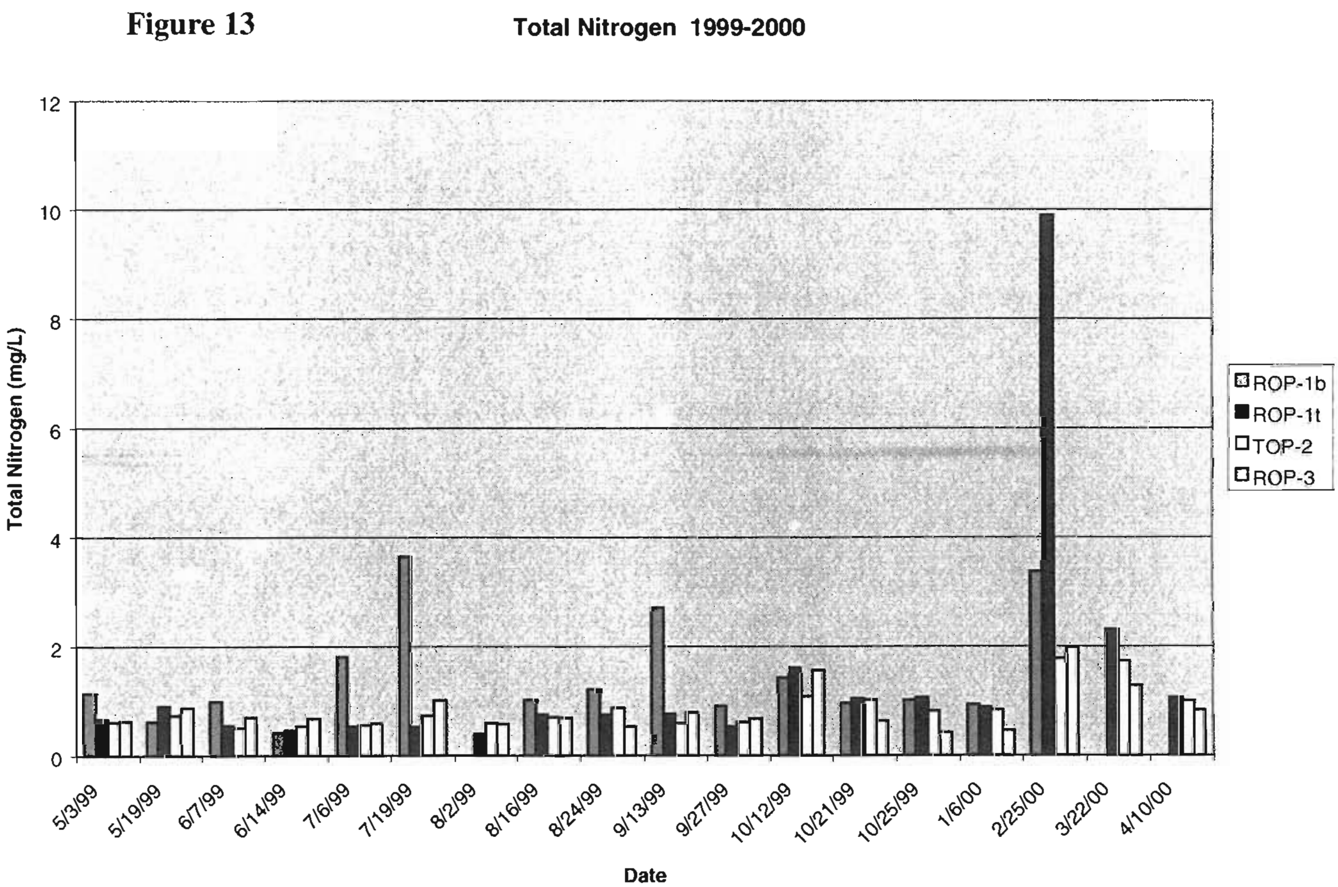
Nitrogen

Nitrogen is an important nutrient for plant growth as its availability will affect plant and algae growth leading to eutrophication of a lake. The forms of nitrogen sampled for included total nitrogen, ammonia nitrogen, nitrate + nitrite nitrogen and total kjeldahl nitrogen.

Total Nitrogen

Total nitrogen is the sum of kjeldahl nitrogen and nitrite + nitrate nitrogen. It is used to determine the ratio of nitrogen to phosphorus. This determination will yield the limiting nutrient for a lake. A ratio of total nitrogen to total phosphorus of greater than 7:1 is defined as a phosphorus limited lake. Governor Bond Lake had a ratio of 15:1 and therefore phosphorus is the limiting nutrient. Nitrogen does, however, play a role as a polluter and therefore should be controlled when possible. It should be noted that nitrogen is much harder to control than phosphorus. Total nitrogen levels peaked in the lake at ROP-1t on 2/25/00 at 9.89 mg/L (Figure 13). This could be a result of the large numbers of birds on the lake in February (Table 22). Historical total nitrogen averages are similar to 1999-2000 data (Table 13).

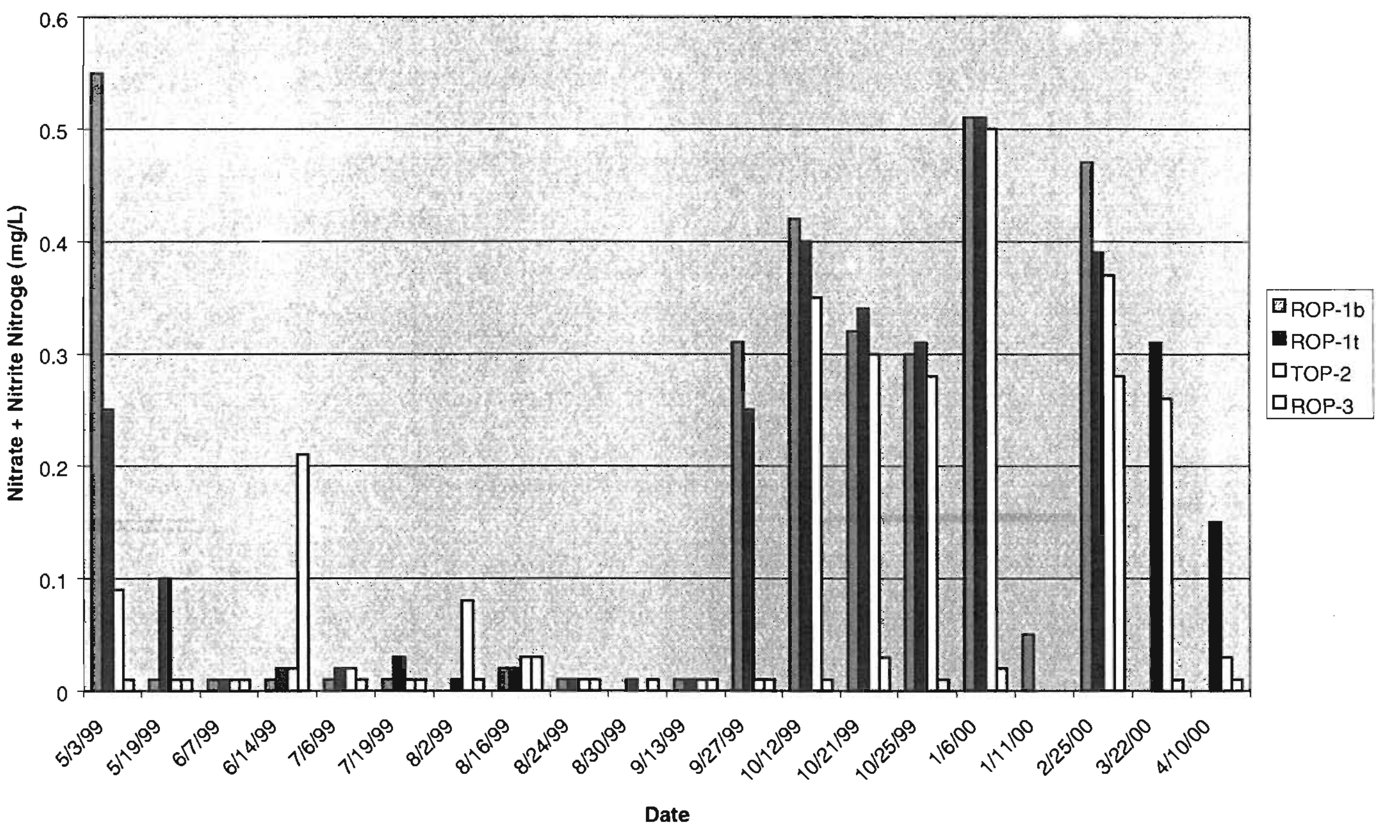
Figure 13



Nitrate + Nitrite Nitrogen

Nitrate + Nitrite nitrogen are inorganic forms of nitrogen which can enter a lake through agricultural runoff, septic tank effluent and other forms of waste. Due to the fact that increased levels of nitrates can cause physiological effects for infants less than 6 months old, nitrate concentrations are of particular concern for drinking water reservoirs. The standard for nitrate is 10mg/L. Concentrations greater than 10 mg/L can have dangerous effects for infants. All samples for Governor Bond Lake fell below 10 mg/L (Figure 14). The 1999-2000 nitrate + nitrite nitrogen average values are lower than historic averages. Lake site ROP-1t's historic nitrate + nitrite nitrogen average is 0.32 mg/L while the 1999 average is 0.17 mg/L. Lake site ROP-2 historic nitrate + nitrite nitrogen average is 0.3 mg/L while the 1999-2000 average is 0.13 mg/L. Lake site ROP-3 historic nitrate + nitrite nitrogen average is 0.3 mg/L while the 1999-2000 average is 0.04 mg/L (Table 13).

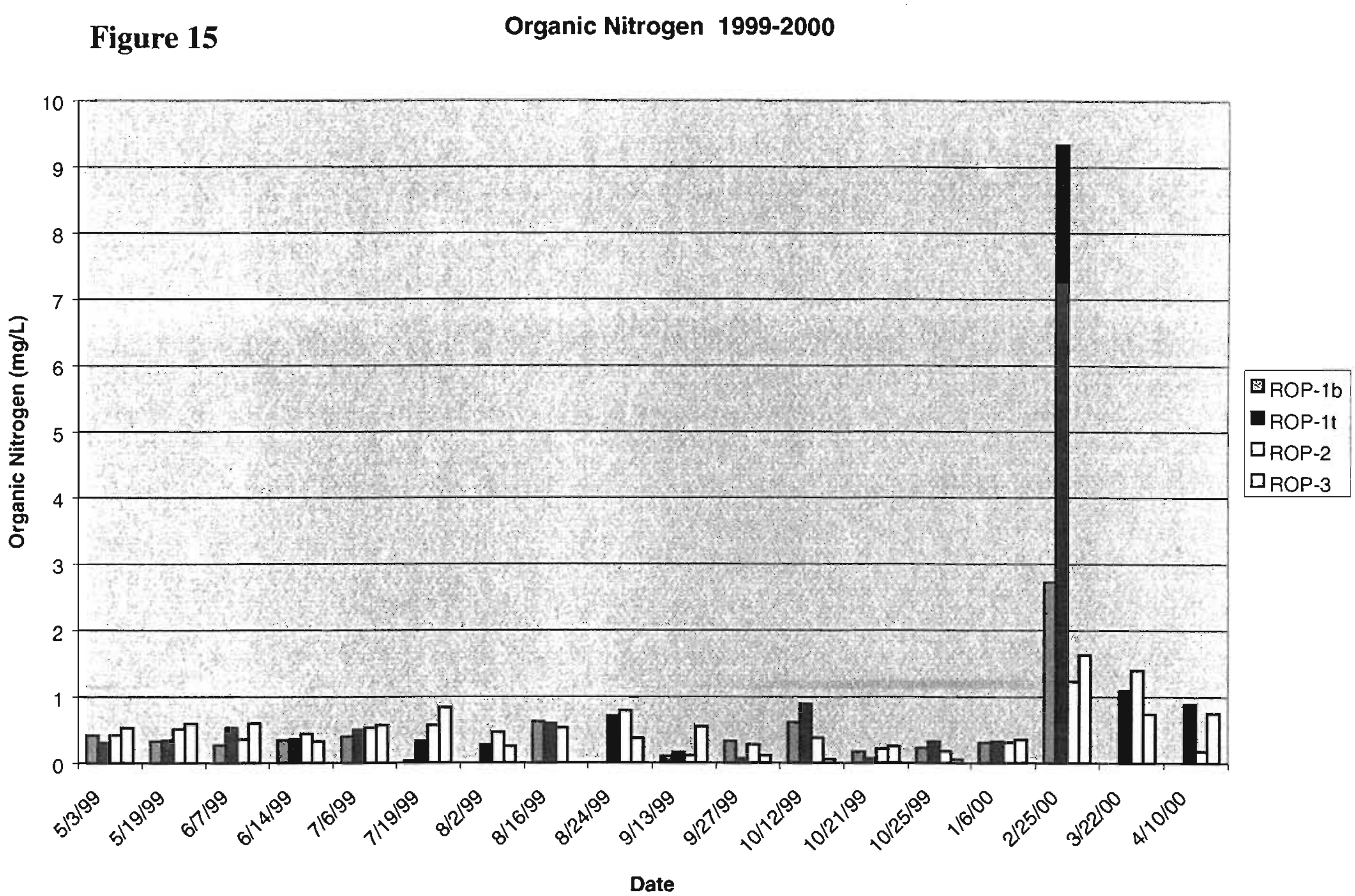
Figure 14 Nitrate + Nitrite Nitrogen 1999-2000



Organic Nitrogen

Kjeldahl nitrogen is ammonia nitrogen plus organic nitrogen. Organic nitrogen is calculated by subtracting ammonia nitrogen from kjeldahl nitrogen. Organic nitrogen can enter a lake through decaying organic matter, septic systems, agricultural waste and waterfowl. Levels in Governor Bond Lake on most dates were recorded below 1 mg/L. Levels peaked on 2/25/00 at ROP-1t at 9.33 mg/L (Figure 15). This corresponded to the large numbers of birds found in the lake in February (Table 22). ROP-1t 1999-2000 organic nitrogen levels were higher than historical averages with a 1999-2000 average of 0.95 mg/L and a historic average of 0.7 mg/L. Lake site ROP-2 1999-2000 organic nitrogen levels were lower than historical averages with a 1999-2000 average of 0.49 mg/L and a historic average of 1.1 mg/L. Lake site ROP-3 1999-2000 organic nitrogen levels were lower than historical averages with a 1999-2000 average of 0.5 mg/L and a historic average of 1.2 mg/L (Table 13).

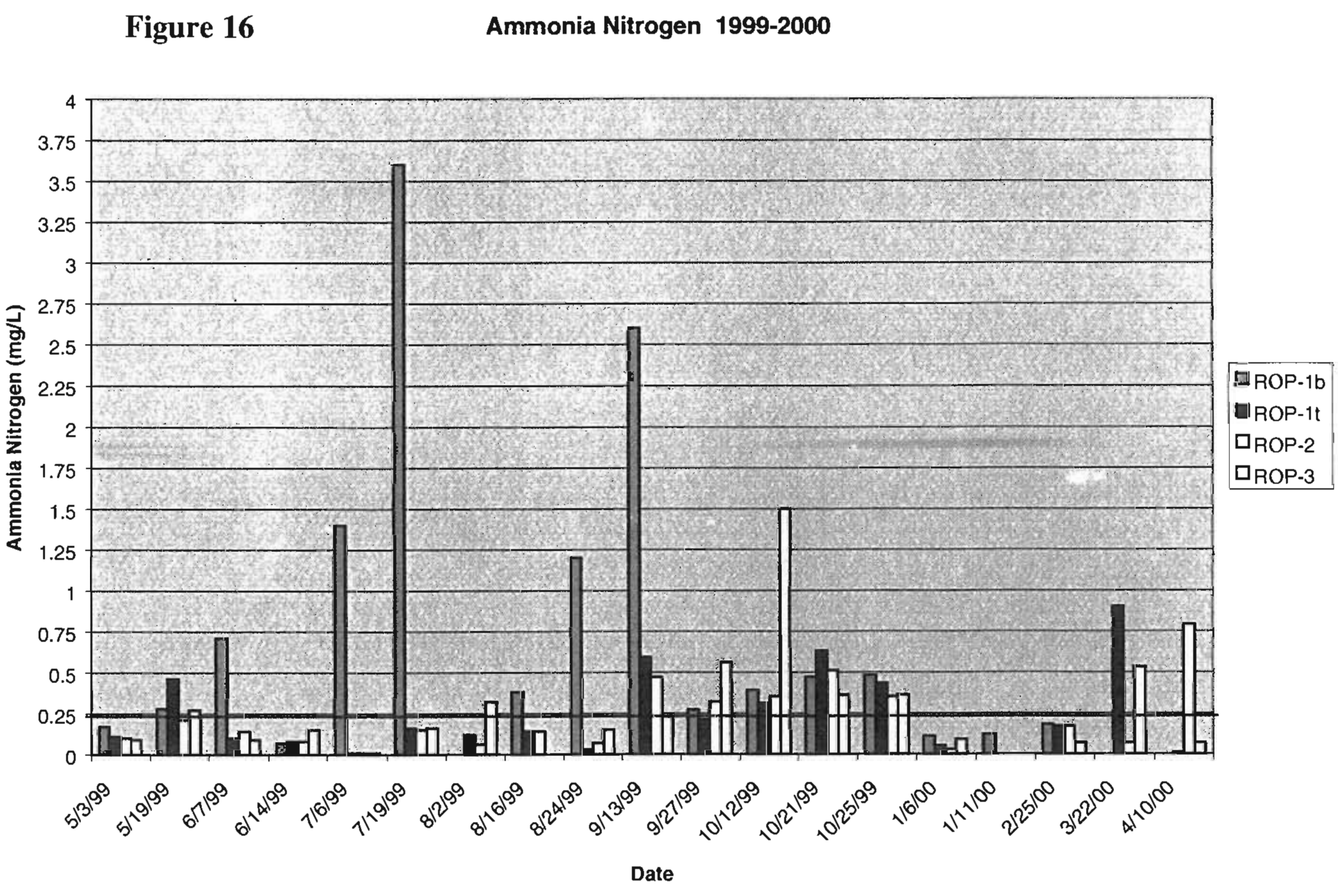
Figure 15



Ammonia Nitrogen

Ammonia nitrogen is the form of nitrogen that is most readily usable for plant growth. High ammonia concentrations can also have adverse affects on fish and other aquatic organisms. Ammonia is made available after bacterial decomposition of organic matter, found in the sediment at the bottom of the Lake. The IEPA 305(b) water quality report sets a guideline of impairment if a single surface sample is greater than 0.25 mg/L. The pollution control board Part 302 states that total ammonia shall in no case exceed 15 mg/L. Forty-six percent of the samples from Governor Bond Lake were above the 0.25 mg/L guideline. None of the samples exceeded the 15mg/L standard (Figure 16). The peak concentrations were found at ROP-1b at the bottom of the lake, which would be expected. These peak concentrations are most commonly a result of bacterial decomposition processes. Lake site ROP-1 1999-2000 ammonia nitrogen levels were lower than historical averages with a 1999-2000 average of 0.24 mg/L and a historic average of 0.5 mg/L. Lake site ROP-2 1999-2000 ammonia nitrogen levels were higher than historical averages with a 1999-2000 average of 0.25 mg/L and a historic average of 0.1 mg/L. Lake site ROP-3 1999-2000 ammonia nitrogen levels were higher than historical averages with a 1999-2000 average of 0.29 mg/L and a historic average of 0.1 mg/L (Table 13).

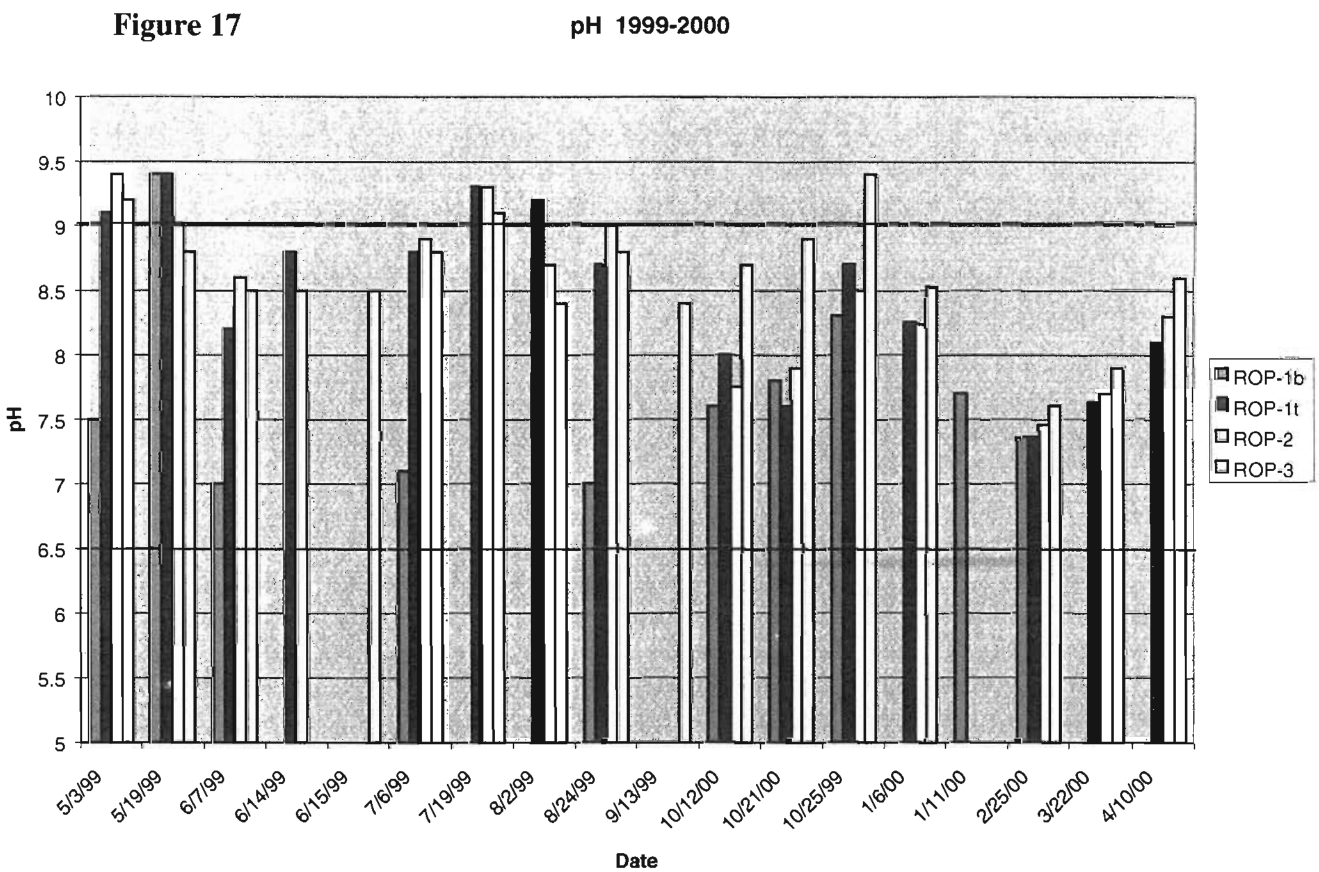
Figure 16



pH

A lake's pH is a measure of the acidity of the water. pH measures the hydrogen ions present in solution on a scale of 0-14. A reading of 7 is neutral. A reading higher than 7 is basic or alkaline. A reading less than 7 is acidic. The pH range for most lakes is between 6 and 9. The pH standard in Illinois is within the range of 6.5 to 9 except for natural causes. The loss of carbon dioxide during photosynthesis results in an increase in pH of the photic, or lighted, zone. As decomposition occurs near the bottom of the lake, the pH will decrease. Therefore pH levels near the bottom of the lake are often lower than near the surface. Organic material is decomposing and photosynthesis is not occurring. The pH levels in Governor Bond Lake near the bottom were recorded to be lower than the pH at the surface. The pH in Governor Bond Lake fell within the range of 6.5 and 9 during most of the study; however, there were several dates that the pH was higher than 9 but lower than 9.5 (Figure 17). The water in Governor Bond Lake during the study period was more alkaline than acidic. Historical lake average pH for site ROP-1 is 7.9, ROP-2 is 8.5 and ROP-3 is 8.4. The 1999-2000 lake average pH for site ROP-1 was 8.4, ROP-2 was 8.4 and ROP-3 was 8.6. Historical data peaks where similar to 1999-2000 peaks (Table 13).

Figure 17



Dissolved Oxygen and Temperature

Dissolved oxygen is an important factor in the overall health of a lake. Oxygen levels are a key factor in fish health. Low oxygen levels can cause fish kills and limited oxygen levels can decrease the number of fish for a given lake. Low levels of oxygen near the bottom allow nutrients to be released adding to the eutrophication of the lake.

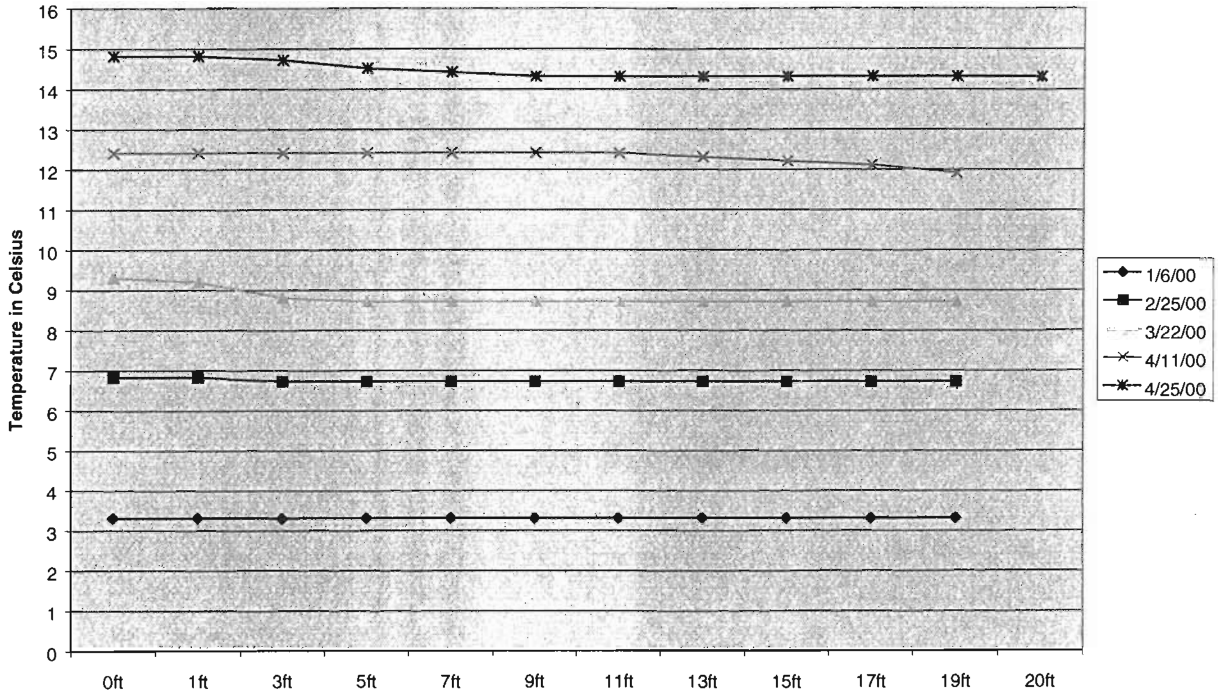
Lake oxygen level is controlled by a variety of factors. Plants and algae release oxygen into the water through photosynthesis. Wave action on the surface adds oxygen to the water. Microbial respiration, during decomposition of organic materials in the lake, uses oxygen.

Water temperature is important for a variety of biological and chemical processes in the lake. Different types of algae grow better at different temperatures. Density gradients due to temperature differences cause the stratification of lakes. Cold water remains near the bottom of the lake and microbial decomposition of organic materials depletes the oxygen levels. As long as the lake remains stratified the oxygen continues to deplete.

Regulations set by the IEPA and Illinois Pollution Control Board (IPCB) state that dissolved oxygen (DO) shall not fall below 6 mg/L for a 16 hour period and never allowing the DO to fall below 5 mg/L at 1 foot depth (IPCB Part 302). Levels below 3mg/L will likely cause fish kills. The south/lower end of Governor Bond Lake demonstrated conditions found in a typical stratified lake. During the winter, the temperature was uniform throughout the lake and the dissolved oxygen was well mixed at all depths. During the summer months, the lake stratified. The cold water sank to the bottom of the lake and warm water remained near the surface. Wind action and algae growth keep the upper levels oxygen rich while microbial decomposition processes near the bottom depleted the available oxygen. Chemical reactions are allowed to take place under low oxygen conditions which release nutrients bound to the sediment. During the fall as the temperature changed the water mixed and the dissolved oxygen and temperature levels became more uniform at all depths. This mixing also mixed the released nutrients from the bottom resulting in internal nutrient loading. This stratified condition was found on the south end of the lake at sites ROP-1 and ROP-2 (Figures 18-23). The north end of the lake had more uniform oxygen and temperature throughout the year (Figures 24-26). This is most likely due to the fact that the water is much shallower at this end of the lake. Wave action can mix the water and stratification does not occur. There was one date in August when the DO levels became very low at ROP-3. This could have been a result of little wind or wave action resulting in poor oxygen mixing and or increased microbial decomposition.

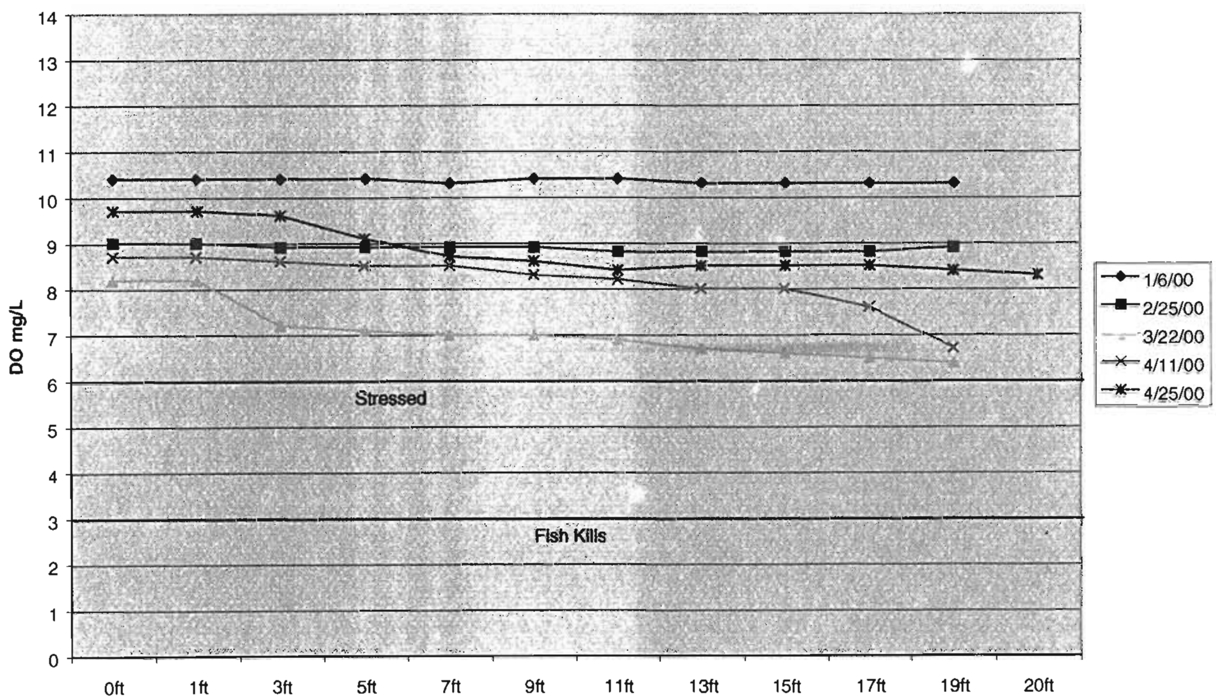
Figure 18

Temperature ROP-1
Winter/ Spring



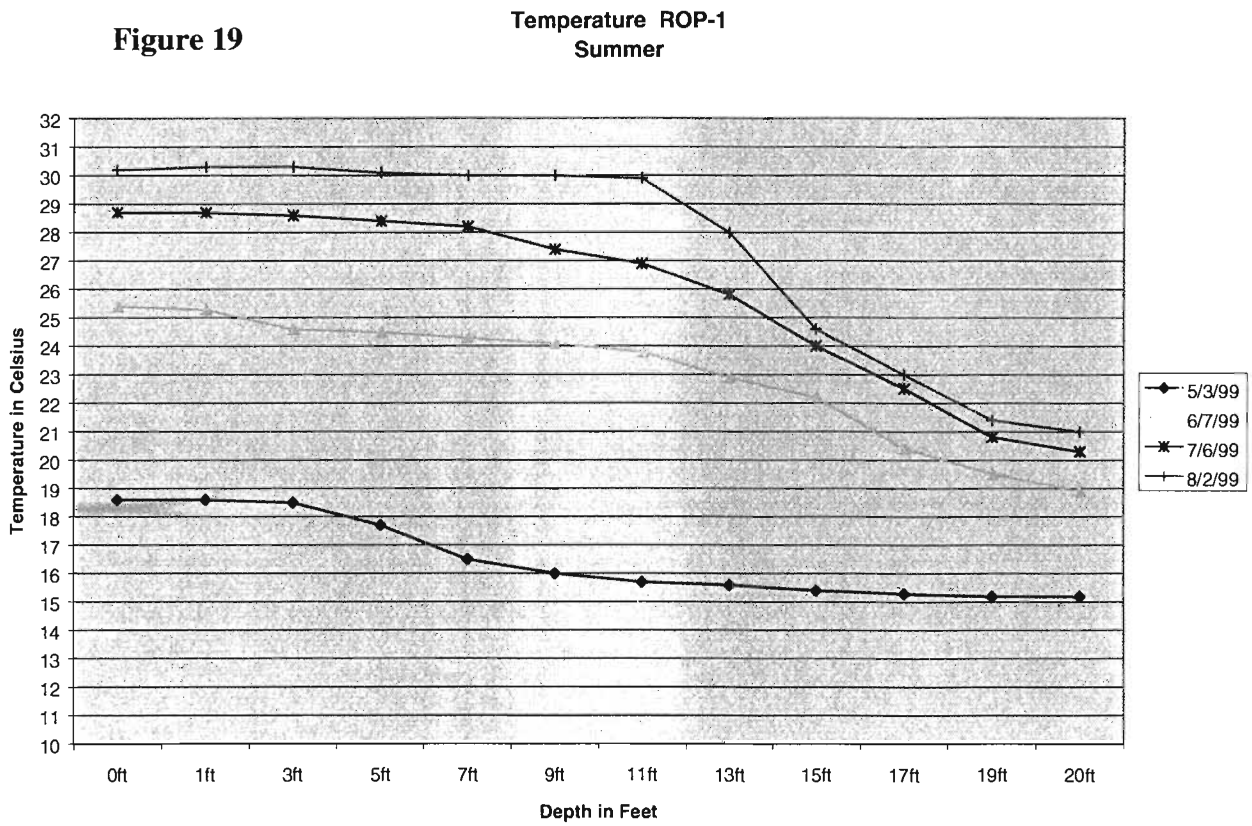
Depth in Feet

Dissolved Oxygen ROP-1
Winter/Spring



Depth in Feet

Figure 19


Temperature ROP-1
Summer
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
Temperature in Celsius
0ft
1ft
3ft
5ft
7ft
9ft
11ft
13ft
15ft
17ft
19ft
20ft
Depth in Feet
5/3/99
6/7/99
7/6/99
8/2/99

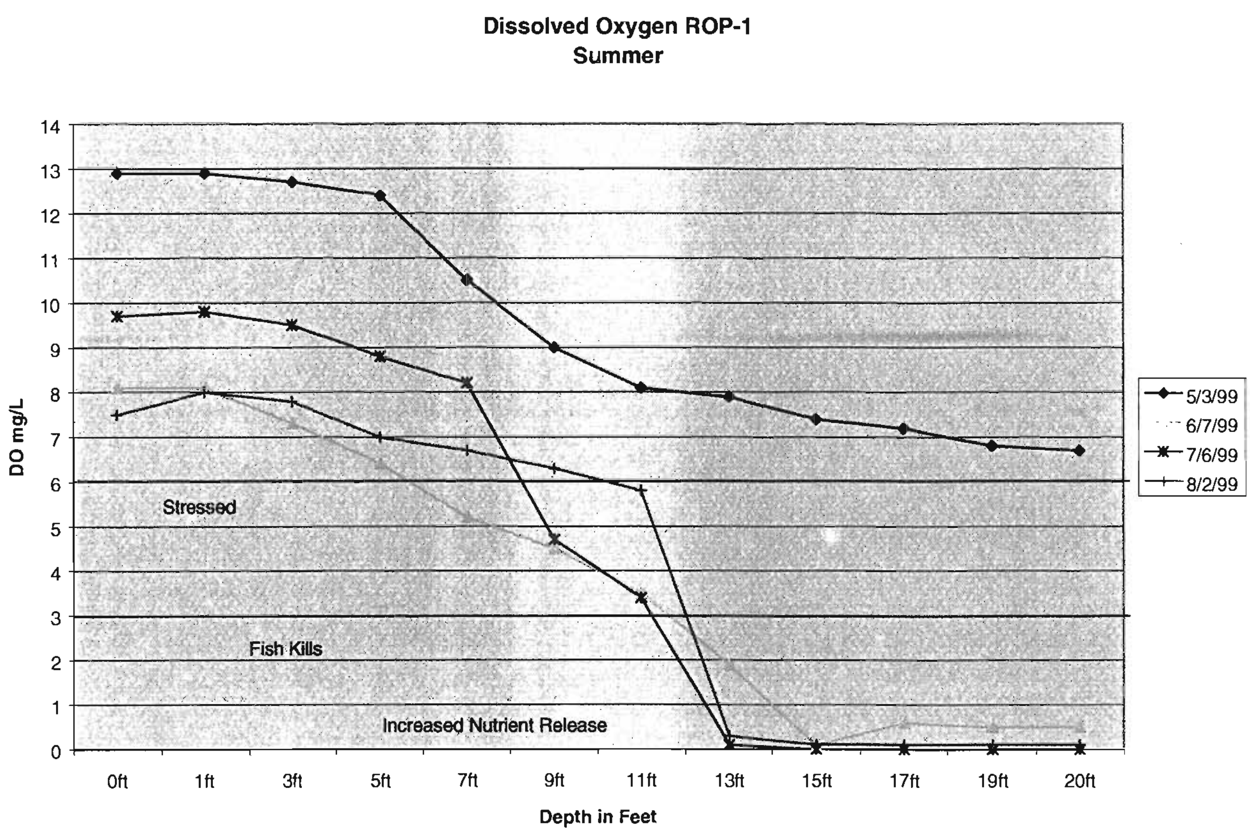
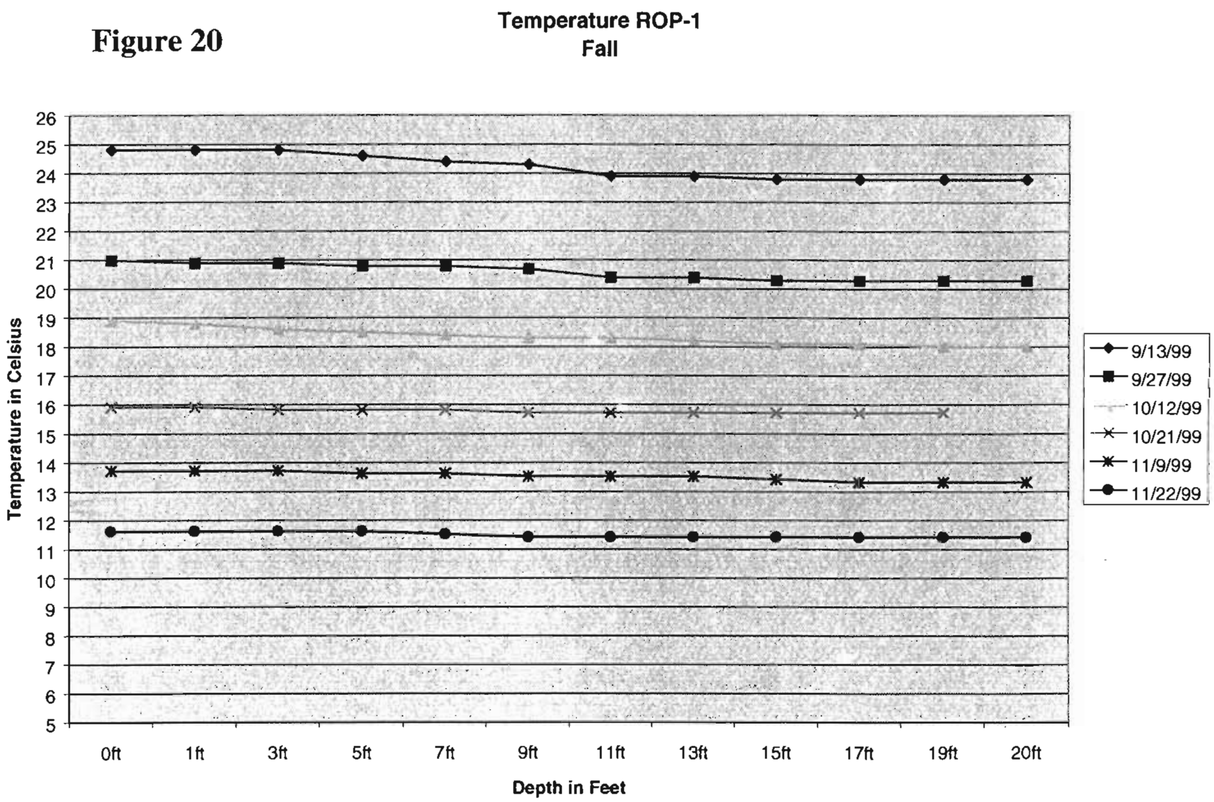
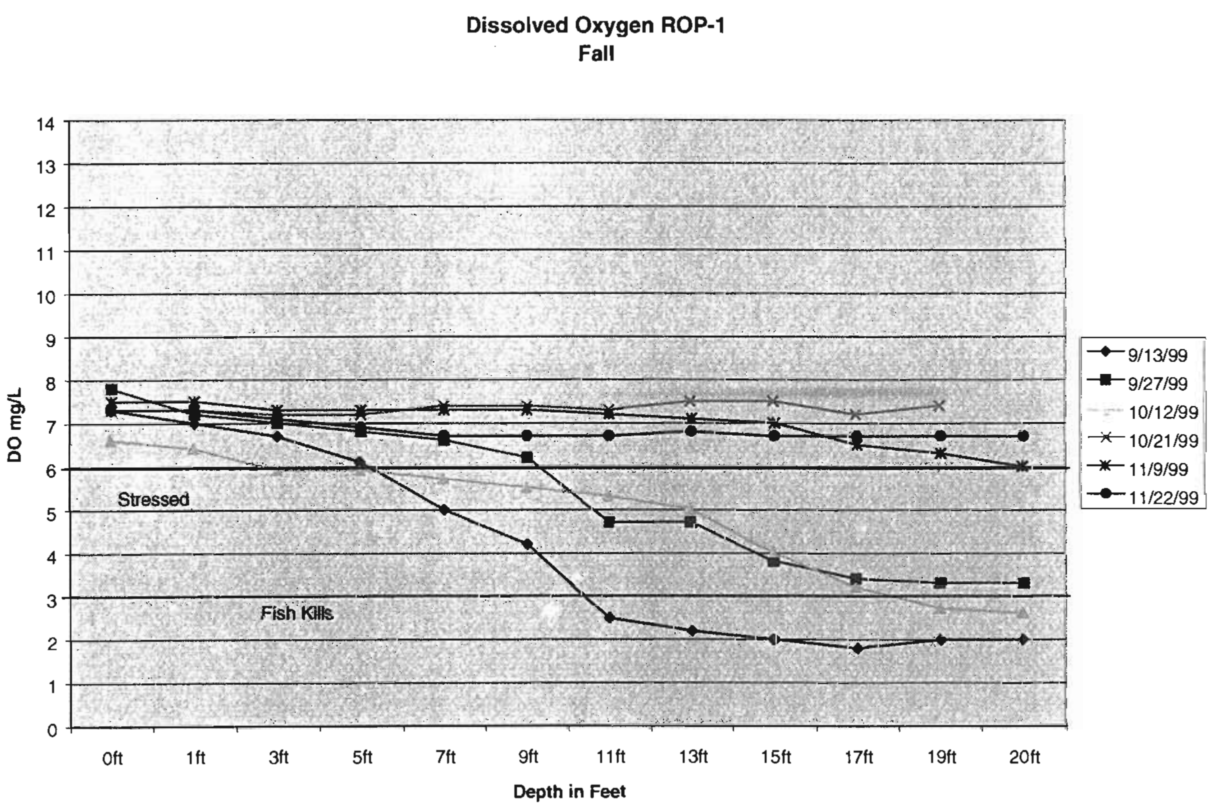

Dissolved Oxygen ROP-1
Summer
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
DO mg/L
Stressed
Fish Kills
Increased Nutrient Release
0ft
1ft
3ft
5ft
7ft
9ft
11ft
13ft
15ft
17ft
19ft
20ft
Depth in Feet
5/3/99
6/7/99
7/6/99
8/2/99

Figure 20

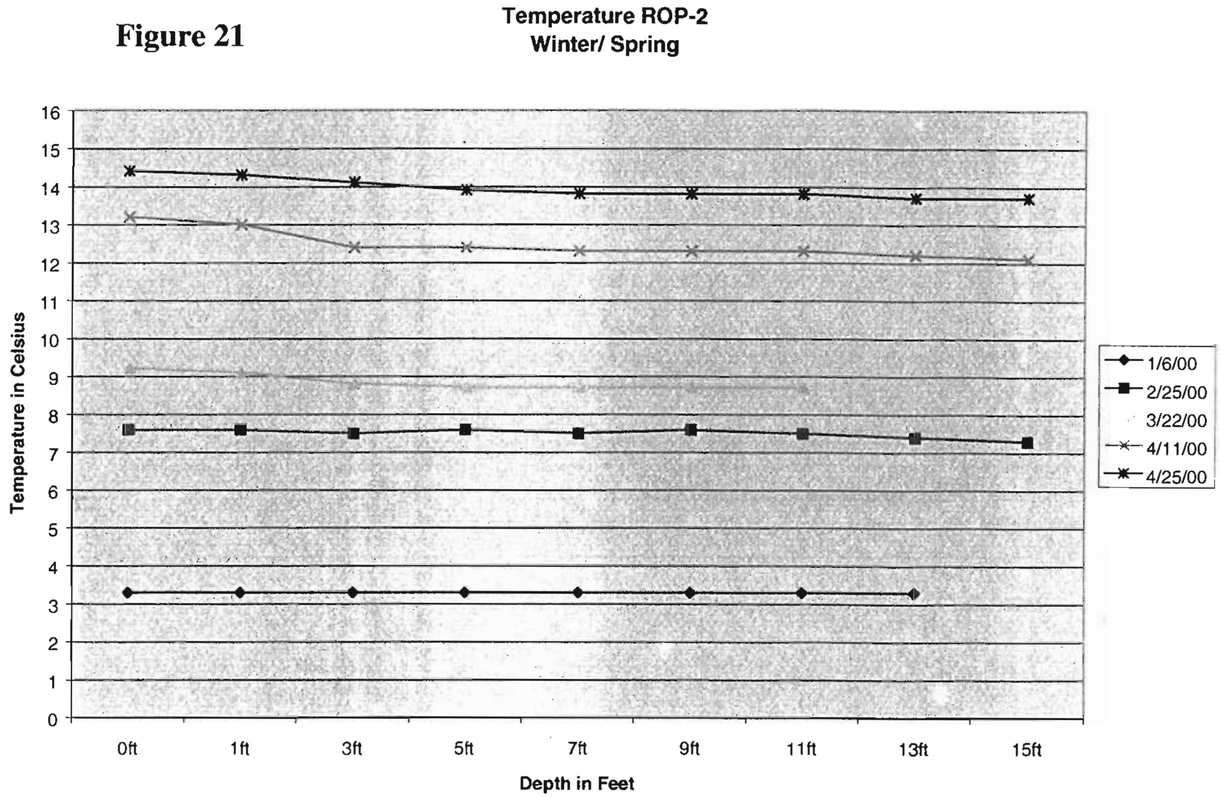


Temperature ROP-1
Fall
Temperature in Celsius
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
0ft
1ft
3ft
5ft
7ft
9ft
11ft
13ft
15ft
17ft
19ft
20ft
Depth in Feet
9/13/99
9/27/99
10/12/99
10/21/99
11/9/99
11/22/99



Dissolved Oxygen ROP-1
Fall
DO mg/L
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Stressed
Fish Kills
0ft
1ft
3ft
5ft
7ft
9ft
11ft
13ft
15ft
17ft
19ft
20ft
Depth in Feet
9/13/99
9/27/99
10/12/99
10/21/99
11/9/99
11/22/99

Figure 21


Temperature ROP-2
Winter/ Spring
Temperature in Celsius
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0ft
1ft
3ft
5ft
7ft
9ft
11ft
13ft
15ft
Depth in Feet
1/6/00
2/25/00
3/22/00
4/11/00
4/25/00

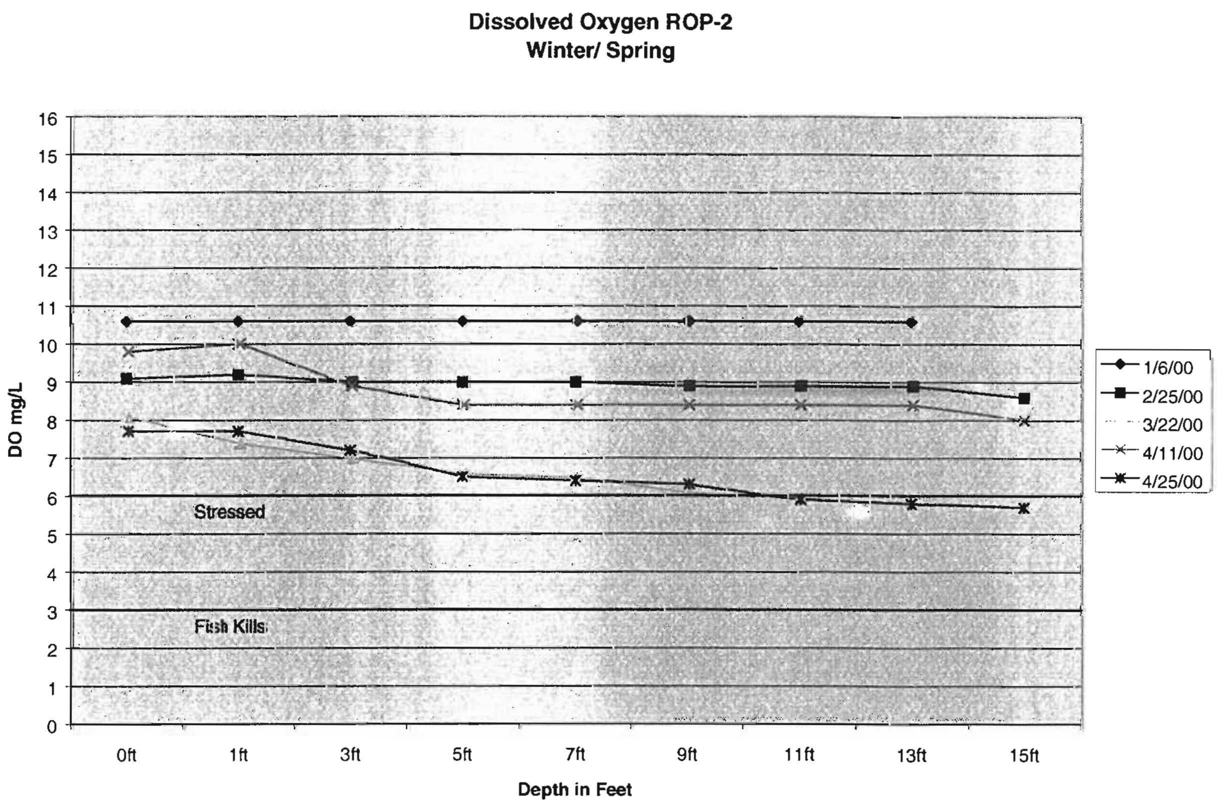
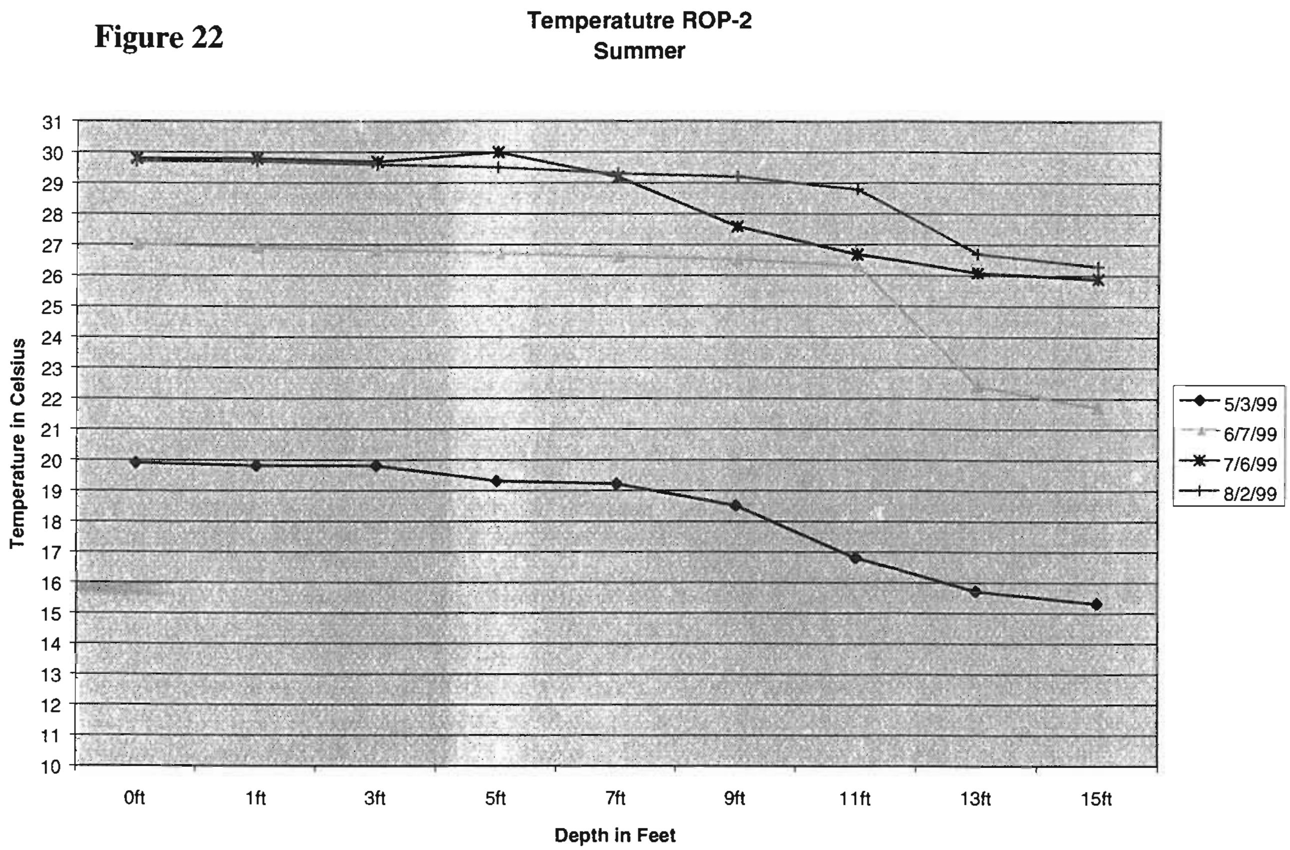
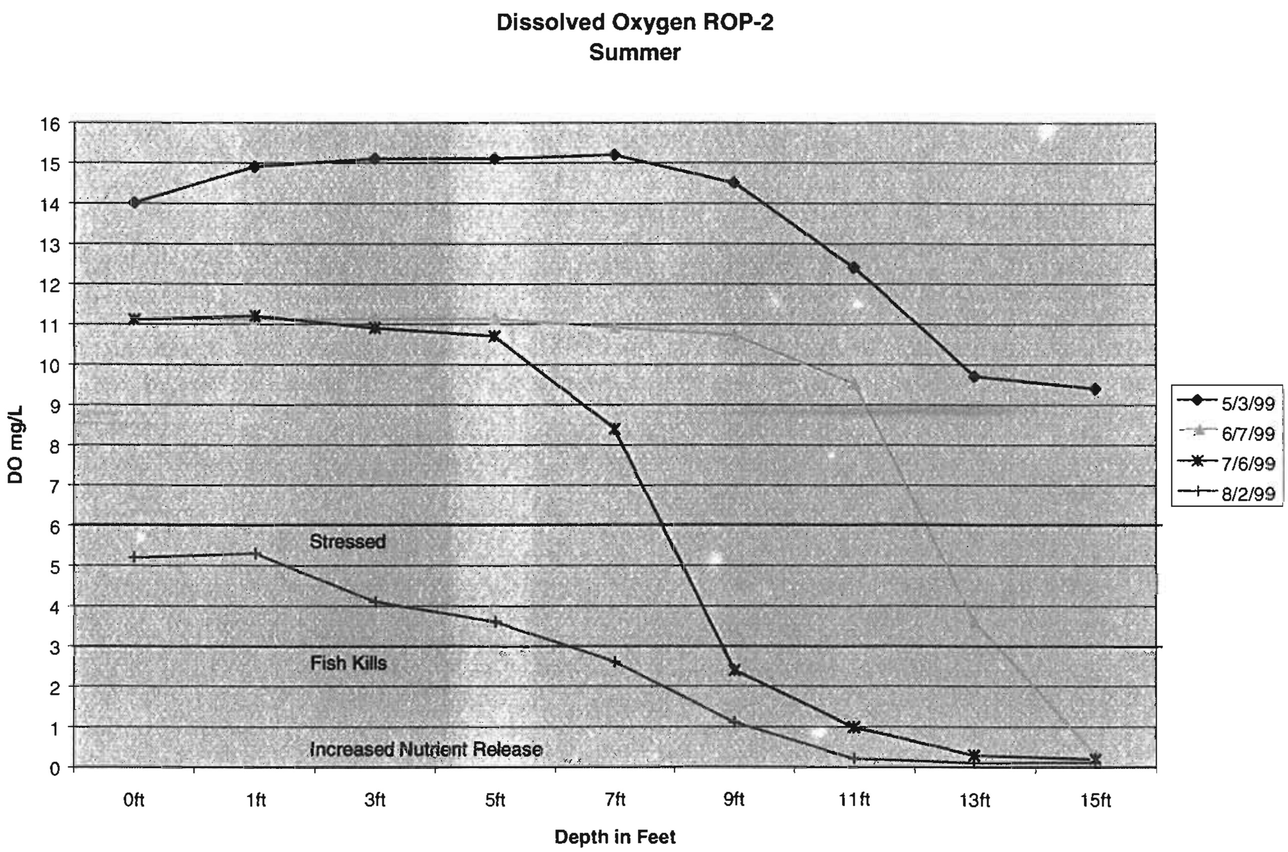

Dissolved Oxygen ROP-2
Winter/ Spring
DO mg/L
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Stressed
Fish Kills
0ft
1ft
3ft
5ft
7ft
9ft
11ft
13ft
15ft
Depth in Feet
1/6/00
2/25/00
3/22/00
4/11/00
4/25/00

Figure 22

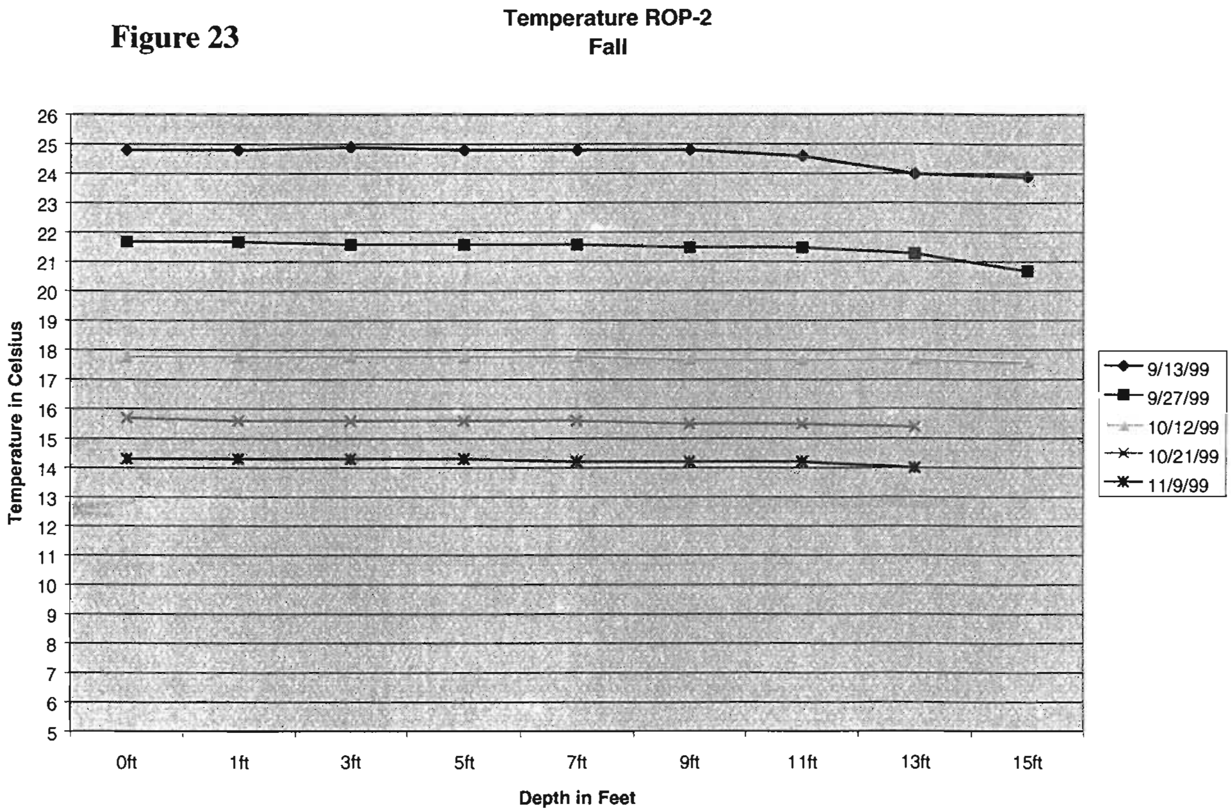


Temperatutre ROP-2
Summer
Temperature in Celsius
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
0ft
1ft
3ft
5ft
7ft
9ft
11ft
13ft
15ft
Depth in Feet
5/3/99
6/7/99
7/6/99
8/2/99



Dissolved Oxygen ROP-2
Summer
DO mg/L
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Stressed
Fish Kills
Increased Nutrient Release
0ft
1ft
3ft
5ft
7ft
9ft
11ft
13ft
15ft
Depth in Feet
5/3/99
6/7/99
7/6/99
8/2/99

Figure 23


Temperature ROP-2
Fall
Temperature in Celsius
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
0ft
1ft
3ft
5ft
7ft
9ft
11ft
13ft
15ft
Depth in Feet
9/13/99
9/27/99
10/12/99
10/21/99
11/9/99

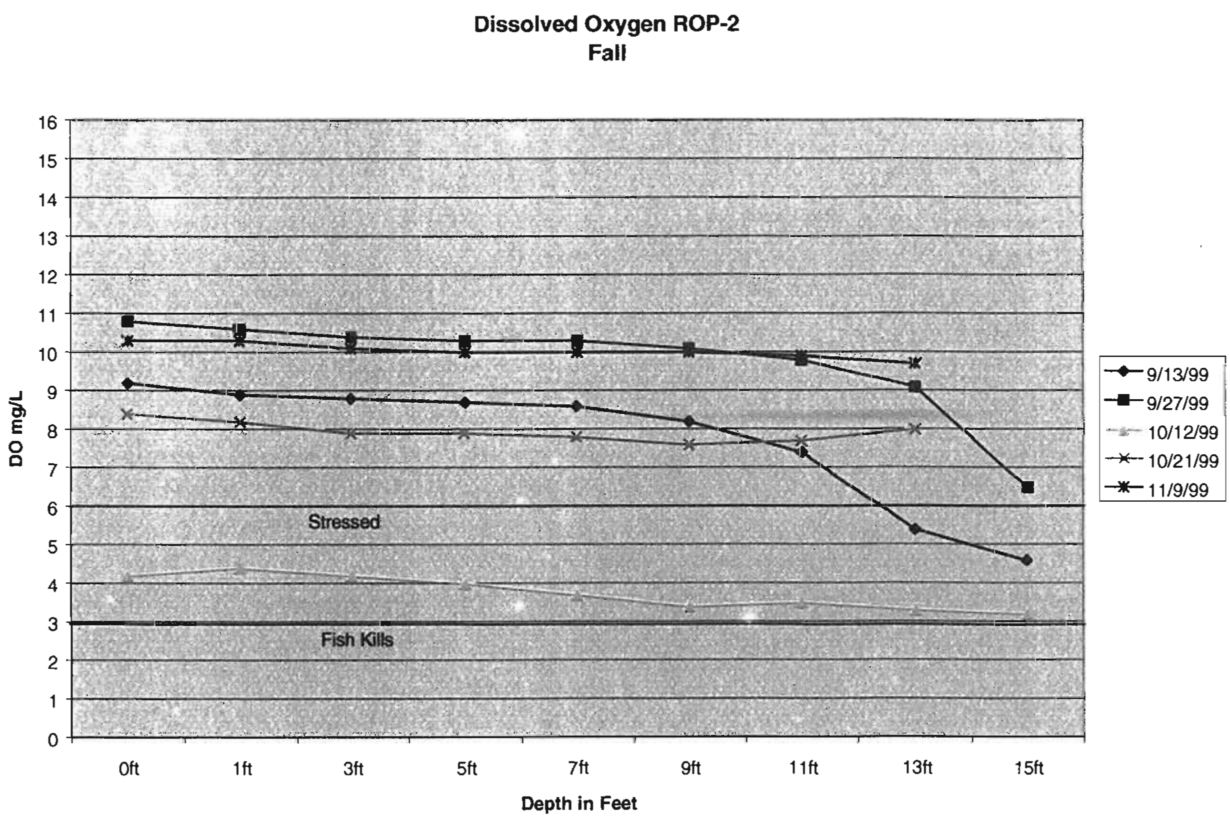
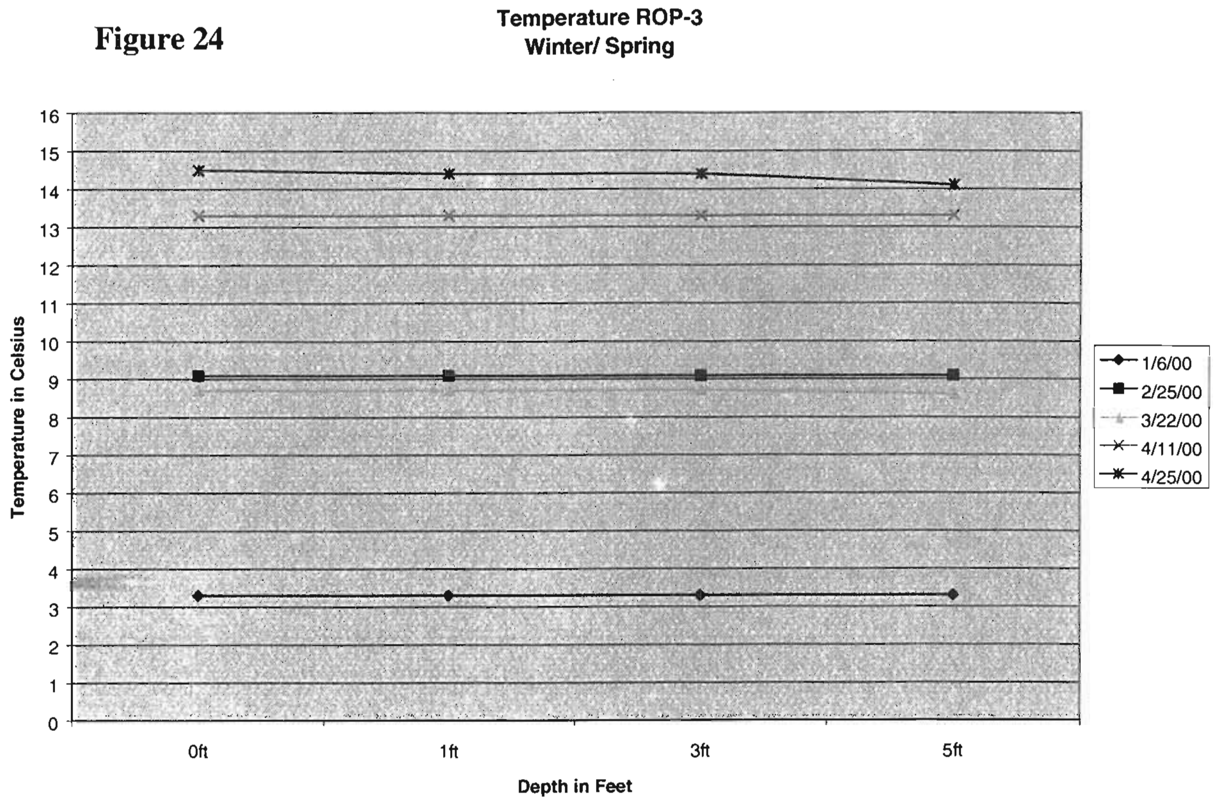

Dissolved Oxygen ROP-2
Fall
DO mg/L
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Stressed
Fish Kills
0ft
1ft
3ft
5ft
7ft
9ft
11ft
13ft
15ft
Depth in Feet
9/13/99
9/27/99
10/12/99
10/21/99
11/9/99

Figure 24


Temperature ROP-3
Winter/ Spring
Temperature in Celsius
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0ft
1ft
3ft
5ft
Depth in Feet
1/6/00
2/25/00
3/22/00
4/11/00
4/25/00

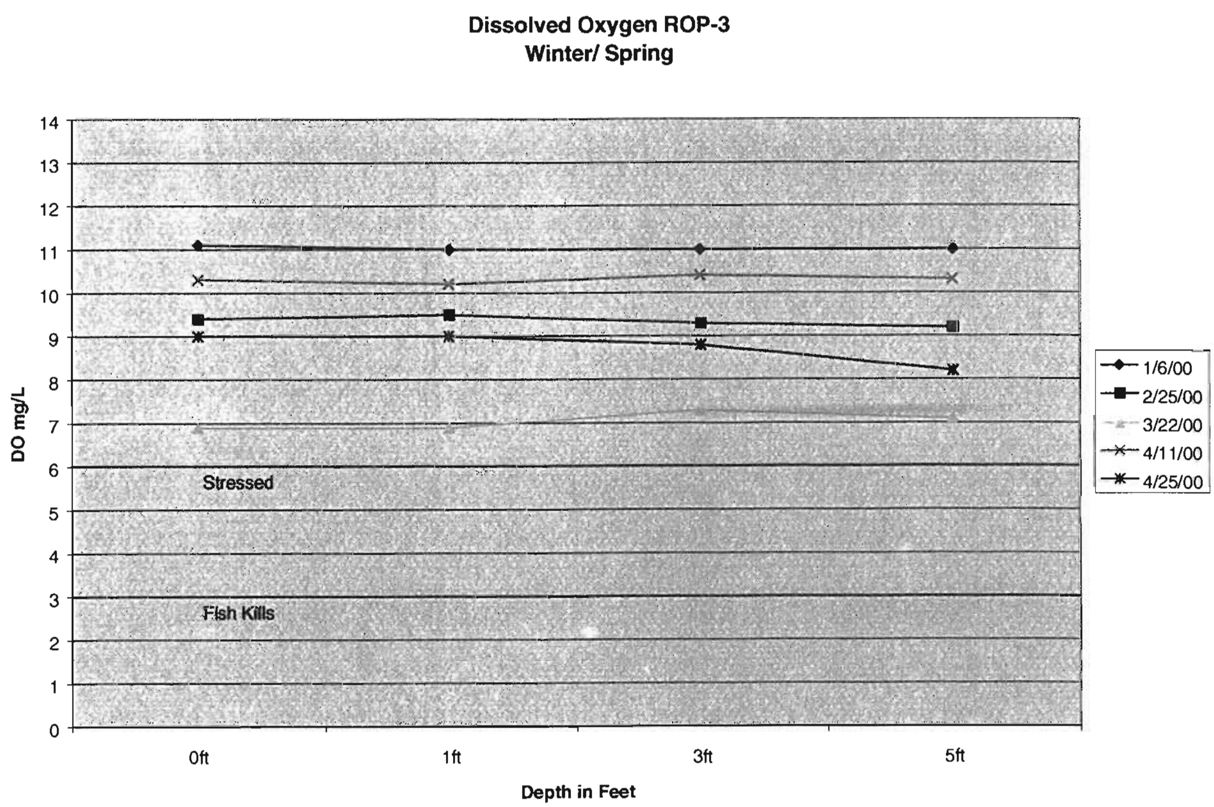
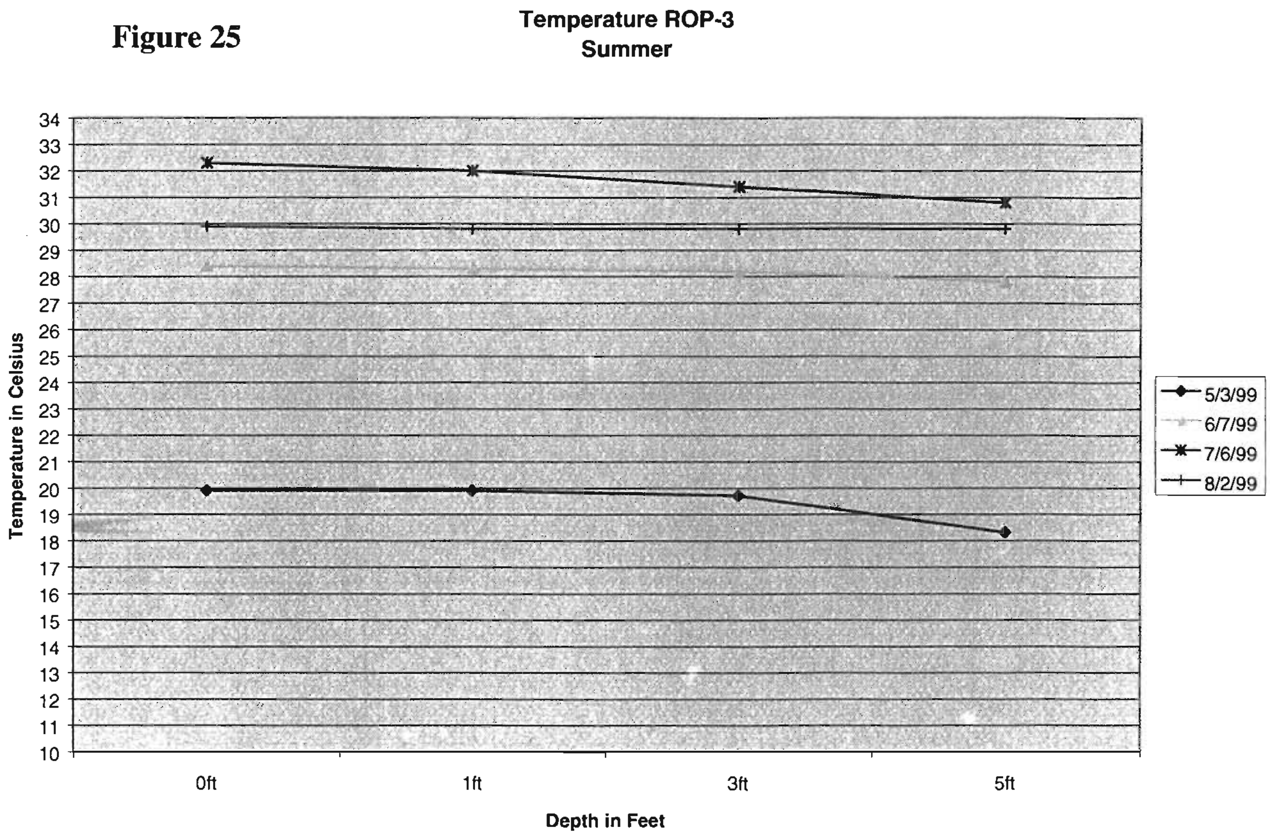
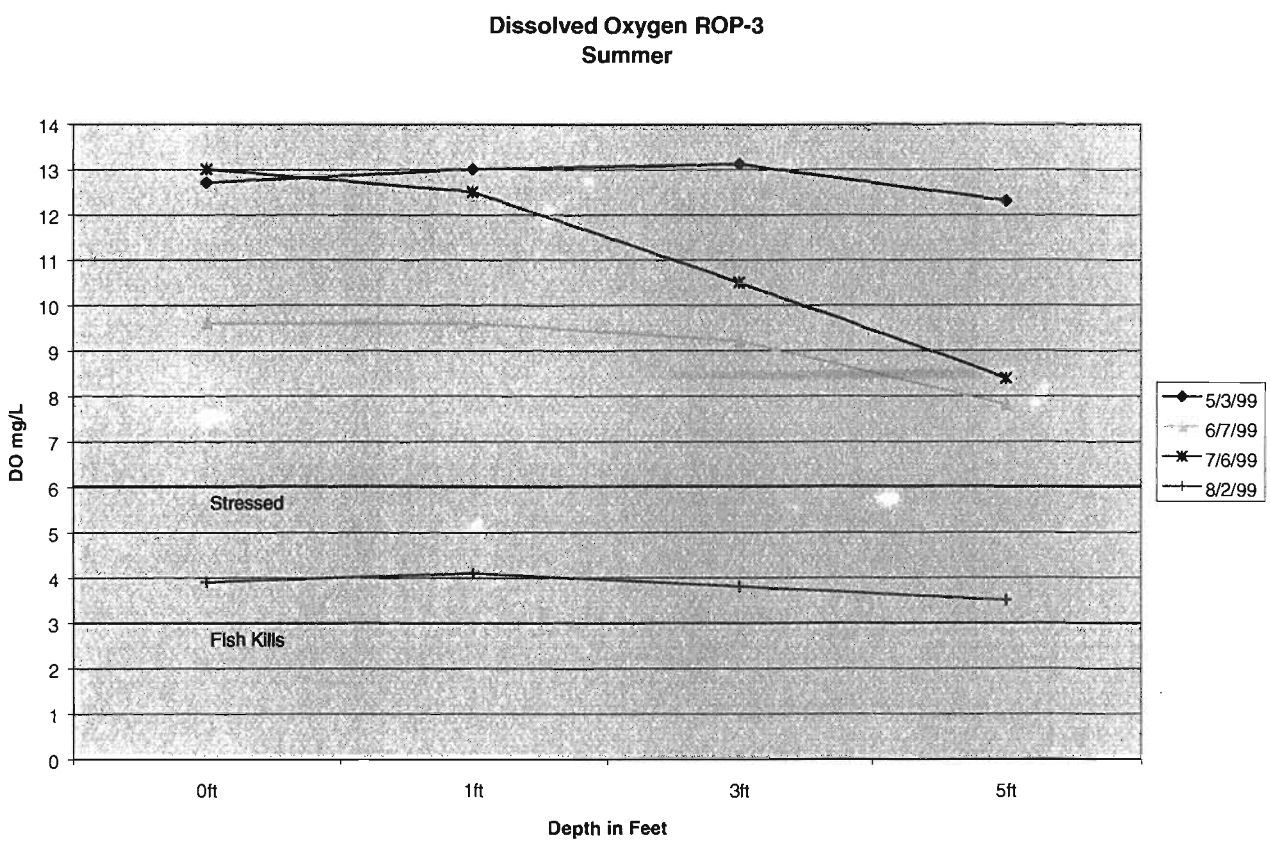

Dissolved Oxygen ROP-3
Winter/ Spring
DO mg/L
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Stressed
Fish Kills
0ft
1ft
3ft
5ft
Depth in Feet
1/6/00
2/25/00
3/22/00
4/11/00
4/25/00

Figure 25

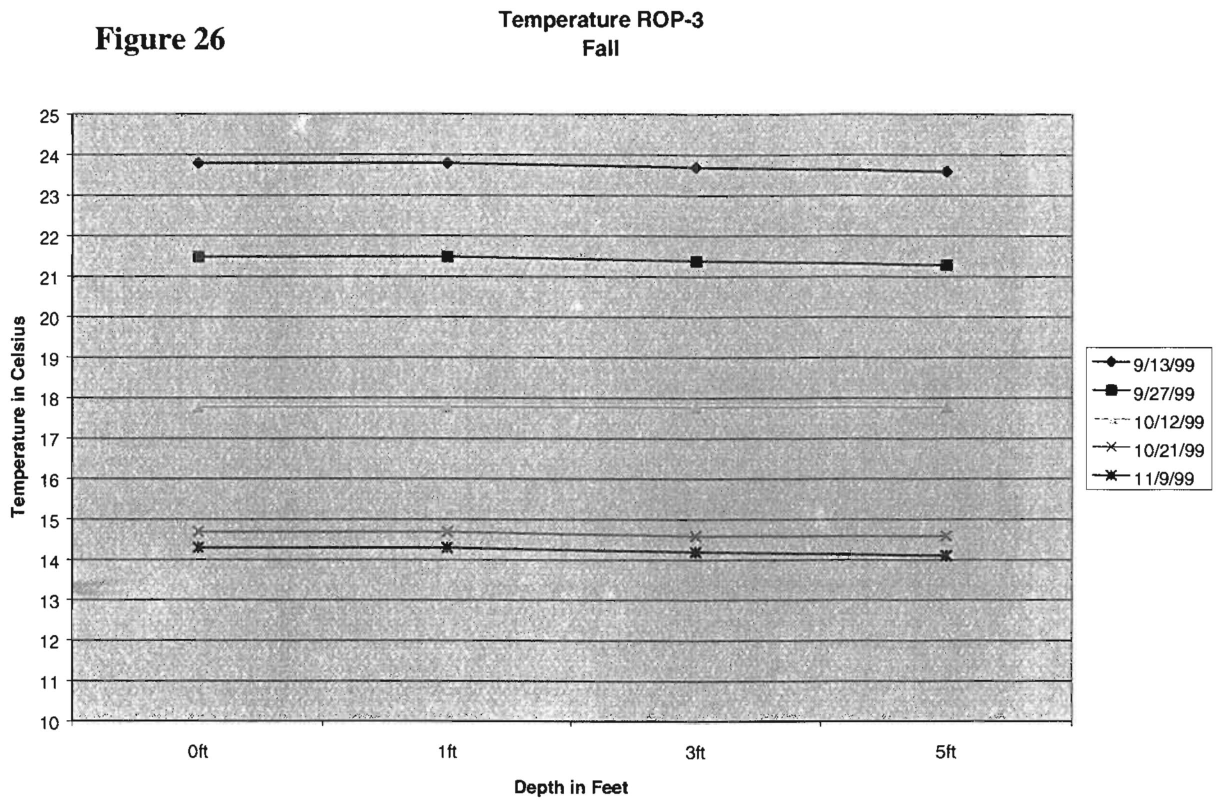


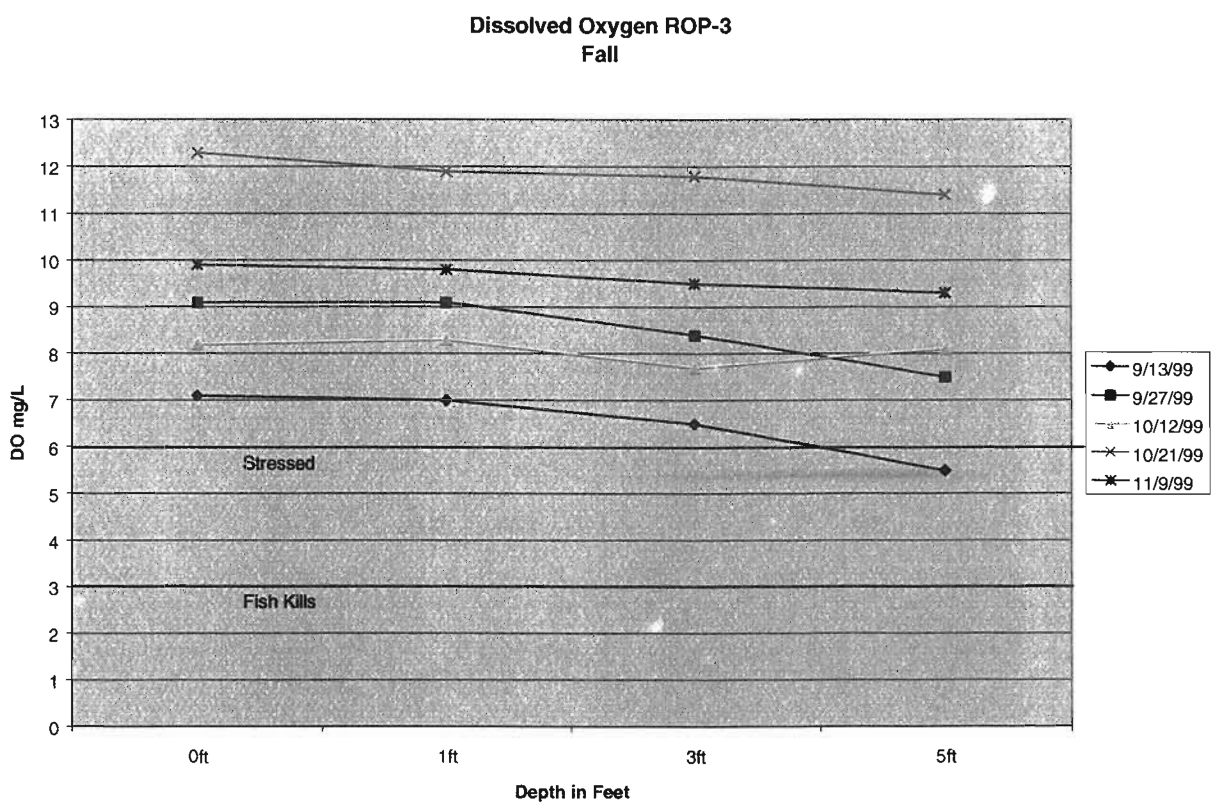
Temperature ROP-3
Summer
Temperature in Celsius
34
33
32
31
30
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
0ft
1ft
3ft
5ft
Depth in Feet
5/3/99
6/7/99
7/6/99
8/2/99



Dissolved Oxygen ROP-3
Summer
DO mg/L
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Stressed
Fish Kills
0ft
1ft
3ft
5ft
Depth in Feet
5/3/99
6/7/99
7/6/99
8/2/99

Figure 26


Temperature ROP-3
Fall
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
Temperature in Celsius
0ft
1ft
3ft
5ft
Depth in Feet
9/13/99
9/27/99
10/12/99
10/21/99
11/9/99

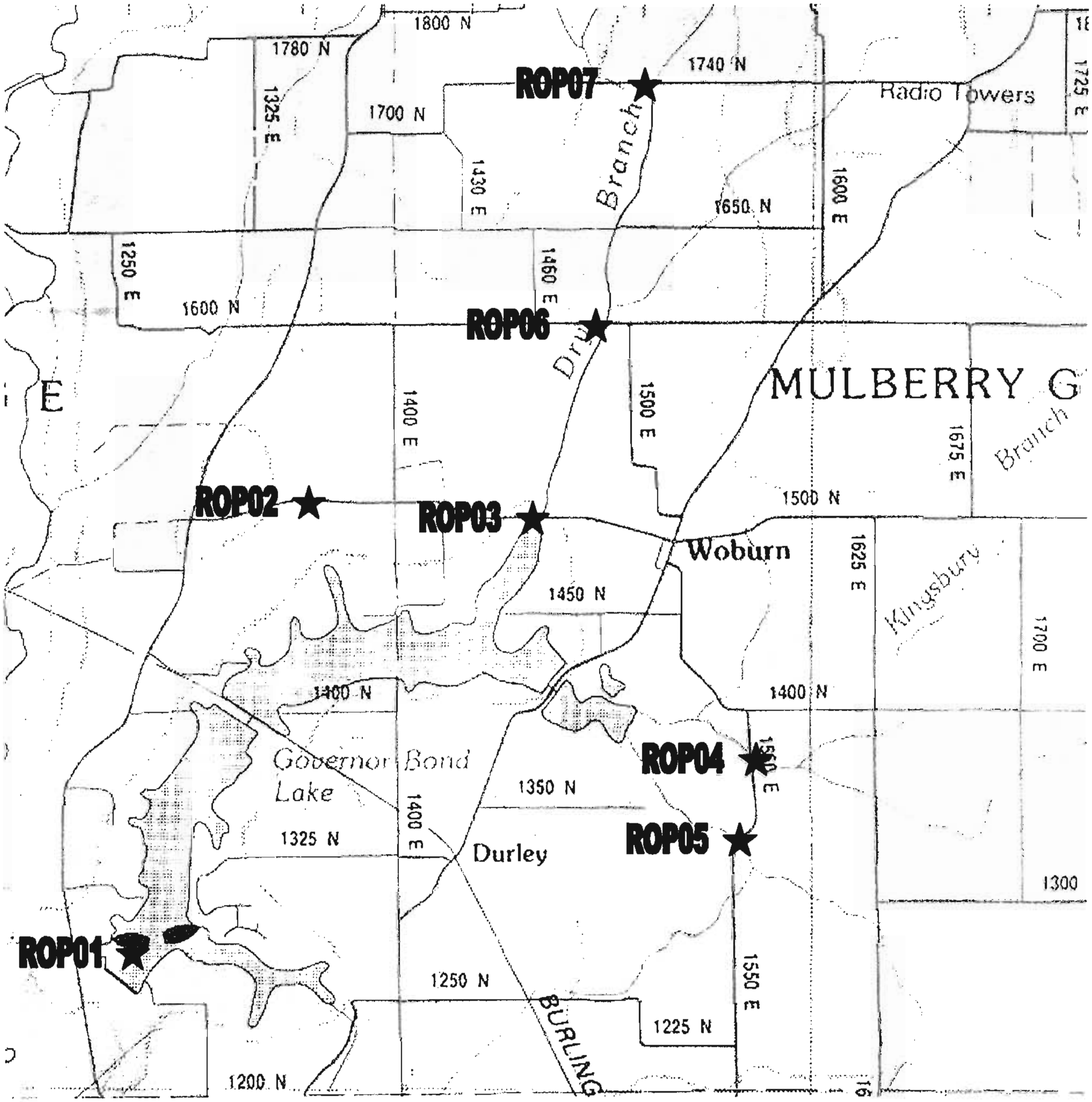

Dissolved Oxygen ROP-3
Fall
13
12
11
10
9
8
7
6
5
4
3
2
1
0
DO mg/L
Stressed
Fish Kills
0ft
1ft
3ft
5ft
Depth in Feet
9/13/99
9/27/99
10/12/99
10/21/99
11/9/99

TRIBUTARY MONITORING

Gauging and sampling stations were located in all of the major tributaries in an effort to develop an understanding of the volume of water, nutrients and other material entering the lake (Figure 27). These stations were located near the mouths of tributaries where reasonable access was available. A staff gauge was placed at each of these sites. A staff gauge is a measuring rod that allows relational water depths to be observed and recorded in tenths of a foot. Cross-sectional areas were taken at each of the staff gauge sites. Seven staff gauge sites were placed in the tributaries around the lake. The relationship between the staff gauge reading and the cross-sectional area was used to determine volumes of water entering the lake from each tributary. The staff gauge locations were labeled ROP01 through ROP07 (Figure 27). ROP01 is located near the spillway and was used to determine lake outflow. ROP02 is located north of the first bridge on Woburn Road; it corresponds to lake site ROP-5. ROP03 is located near the mouth of Dry Branch tributary at the next bridge on Woburn Road; it corresponds with lake site ROP-6. ROP06 is located further upstream on Dry Branch on County Road 1600 N. ROP07 is located even further upstream on Dry Branch on County Road 1740 N. They correspond to lake site ROP-6 as well. ROP04 is located on Kingsbury Branch on County Road 1560 E; it corresponds to lake site ROP-7. ROP05 is located south of ROP04 on County Road 1550 E; it also corresponds to lake site ROP-7 (Figure 6).

ZIES staff recorded daily staff gauge readings at ROP01 – ROP05. These five sites gave data for all of the major tributaries entering the lake. During storm events (more than ½ inch of rain) ZIES staff collected water samples from all seven sites and recorded staff heights for each site. Water samples were collected and shipped according to IEPA protocol to IEPA laboratories for analysis. Water samples were analyzed for total suspended solids, volatile suspended solids, phosphorus, nitrate + nitrite nitrogen, ammonia nitrogen and kjeldahl nitrogen. ZIES staff tested for pH and turbidity on site using a Hydrolab probe during collection of the other water samples.

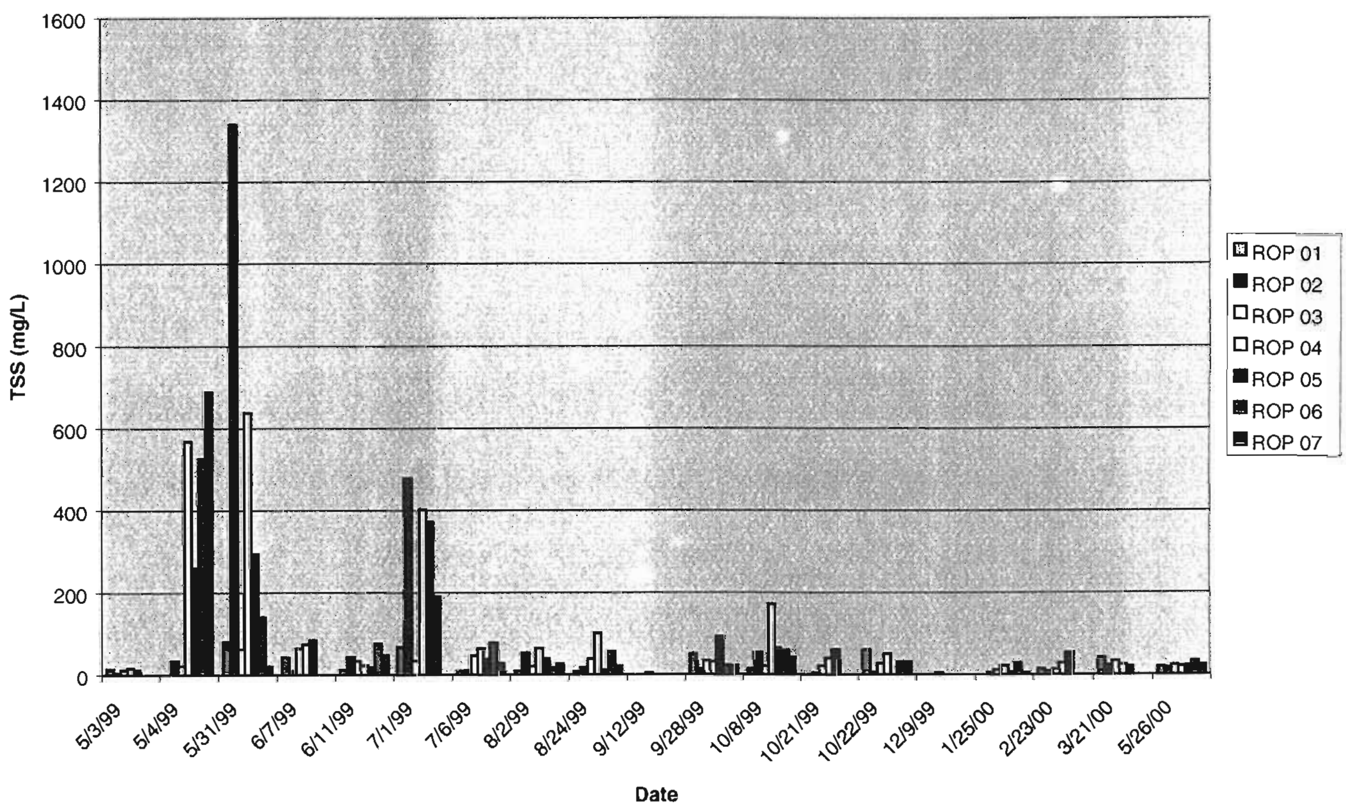
Figure 27 **Tributary Sampling Sites**



Total Suspended Solids

Total suspended solids (TSS) is a measurement of all of the suspended material in the water including both organic and inorganic materials. This would include materials such as algae, decaying plant materials, minerals, and soil particles. Peak levels corresponded with rain events on most dates; this would indicate that materials are washing in from the watershed or stream banks (Figure 28).

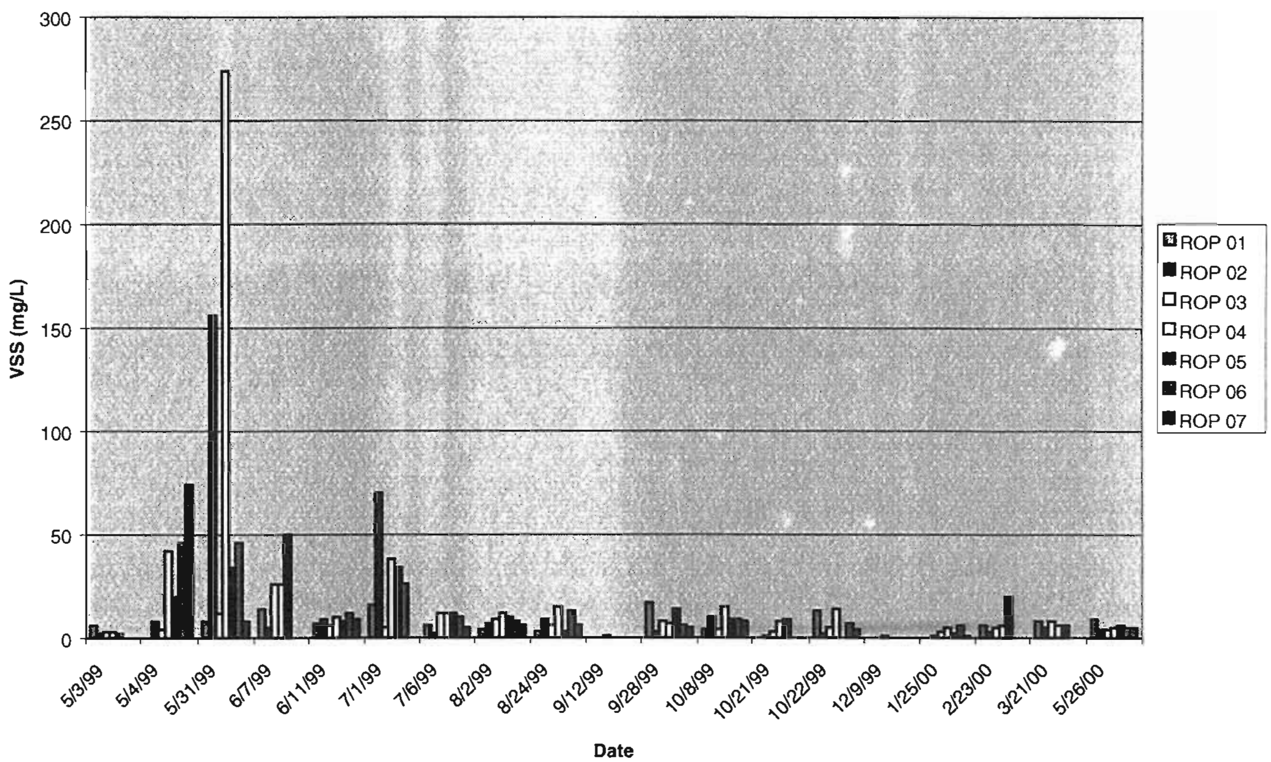
Figure 28 **Tributary Sites Total Suspended Solids (TSS) 1999-2000**



Volatile Suspended Solids

Volatile suspended solids (VSS) is a measurement of only the organic material suspended in the water. This material would include algae, decaying plant material and all other organic material suspended in the water. Peak VSS levels corresponded to rain indicating that organic materials were washing into the tributaries and or algae growth increased during such rainfall events (Figure 29).

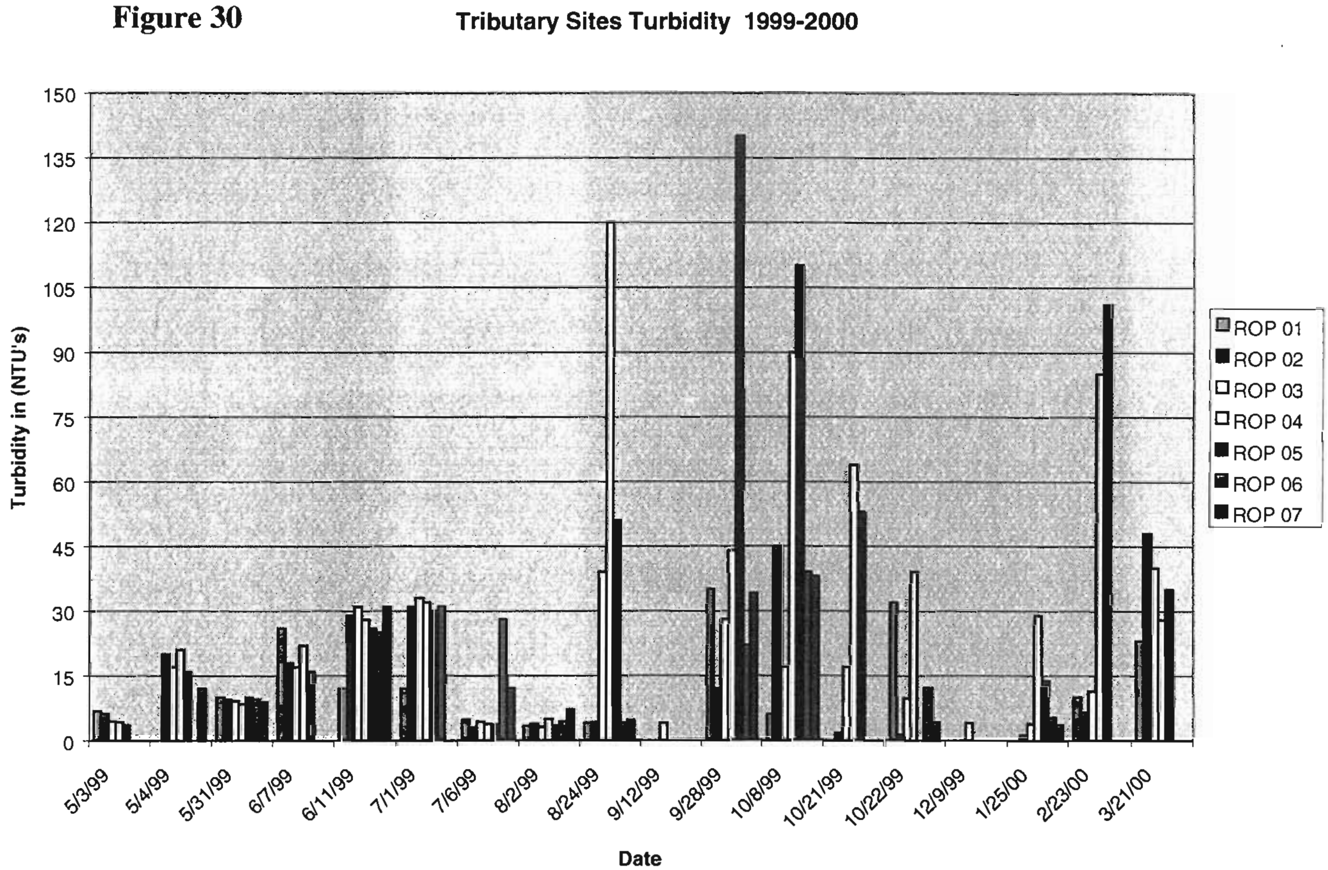
Figure 29 **Tributary Sites Volatile Suspended Solids (VSS) 1999-2000**



Turbidity

Turbidity is a measure of suspended materials in the water. Turbidity was measured using a Hydrolab water measurement instrument and was calibrated to a known turbidity test standard (NTUs). Turbidity is a measure of materials in the water causing light to scatter. Turbidity in the tributaries is an indicator of bank and soil erosion in and around the stream. The Kingsbury Branches at ROP04 and ROP05 had higher peak values than other sites. These higher turbidity levels at ROP04 and ROP05 would indicate that more material is entering these streams from surface runoff or stream bank erosion than the other sites (Figure 30).

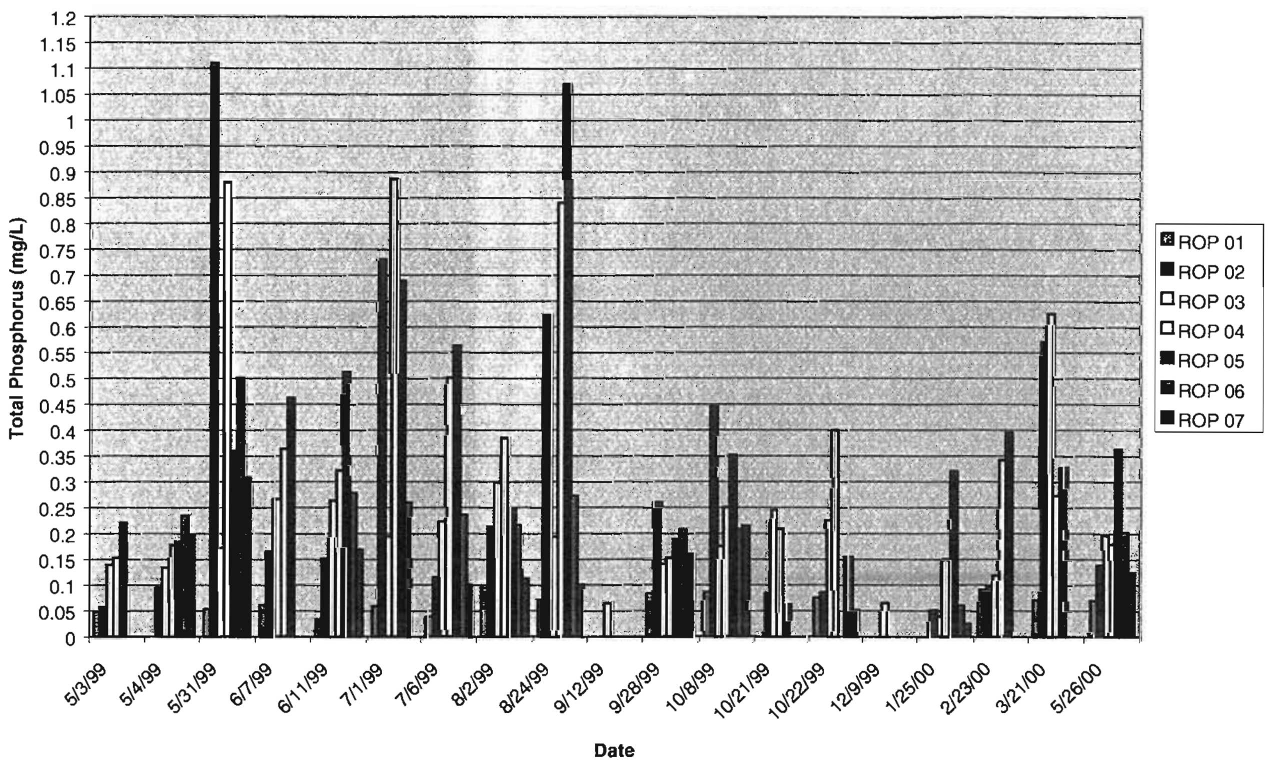
Figure 30



Phosphorus

Phosphorus is a component found in both agricultural and residential fertilizer. It can also leach from septic systems and feed lots. Large amounts of phosphorus runoff can lead to poor water quality in the lake. High phosphorus levels can lead to algae blooms and poor water quality. The IPCB Part 302 states phosphorus as P shall not exceed 0.05 mg/L in any reservoir or lake with a surface area of 8.1 hectares or more, or in any stream at the point where it enters any such reservoir or lake. The phosphorus levels on all dates at sites entering the lake were above the standard. Phosphorus found at sites ROP02 on 5/31/99 peaked at 1.11 mg/L and ROP05 peaked on 8/24/99 at 1.07 mg/L. Levels peaked on 7/1/99 at ROP04 at .88 mg/L and on 3/21/00 at ROP03 at .63 mg/L (Figure 31). This data demonstrates that phosphorus is entering the lake from all of the tributaries at high levels.

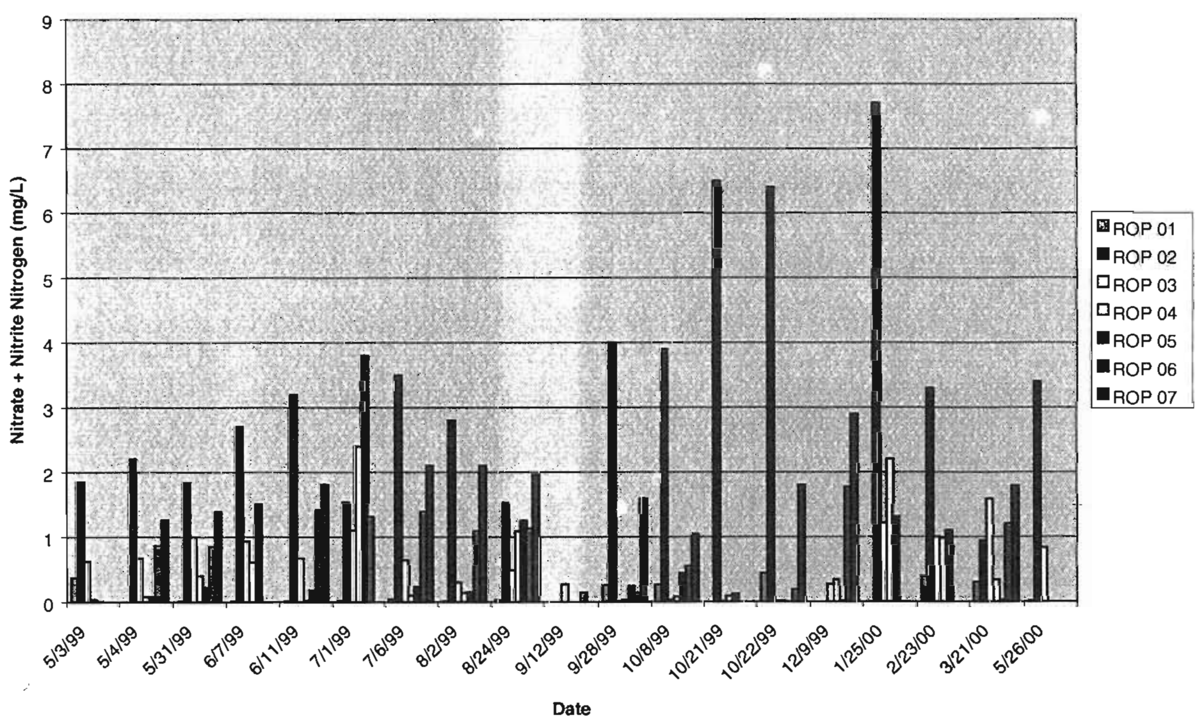
Figure 31 **Tributary Sites Total Phosphorus 1999-2000**



Nitrate + Nitrite Nitrogen

Nitrate and nitrate are inorganic forms of nitrogen, which can enter a lake through agricultural runoff, septic tank effluent and other forms of waste (Meyers 1999). Concentrations were found constantly higher at ROP02 than other sites and they peaked at this site on 1/25/00 at 7.7 mg/L. ROP04 and ROP05 both peaked on 7/1/99 at 2.4 mg/L and 3.8 mg/L respectively. Concentrations became decreasingly weaker in Dry Branch. The highest concentrations were found near the north end of the tributary at ROP07 and they decreased in concentration as samples were next taken at ROP06 and ROP03 (Figure 32).

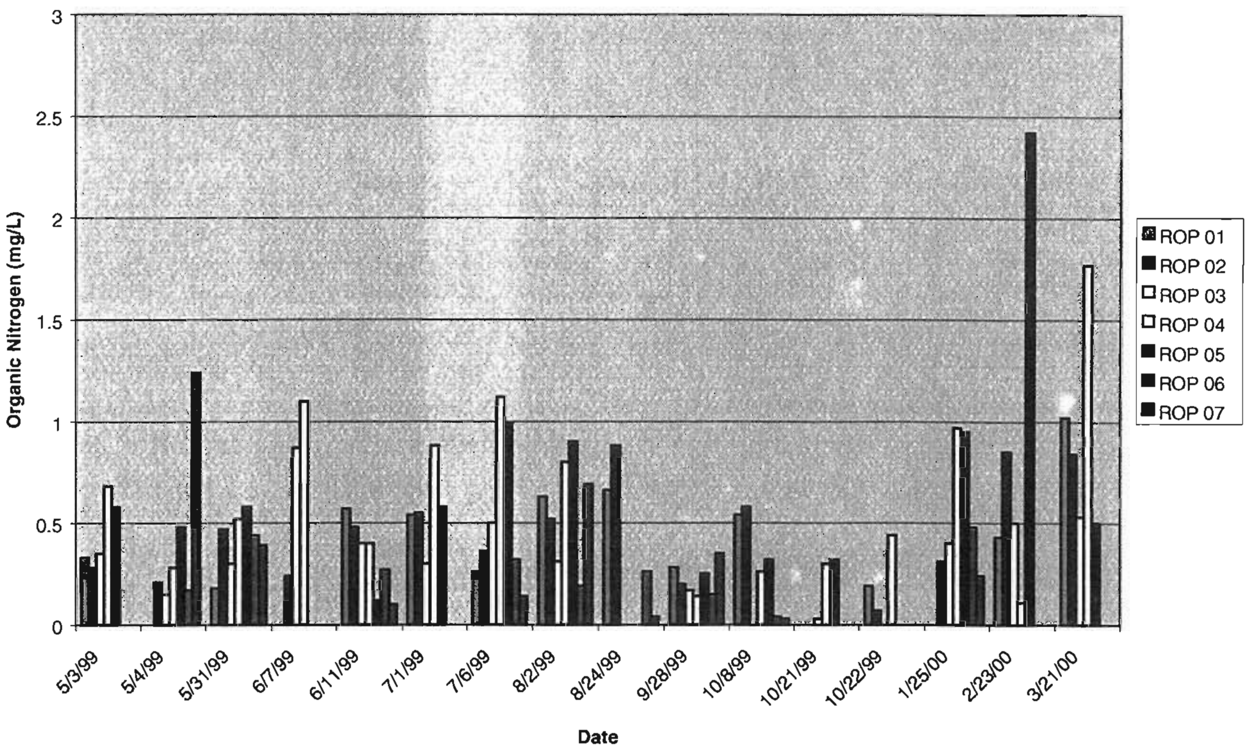
Figure 32 Tributary Sites Nitrate + Nitrite Nitrogen 1999-2000



Organic Nitrogen

Kjeldahl nitrogen is ammonia nitrogen plus organic nitrogen. Organic nitrogen is calculated by subtracting ammonia nitrogen from kjeldahl nitrogen. Organic nitrogen can enter tributaries through decaying organic matter, septic systems and agricultural waste (Myers 1997). Organic nitrogen peaked in the tributaries at ROP 05 on 2/23/00 at 2.42 mg/L (Figure 33).

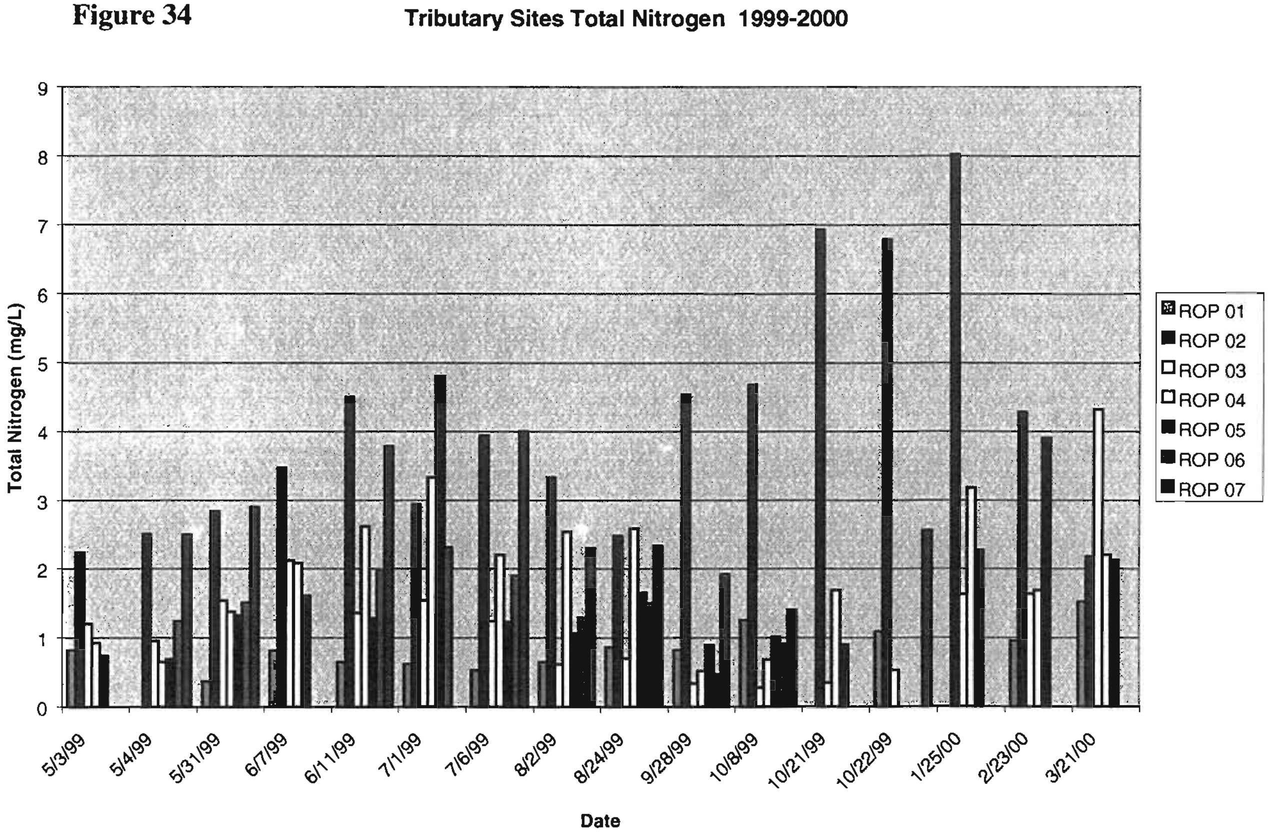
Figure 33 **Tributary Sites Organic Nitrogen 1999-2000**



Total Nitrogen

Total nitrogen is the sum of all nitrogen. It is calculated by adding kjeldahl nitrogen and nitrate and nitrite. It was found in consistently higher concentrations at ROP 02 and peaked at this site on 1/25/00 at 8.02 mg/L (Figure 34).

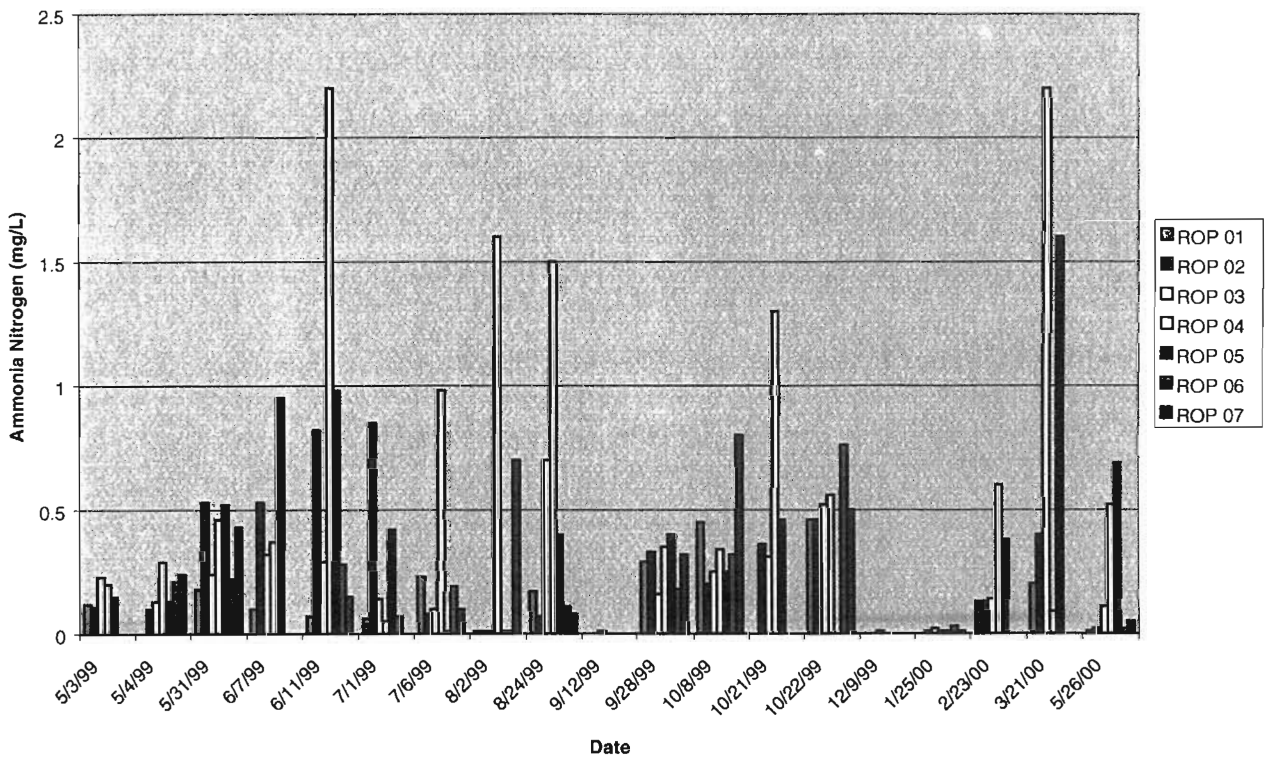
Figure 34



Ammonia Nitrogen

Ammonia nitrogen is the form of nitrogen that is most readily usable for plant growth. High ammonia concentrations can also have adverse affect on fish and other aquatic organisms. The IPCB Part 302 states that total ammonia shall in no case exceed 15 mg/L. No tributary sample exceeded this standard. Ammonia concentrations were found at consistently higher concentrations at ROP03, the mouth to Dry Branch (Figure 35).

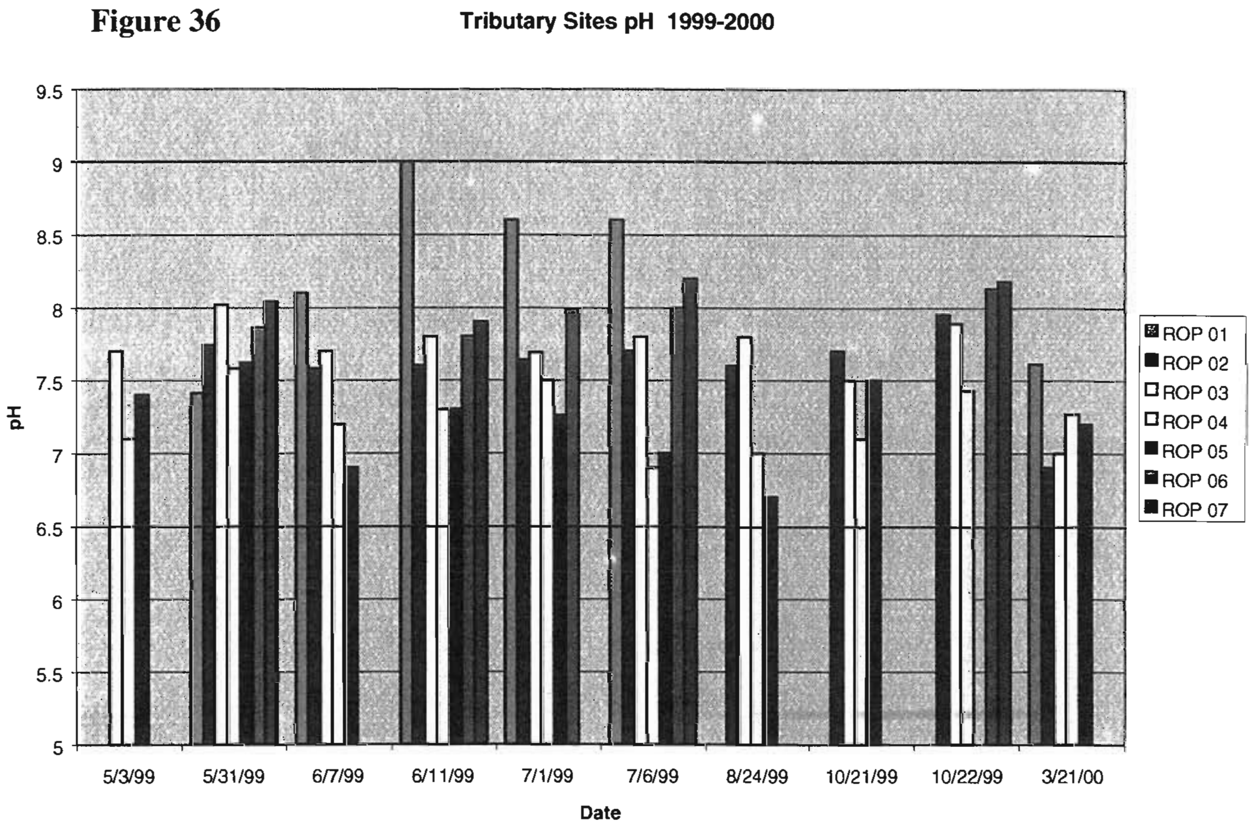
Figure 35 **Tributary Sites Ammonia Nitrogen 1999-2000**



pH

pH measures the acidity of water. PH measures the hydrogen ions present in solution on a scale of 0-14. A reading of 7 is neutral. A reading higher than 7 is basic or alkaline. A reading less than 7 is acidic. The Illinois standard states that the pH should be within the range of 6.5 to 9. pH was measured by ZIES staff at the time of other water sample collection using a Hydrolab water sampling probe. The pH levels in the tributaries never measured outside of the 6.5- 9 range (Figure 36).

Figure 36



SEDIMENT SURVEY

The Natural Resources Conservation Service conducted a sediment survey in Governor Bond Lake in 1995 (Table 14). The report states that Governor Bond Lake is silting in at a very fast rate. An estimated 32,670 tons of sediment is delivered to the lake on an annual basis. Recreational and fish habitats have been affected. The railroad trestle that divides the lake tends to create two lakes with different water quality characteristics; Woburn Road causeway creates a third, smaller basin at the north east end of the lake (at Kingbury Branch). The areas north and east of the trestle and roadway act as a silt basins, trapping most of the soil particles before they are transported to the lower end of the lake. The upper areas of the lake, therefore, have higher levels of turbidity above both the roadway and railroad trestle. Using the 1985 Food Security Act definition, there are 1,780 acres of highly erodible soils in the Governor Bond Lake watershed in pasture, hayland and woodland. About 1,505 acres of the highly erodible soils are in cropland and are eroding at an average of 16 ton/acre/year. There are 5,642 acres of potentially highly erodible soils in the watershed where sheet and rill erosion generates approximately 6.5 tons/acre/year. Another 10,552 acres of cropland contribute an average annual soil loss of 2.5 tons/acre/year. The remaining 2,622 acres of watershed contains pasture, woodland, urban areas, and streams, ponds and lakes. These erosion figures are based on pre-1985 Food Security Act FSA plan applications and soil losses. Housing developments and construction activities add to the soil lost and eroded into the lake, since all are close to the shoreline. Any erosion that takes place is discharged directly into the lake.

Table 14 NRCS Sediment Survey Source: GBL Lake Ecosystem Plan

Erosion Sources	Gross Erosion (Ton/yr.)	Sediment Delivery Ration (SDR)	Gross Sedimentation (Tons/yr.)
Sheet and Rill			
Cropland	85,316	0.70	59,700
Pasture	5,400	0.75	4,050
Woodland	6,969	0.80	5,575
Other	862	0.80	690
Total Sheet & Rill	98,546		70,015
Ephemeral	11,825	0.90	10,600
Gully	11,390	0.90	10,250
Streambank	1,050	1.0	1,050
Shoreline	1,420	1.0	1,420
Total	124,231		93,320
Sediment Transport Factor (STF)			x 0.35
Sediment delivered to	the lake yearly		32,670 tons

Bathymetric Mapping

In order to develop an understanding of the depth of sedimentation and the loss of volume to the lake a bathymetric map of the bottom contours of the lake was made (Figure 6). A GPS unit and depth finding equipment were used. GPS points were collected throughout the lake in a transect pattern. The GPS technology allowed staff to collect points with an exact knowledge of the location of these points. Along with the GPS points, depth points were taken. A total current volume was calculated. This volume was compared to the original volume of the lake. The difference gives an accurate estimation of the sediment that has collected on the bottom of the lake. The problem with this methodology is the accuracy of determining the original volume of the lake. The NRCS, in a similar survey, used the volume the dam was built to hold, not volumes determined from contours. Using this latter method, the 1969 volume of 9,900 acre-ft was used in the ZIES survey. The current 1999 volume is 6,839 acre-feet, resulting in a sediment volume of 3,061 acre-feet or 102.03 acre-feet of sediment/year. This would calculate into a 31% loss of volume over a 30-year period. This calculation is lower than previous studies, but within a similar range.

Sediment Sampling

To develop a better understanding of the types of materials in the sediment, ZIES and IEPA collected sediment grab samples for laboratory analysis. The IEPA collected samples at sites ROP-1 and ROP-3 and ZIES collected samples at all seven lake sites ROP-1 through ROP-7. The data from these samples was analyzed for organic and heavy metal concentrations at IEPA laboratories (Tables 15, 16). These data reveal the types of materials that have been trapped in the sediment. The information will give baseline data to make informed decisions about restoration techniques, including dredging of the lake bottom. High concentrations of pesticides and heavy metals in the sediment could affect the dredging options.

Most of the parameters tested for were at the normal to low level according to the IEPA 305(b) water quality report. Concentrations of several parameters were elevated at a few sites. Phosphorus levels were elevated at sites ROP-1, ROP-2, ROP-3 and ROP-4. Kjedahl-N was at elevated and highly elevated levels at ROP-1. These two elements are an indicator of the nutrient loads to the lake. Silver was reported at elevated levels at ROP-1 and ROP-3. Manganese was also elevated at ROP-3. Increased levels of Atrazine were also reported at site ROP-3. None of these elevated levels should be prohibitive in regards to the restoration program. The categorization of parameters as low, normal, elevated and highly elevated is in comparison to other lakes in Illinois, not usage criteria.

Table 15 Sediment Metals

	ROP-1	ROP-2	ROP-3	ROP-4	ROP-5	ROP-6	ROP-7	ROP-1	ROP-2	ROP-3
Sample Depth	22	18	7	17.5	5.5	3.5	4	22ft	18ft	7ft
Phosphorus-P, Sed.	1160	1620	722	1200	427	440	825	750	1620	1620
Kjedahl-N, Sed	7100	3100	2500	3200	3100	1100	2000	17000	3100	3462
Solids, Vol, Sed.	10.5%	9.2%	6.7%	7.3%	4.2%	4.9%	5.8%	7.1%	9.2%	9.7%
Mercury, Sed.	.10K	.10K	.10K	.10K	.10K	.10K	.10K	.10K	0.10k	.10K
Barium, Sed.	80	67	50	68	47	61	69	170	67	250
Chromium, Sed.	7	6	6	7	6	7	8	22	6	26
Iron, Sed.	9000	7400	6600	8700	6700	8400	8700	22000	7400	31000
Manganese, Sed.	620	450	260	540	280	380	470	750	450	2100
Silver, Sed.	1K	1K	1K	1K	1K	1K	1K	0.67	1k	0.37
Toc, Sed.	1.9%	2%	1.4%	1.9%	1.1%	1.3%	1.7%	1.11	2	0.47
Solids, % Wet Sample	40.03%	42.85%	52.02%	44.17%	48.72%	44.18%	47.39%	28.1	42.85	10.4
Arsenic, Sed.	3.1	2.6	1.9	2.8	1.7	2.3	2.4	5.6	2.6	10
Potassium, SE d/wt	620	560	540	630	510	590	660	1400	560	1600
Cadmium, Sed.	1K	1K	1K	1K	1K	1K	1K	.3K	1k	.3K
Copper, Sed.	12	8	7	11	7	8	8	20	8	38
Lead, Sed.	8	7	6	7	7	8	8	20	7	26
Nickel, Sed.	7	5	5	7	6	6	8	16	5	23
Zinc, Sed.	27	23	22	28	6	30	6	73	23	90
collected by:	ZIES	ZIES	ZIES	ZIES	ZIES	ZIES	ZIES	EPA	EPA	EPA

Units of measure mg/Kg

	Detection Limit	Low	Normal	Elevated	Highly Elevated
Phosphorus-P, Sed.	0.1mg/Kg	less than 394	394<1115	1115<2179	2179 or greater
Kjedahl-N, Sed	1.0mg/Kg	less than 1300	1300<5357	5357<11700	11700 or greater
Mercury, Sed.	0.1 mg/Kg	n/a	less than 0.15	0.15<0.701	.701 or greater
Barium, Sed.	1.0mg/Kg	less than 94	94<271	271<397	397 or greater
Chromium, Sed.	10mg/Kg	less than 13	13<27	27<49	49 or greater
Iron, Sed.	10mg/Kg	less than 1600	1600<37000	37000<56000	56000 or greater
Manganese, Sed.	10mg/Kg	less than 500	500<1700	1700<5500	5500 or greater
Silver, Sed.	0.1mgKg	n/a	less than 0.1	0.1<1	1 or greater
Arsenic, Sed.	0.5mg/Kg	less than 4.1	4.1<14	14<95.5	95.5 or greater
Potassium, SE d/wt	10mg/Kg	lesss than 410	410<2100	2100<2797	2797 or greater
Cadmium, Sed.	0.1mg/Kg	n/a	less than 5	5<14	14 or greater
Copper, Sed.	10mg/Kg	less than 16.7	16.7<100	100<590	590 or greater
Lead, Sed.	0.1mg/Kg	less than 14	14<59	59<339	339 or greater
Nickel, Sed.	1.0mg/Kg	less than 14.3	14.3<31	31<43	43 or greater
Zinc, Sed.	10mg/Kg	less than 59	59<145	145<1100	1100 or greater

	Detection Limit	Low	Normal	Elevated	Highly Elevated
Sample Depth					
Phosphorus-P, Sed.	0.1mg/Kg	less than 394	394<1115	1115<2179	2179 or greater
Kjedahl-N, Sed	1.0mg/Kg	less than 1300	1300<5357	5357<11700	11700 or greater
Solids, Vol, Sed.					
Mercury, Sed.	0.1 mg/Kg	n/a	less than 0.15	0.15<0.701	.701 or greater
Barium, Sed.	1.0mg/Kg	less than 94	94<271	271<397	397 or greater
Chromium, Sed.	10mg/Kg	less than 13	13<27	27<49	49 or greater
Iron, Sed.	10mg/Kg	less than 1600	1600<37000	37000<56000	56000 or greater
Manganese, Sed.	10mg/Kg	less than 500	500<1700	1700<5500	5500 or greater
Silver, Sed.	0.1mgKg	n/a	less than 0.1	0.1<1	1 or greater
Toc, Sed.					
Solids, % Wet Sample					
Arsenic, Sed.	0.5mg/Kg	less than 4.1	4.1<14	14<95.5	95.5 or greater
Potassium, SE d/wt	10mg/Kg	lesss than 410	410<2100	2100<2797	2797 or greater
Cadmium, Sed.	0.1mg/Kg	n/a	less than 5	5<14	14 or greater
Copper, Sed.	10mg/Kg	less than 16.7	16.7<100	100<590	590 or greater
Lead, Sed.	0.1mg/Kg	less than 14	14<59	59<339	339 or greater
Nickel, Sed.	1.0mg/Kg	less than 14.3	14.3<31	31<43	43 or greater
Zinc, Sed.	10mg/Kg	less than 59	59<145	145<1100	1100 or greater

Table 16 Organic Sediments

Organic Sediments		
***all in ug/kg	ROP-1	ROP-3
	k=less than value	
Total PCBS	10K	10k
HEXACHLOROBENZENE	1k	1k
TRIFLURALIN	10k	10k
ALPHA-BHC	1k	1k
GAMMA-BHC (LINDANE)	1k	1k
ATRAZINE	50k	55
HEPTACHLOR	1k	1k
ALDRIN	1k	1k
ALACHLOR	10k	11
METRIBUZIN	10k	10k
METOLACHLOR	25k	25k
HEPTACHLOR EPOXIDE	1k	1k
PENDIMETHALIN	10k	10k
GAMMA-CHLORDANE	2k	2k
ALPHA-CLORDANE	2k	2k
TOTAL ALPHA AND GAMMA CHLORI	5k	5k
DIELDRIN	1k	1.2
CAPTAN	10k	10k
CYANAZINE	25k	25k
ENDRIN	1k	1k
P,P'-DDE	1k	1k
P,P'-DDD	1.1	1k
P'P'-DDT	1k	1k
TOTAL DDT	10k	10k
METHOXYCHLOR	5k	5k

SHORELINE EROSION

Shoreline erosion is important to consider when looking at the overall health of a lake. Erosion can affect a lake in many ways including sedimentation, loss of shoreline vegetation, interference with light, release of nutrients, stressed fish, oxygen depletion and loss of underwater habitat. (Fuller 1997). Sedimentation due to erosion can have a significant impact on the volume of the lake over time. Although shoreline erosion is not the only source, it can contribute significantly to this problem. Erosion can affect shoreline vegetation and habitats by destroying plants and trees near the shoreline. Suspended sediments will interfere with light, interfering with the food chain. Nutrients eroded into the lake can increase algae growth and lead to oxygen depletion. Fish like bass rely on sight to feed. Increased turbidity can affect their feeding. Erosion degrades both plant and fish habitats.

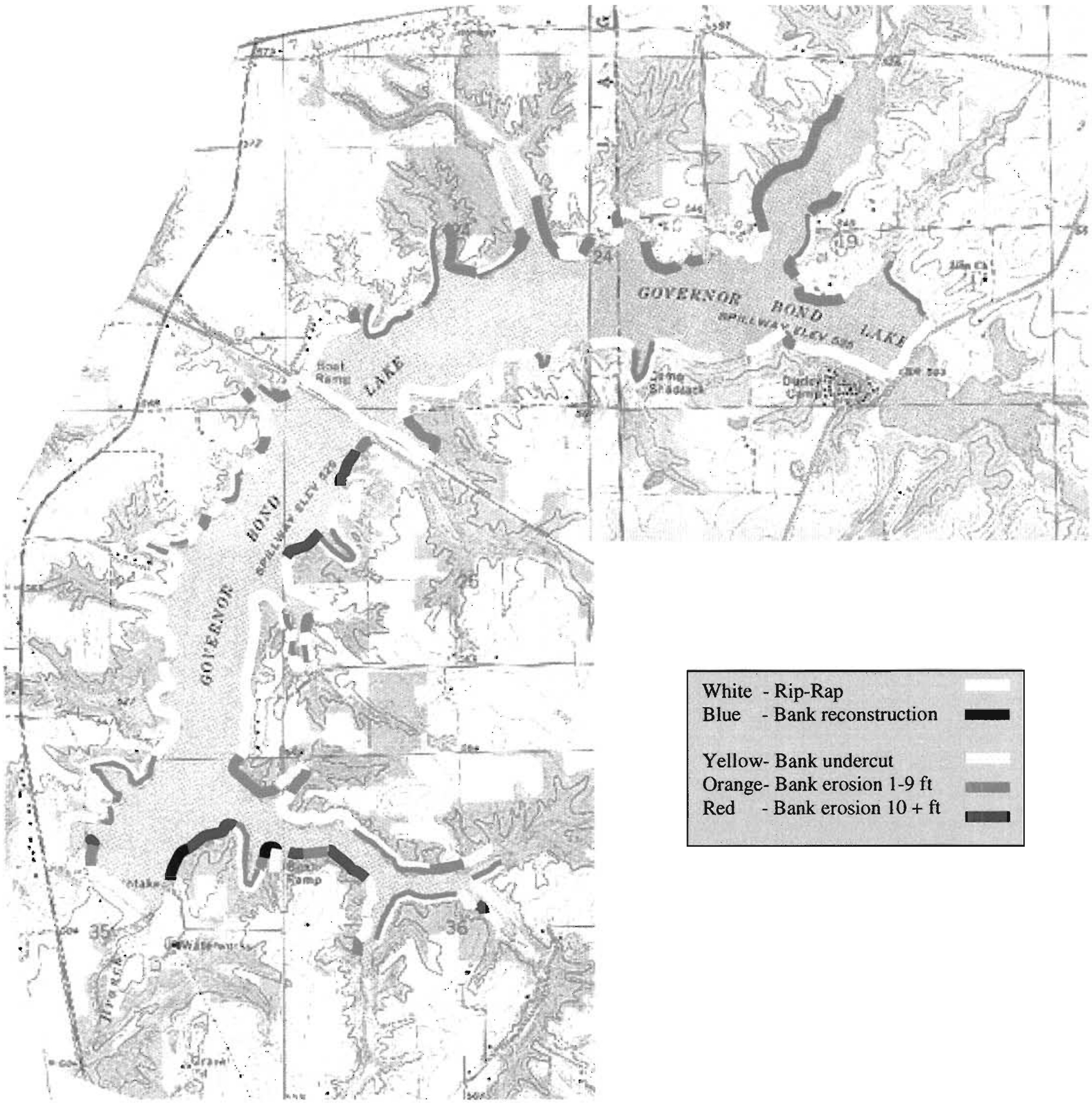
There are several causes for shoreline erosion - some of them are controllable and some of them are not. Some of the causes include loss of vegetation, powerboat waves, wind-generated waves and ice. The loss of vegetation on or near the shoreline makes the shoreline more susceptible to erosion. High-speed boats can increase the erosion on lakes. The size of the wave generated by a boat is a function of the water displaced by the boat and the speed at which the boat is traveling. In the case of some bass boats, which are designed to skim across the surface, they create smaller waves because they displace less water. Waves generated from the wind also contribute to shoreline erosion (Fuller 1997).

To obtain a better understanding of the shoreline erosion situation on Governor Bond Lake, ZIES staff did an intensive survey of the shoreline around Governor Bond Lake (Figure 37). A map was generated in which areas of the shoreline were labeled in the following manor: rip-rap, bank reconstruction, undercut, bank erosion 1-9 ft and severe bank erosion 10+ ft.

The survey indicates that there are 27,812 linear feet of shoreline that has been rip-rapped, 680 linear feet of bank reconstruction, 7,752 linear feet of undercut bank, 21,720 linear feet of erosion 1-9 ft and 2,720 linear feet of severe bank erosion 10 + ft.

Figure 37

Shoreline Erosion Study



TROPHIC CONDITION

The trophic status of a lake is a phrase that refers to the current degree of eutrophication. Eutrophication is the process of increased nutrient loads, biological productivity and the filling of a lake with sediment and organic materials. The trophic status gives an understanding of water quality problems and the biological aging of a lake. There are four main trophic status characterizations.

Oligotrophic lakes have low nutrient levels resulting in small quantities of macrophytes and algae. The water in oligotrophic lakes is usually well oxygenated because little decomposition is taking place.

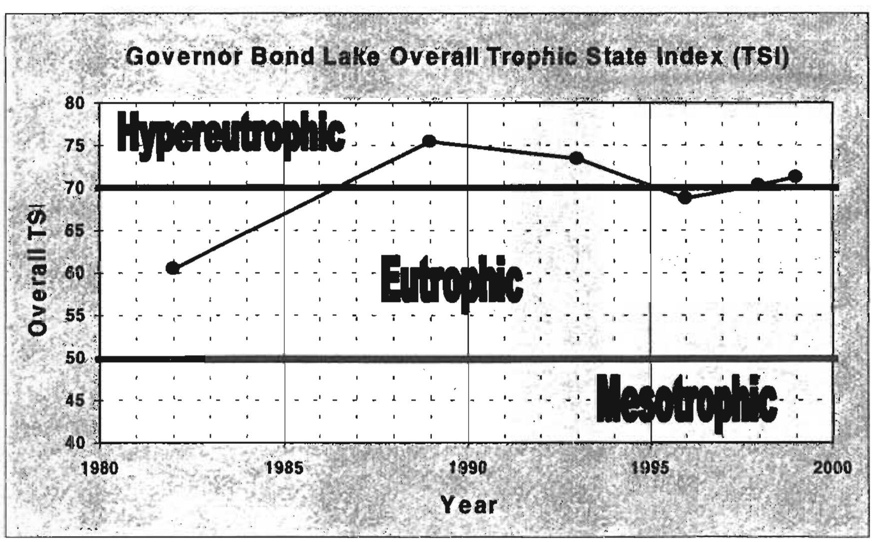
Mesotrophic lakes have moderate nutrient levels resulting in moderate biological aging.

Eutrophic lakes are rich in nutrients resulting in high biological production of algae and macrophytes. Biological processes in eutrophic lakes speed the aging of the lake by collecting dead and decaying plant material in the bottom of the lake. This decomposing material releases nutrients back into the water leading to increased algae and macrophytes. Decomposition leads to low oxygen levels near the bottom of the lake.

Hypereutrophic lakes are extremely nutrient rich and productive. These lakes often have large quantities of aquatic plants and high concentrations of algae. They can experience alga blooms, which can result in low oxygen levels and fish kills.

The Illinois EPA uses Carlson's Trophic State Index (TSI) (Carlson 1977) to determine the eutrophication levels for its lakes. Carlson's TSI is based on Secchi disk readings, chlorophyll a, and total phosphorus readings. The trophic condition for Governor Bond Lake is currently hypereutrophic. It historically has been in the eutrophic to hypereutrophic range.

Figure 38



Source: Tetra Tech

BIOLOGICAL MONITORING

In addition to the physical and chemical measurements taken several biological parameters were studied as a part of the project. These studies included a phytoplankton survey, chlorophyll a analysis, macrophyte survey, fish survey, bacteriological analysis, and a bird survey.

Phytoplankton

Phytoplankton are microscopic algae that live suspended in the water column. Developing an understanding of the types of phytoplankton found in a lake will give insight into the lake's health. High concentrations of blue-green algae (Cyanobacteria) are usually an indicator of a eutrophic lake because they thrive in organically rich waters. Phytoplankton are at the bottom of the food chain, providing food material for larger organisms including fish. Communities of phytoplankton are good indicators of a lake's trophic status and can influence the overall biological health of a lake. They influence food availability, light penetration, and oxygen availability. As phytoplankton die, they contribute to sedimentation and filling of a lake.

Algae Genera Cell Density and Cell Volumes

As part of the IEPA's ALMP program, Zanhiser staff collected water samples to be tested for algal genera, cell density and cell volumes. Phytoplankton analysis was conducted at Western Illinois University in the lab of Dr. Larry M. O'Flaherty. The summary of his report and the cell density and cell volumes is presented in the following paragraphs and tables (Tables 17-19).

Governor Bond Lake was sampled at three sites on 3 May, & June, 6 July, 24 August and 21 October 1999. Samples were analyzed using the sweep method employing a sedgewick-rafter cell. Except for the July sample, total phytoplankton production at Site 1 in 1999 was greater on each date than it had been in 1993. Total densities did vary from site to site in 1999, but they followed a similar pattern with high numbers in May, lower in June, higher again in July, peaking in August and lower again in October. Blue-green (Phylum Cyanophyta) dominated the total phytoplankton on every date at Site 3 and every date except May 3rd at Sites 1 and 2. In 1999 each site had differences in the taxa composing their phytoplankton. Diatoms (Phylum Bacillariophyta) reached their peak densities at each site in 1999 on August 24th. *Cyclotella meneghniniana*, *Nitzxchia acicularis*, *N. linearis* and *N. Palea* were abundant (100 or more/mL) at each site on August 24th. *Cyclotella chaetoceros* was abundant at Site 1 and *Navicula cryptocephala* was abundant at Site 3 on August 24th. *Fragilaria crotonensis* was not found in 1999 although it was present in 1993 samples. All of the diatoms seen in 1999 are indicative of eutrophic conditions in a lake. *Nitzschia* spp . is present when organic materials are in high concentrations, in a lake with extensive shallows or after a heavy rainfall washes them into a lake from the bottom of tributary streams. In 1999 each site had the same taxa except for Site 3 which had 3 taxa, *Navicula cryptocephala, Nitzschia sigmoidea and Pinnularia sp.*, not found at the other two sites. Site 3 may be shallower than the other two sites or may have the entrance of a stream near the sampling location. These three species are typically found on the bottom of streams or on the bottom of shallow portions of lakes.

Green algae (Phylum Chlorophyta) peaked on different dates at each site in 1999. They peaked on August 24th at Site 1, on June 7th at Site 2 and on both July 21st and October 21st. Most taxa at each site were similar, but some differences were apparent. For example, Chodatella chodati and Crucigenia truncata were at Site 3 but not at 2 and 1; Chodatella citriformis, Polyedriopsis spinulosa and Treubaria triappendiculata were at 2, but not at 1 or 3. These differences plus variations in total green algal production indicated that each site differed from the other 2 in terms of location, depth or other factors. A number of taxa seen in 1999 were not present in 1993. These included *Cosmarium* spp., *Crucigenia crucifera, Golenkinia radiata, Kirchneriella* spp., *Pediastrum tetras var. teraadon* spp.

Chrysophytes (Phylum Chrysophyta) were not abundant on any date or site. Since chrysophytes typically produce higher densities during late fall, winter and early spring, it is possible that the dates sampled did not fall during their peaks of production.

Cryptomonads (Phylum Cryptophyta) had their peak densities on May 3rd at Sites 1 and 2. They did not reach their maximum density until June 7th at Site 3. The presence of high densities in early spring is typical for cryptomonads. The much higher total density at Site 2 than at Sites 1 and 3 may be due to the location of the site, to its greater depth or to the possible presence of a destratifier at the site.

As was mentioned, blue-green (Phylum Cyanophyta) dominated the total phytoplankton production on all dates in 1999 at Site 3 and on all dates except May 3rd at Sites 1 and 2. All three eutrophic indicator taxa, *Anabaena spiroides* var. *crassa*, *Aphanizomenon flos-aquae* and *Microcystis aeruginosa*, were present in 1999 just as they were in 1993. A *spiroides* reached bloom densities on June 7th 1999 at Site 2 and July 6th at Site 1 and August 24th at Site 3. *Aphanizomenon* reached bloom densities in 1999 only at Site 1 on August 24th . *Microcystis* was never at bloom densities in 1999, but was abundant on July 6th at Sites 2 and 3, on August 24th at Site 2. Two blue-greens indicative of water with high temperatures were present in Governor Bond Lake in 1999. These two were *Anabaenopsis elenkinii* and *Raphidopsis curvata.* The latter species is commonly found in reservoirs used as a source of cooling water for power plants. *A. elenkinii* was at greater than a bloom density on August 24th 1999. *Raphidiopsis* reached bloom densities at Site 1 in July and August in 1999 and site 2 in July and August . This blue-green reached the highest density seen in any year on August 24th 1999 at Site 3. Another blue-green that tolerates high water temperatures, *Schizothrix calcicola*, was present at all sites on all dates in 1999. It reached bloom densities in 1999 on May 3rd at Sites 2 and 3, on June 7th at Site 1 and 2, on July 6th at Sites 1, 2 and 3, on August 24th at Sites 1, 2, and 3 and October 21st at Site 1, 2 and 3. *Schizothrix* characteristically forms extensive mats on the bottom of the shallow areas of a lake. Air bubbles form from photosynthesis conducted by this blue-green and the mats detach from the bottom to become floating masses in the water column. With agitation from the wind or currents, these masses break into individual filaments, which are then seen and counted, in the samples.

Euglenoids (Phylum Eugenophyta) were more numerous on nearly every date at each site in 1999. Their highest density at Site 1 and 2 was on May 3rd 1999. At Site 3, they were at their highest density on June 7th. Euglenoids do well in lakes with extensive shallow, high water temperatures and high concentrations of organic chemicals.

Dinoflagellates (Phylum Pyrrhophyta) were not major contributors to total phytoplankton production at any of the three sites. *Ceratium hirundinella* and *Glenodinium gymnodinium* appeared in samples in 1999. They had not been seen in Governor Bond Lake in previous studies.

In summary Governor Bond Lake remained eutrophic in 1999. Water quality appeared worse in 1999 than it was in 1993. This conclusion is based on observations of the diatom flora, the appearance of green algae indicative of eutrophic waters, the increase in bloom densities of indicator blue-green taxa on more dates, the increase in numbers of blue-green indicative of higher water temperatures, the increase in the number of taxa of euglenoids and the overall presence of higher total densities of the group and the appearance of the dinoflagellate, *Ceratium hirundinella.* More specifically, the absence of the diatom *Fragilaria crotonensis* in August and October 1999 was of concern. The appearance of more numbers of *Nitxchia spp.*was involved in coming to a portion of this conclusion regarding water quality. The presence of more green algal taxa in 1999 than were seen in 1993 supported the conclusion. The fact that *Anabaena spiroides var. crassa* bloomed on more dates in 1999 than in 1993 lent further support to this conclusion. Higher concentrations of *Raphidiopsis* in 1999 than in 1993 were of concern. The presence of more eugenoid taxa in higher total population densities was the final indication of a turn to an even more eutrophic condition.

It should be noted, however, that if lake management practices were changed by the addition of a destratifier, reduction in the input of organic materials and an improvement in the quality of runoff reaching the lake, the changes noted above may have occurred as well. In some cases, organisms have been inhibited by high concentrations of organic materials and when these chemicals are reduced in concentration, the algal flora responds by the appearance of new taxa and by an increase in densities of taxa that were present before the management practices changed.

Table 17 Algae Genera Cell Density and Cell Volumes ROP-1

ROP-1			
Date	**Phylum**	**No./ml**	**Volume**
5/3/99	Bacillariophyta	535.716	771309
	Chlorophyta	1190.480	966713
	Chrysophyta	0	0
	Cryptophyta	5044.659	2288016.2
	Cyanophyta	4151.799	1906122.0
	Euglenophyta	491.073	1284972.7
	Pyrrhophyta	14.881	41759.1
	Total	11428.608	7258892.0
	Arthropoda	0	0
	Protozoa	14.881	140250.4
	Rotatoria	14.881	349748.1
	Total	29.762	489998.5
6/7/99	Bacillariophyta	654.764	606461.7
	Chlorophyta	2366.079	7335020.1
	Chrysophyta	0	0
	Cryptophyta	639.883	986885.6
	Cyanophyta	7410.738	7904385.3
	Euglenophyta	267.858	322737.7
	Pyrrhophyta	0	0
	Total	11339.322	17155490.4
	Arthropoda	14.881	143171870.0
	Protozoa	59.524	431465.6
	Rotatoria	0	0
	Total	74.405	143603335.6
7/6/99	Bacillariophyta	342.263	296383.4
	Chlorophyta	1934.530	3622126.2
	Chrysophyta	0	0
	Cryptophyta	252.977	208923.3
	Cyanophyta	22053.642	268927.8
	Euglenophyta	59.524	163969.2
	Pyrrhophyta	0	0
	Total	24642.936	6990329.9
	Arthropoda	0	0
	Protozoa	59.524	2613137.7
	Rotatoria	0	0
	Total	59.524	26131371.7
8/24/99	Bacillariophyta	2812.509	2011650.7
	Chlorophyta	2514.889	3800413.9
	Chrysophyta	0	0
	Cryptophyta	937.503	1271048.6
	Cyanophyta	23988.172	22724230.2
	Euglenophyta	193.453	192768.4
	Pyrrhophyta	29.762	83518.1
	Total	30476.288	30083629.9
	Arthropoda	0	0
	Protozoa	29.762	208914.3
	Rotatoria	0	0
	Total	29.762	208914.3
10/21/99	Bacillariophyta	773.812	257114.0
	Chlorophyta	1875.006	3477375.9
	Chrysophyta	14.881	26297.7
	Cryptophyta	491.073	587314.4
	Cyanophyta	12366.11	6068196.3
	Euglenophyta	29.762	89836.6
	Pyrrhophyta	0	0
	Total	15550.645	10506134.9
	Arthropoda	14.881	143171870.0
	Protozoa	0	0
	Rotatoria	14.881	1402500.0
	Total	29.762	144574370.0

Table 18 Algae Genera Cell Density and Cell Volumes ROP-2

ROP-2			
Date	**Phylum**	**No./ml**	**Volume**
5/3/99	Bacillariophyta	892.860	1274385.1
	Chlorophyta	2306.555	2493372.8
	Chrysophyta	0	0
	Cryptophyta	26215.203	8121607.7
	Cyanophyta	4181.560	1871037.0
	Euglenophyta	1071.432	3071343.2
	Pyrrhophyta	0	0
	Total	34667.610	16831745.8
	Arthropoda	0	0
	Protozoa	74.405	509381.1
	Rotatoria	0	0
	Total	74.405	509381.1
6/7/99	Bacillariophyta	714.288	589324.8
	Chlorophyta	3377.983	4422751.9
	Chrysophyta	0	0
	Cryptophyta	1904.768	2718141.1
	Cyanophyta	7053.594	11682068.4
	Euglenophyta	520.835	5303222.4
	Pyrrhophyta	0	0
	Total	13571.468	24715508.6
	Arthropoda	0	0
	Protozoa	74.405	504509.0
	Rotatoria	74.405	1748740.7
	Total	148.810	2253249.7
7/6/99	Bacillariophyta	342.263	193606.2
	Chlorophyta	2991.081	3999392.1
	Chrysophyta	14.881	2324.4
	Cryptophyta	967.269	1893407.8
	Cyanophyta	21473.283	12193077.4
	Euglenophyta	476.192	2514316.1
	Pyrrhophyta	104.167	12082694.8
	Total	26369.136	32878818.8
	Arthropoda	0	0
	Protozoa	119.048	4607812.2
	Rotatoria	0	0
	Total	119.048	4607812.2
8/23/99	Bacillariophyta	2842.271	2127819.2
	Chlorophyta	31384.534	6108672.6
	Chrysophyta	14.881	26297.7
	Cryptophyta	2708.342	5308408.3
	Cyanophyta	27723.303	27285046.9
	Euglenophyta	595.240	3986125.7
	Pyrrhophyta	74.405	208795.3
	Total	37142.976	45051165.7
	Arthropoda	0	0
	Protozoa	104.167	730349.0
	Rotatoria	0	0
	Total	104.167	730349.0
10/21/99	Bacillariophyta	848.217	450464.0
	Chlorophyta	2767.866	6177656.5
	Chrysophyta	0	0
	Cryptophyta	342.263	496730.7
	Cyanophyta	14628.023	7199454.5
	Euglenophyta	44.643	32839.4
	Pyrrhophyta	0	0
	Total	18631.012	14377145.3
	Arthropoda	0	0
	Protozoa	14.881	1301694.6
	Rotatoria	0	0
	Total	14.881	1301694.6

Table 19 Algae Genera Cell Density and Cell Volumes ROP-3

ROP-3			
Date	**Phylum**	**No./ml**	**Volume**
5/3/99	Bacillariophyta	1889.887	1804587.6
	Chlorophyta	2425.063	3079750.9
	Chrysophyta	29.762	52595.4
	Cryptophyta	357.144	498922.7
	Cyanophyta	10461.343	3491846.3
	Euglenophyta	119.048	493811.0
	Pyrrhophyta	0	0
	Total	15282.787	9421513.9
	Arthropoda	14.881	98430663.0
	Protozoa	29.762	149137.3
	Rotatoria	0	0
	Total	44.643	98579800.3
6/7/99	Bacillariophyta	1785.720	1575372.5
	Chlorophyta	2202.388	2139877.3
	Chrysophyta	14.881	26297.7
	Cryptophyta	2872.033	5332520.0
	Cyanophyta	6651.807	4979434.0
	Euglenophyta	1383.933	3664981.7
	Pyrrhophyta	0	0
	Total	14910.762	17718483.2
	Arthropoda	0	0
	Gastrotricha	133.929	14818292.0
	Protozoa	133.929	1244721.1
	Rotatoria	193.453	4546725.8
	Total	461.311	20609738.9
7/21/99	Bacillariophyta	1309.528	736590.1
	Chlorophyta	3065.486	4684763.3
	Chrysophyta	0	0
	Cryptophyta	148.810	296575.3
	Cyanophyta	19866.135	22704173.5
	Euglenophyta	267.858	1547373.9
	Pyrrhophyta	14.881	41759.1
	Total	24672.698	30011235.2
	Arthropoda	0	0
	Protozoa	14.881	334069.5
	Rotatoria	29.762	2921873.9
	Total	44.643	3255943.4
8/23/99	Bacillariophyta	3258.741	1895444.9
	Chlorophyta	2351.198	3917747.6
	Chrysophyta	0	0
	Cryptophyta	282.739	281971.2
	Cyanophyta	32381.056	17572691.4
	Euglenophyta	119.048	197924.8
	Pyrrhophyta	0	0
	Total	38392.782	23865779.9
	Arthropoda	0	0
	Gastrotricha	14.881	547851.4
	Protozoa	89.286	1611903.9
	Rotatoria	14.881	349748.1
	Total	119.048	2509503.4
10/21/99	Bacillariophyta	2172.626	1346388.2
	Chlorophyta	3065.486	7281910.1
	Chrysophyta	14.881	26297.7
	Cryptophyta	967.265	1309764.5
	Cyanophyta	14732.190	6655177.5
	Euglenophyta	297.620	1573948.4
	Pyrrhophyta	0	0
	Total	21250.068	18193486.4
	Arthropoda	0	0
	Protozoa	0	0
	Rotatoria	0	0
	Total	0	0

Chlorophyll a

Chlorophyll a is a pigment found in all green plants and is necessary for photosynthesis. The amount of chlorophyll a found in the water is used as a measure of the amount of algae present in the water. Chlorophyll is the key element needed for photosynthesis. It is the basic ingredient for all life in a lake. Chlorophyll a concentrations are used as a variable in determining the degree of eutrophication and trophic status of a lake. According to the Illinois 305(b) report, chlorophyll a samples in lakes which fall between 7.5µg/L and 55µg/L can be classified as eutrophic and concentrations higher than 55µg/L can be classified as hypereutrophic. The 305(b) guidelines for listing of overall use support impairment in lakes uses the ranges between 20-92µg/L as slight, ranges between 92-426µg/L as moderate and anything higher than 426µg/L as High. Chlorophyll a samples were collected at seven sites by ZIES staff as part of the Illinois Volunteer Lake Monitoring Program (VLMP) and analyzed at IEPA laboratories. All sample values were corrected for pheophytin a. The corrected chlorophyll a values equal only the living chlorophyll a.

Chlorophyll a peaked at ROP-1 on July 17th at 102.51 µg/L, ROP-2 September 27th at 145.64 µg/L, ROP-3 May 25th at 117.48 µg/L , ROP-4 September 27th at 139.86µg/L, ROP-5 October 16th at 148.76 µg/L, ROP-6 October 16th at 173.06 µg/L and ROP-7 May 7th at192.24 µg/L.

Figure 39

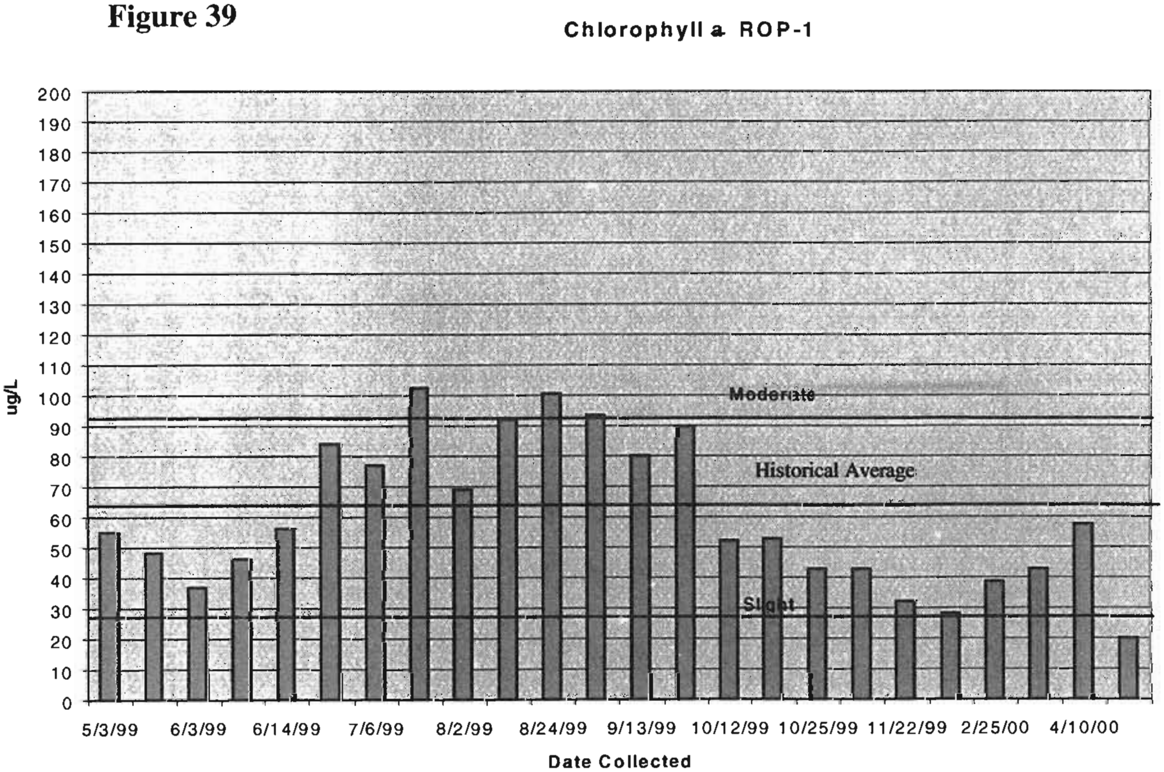


Figure 40

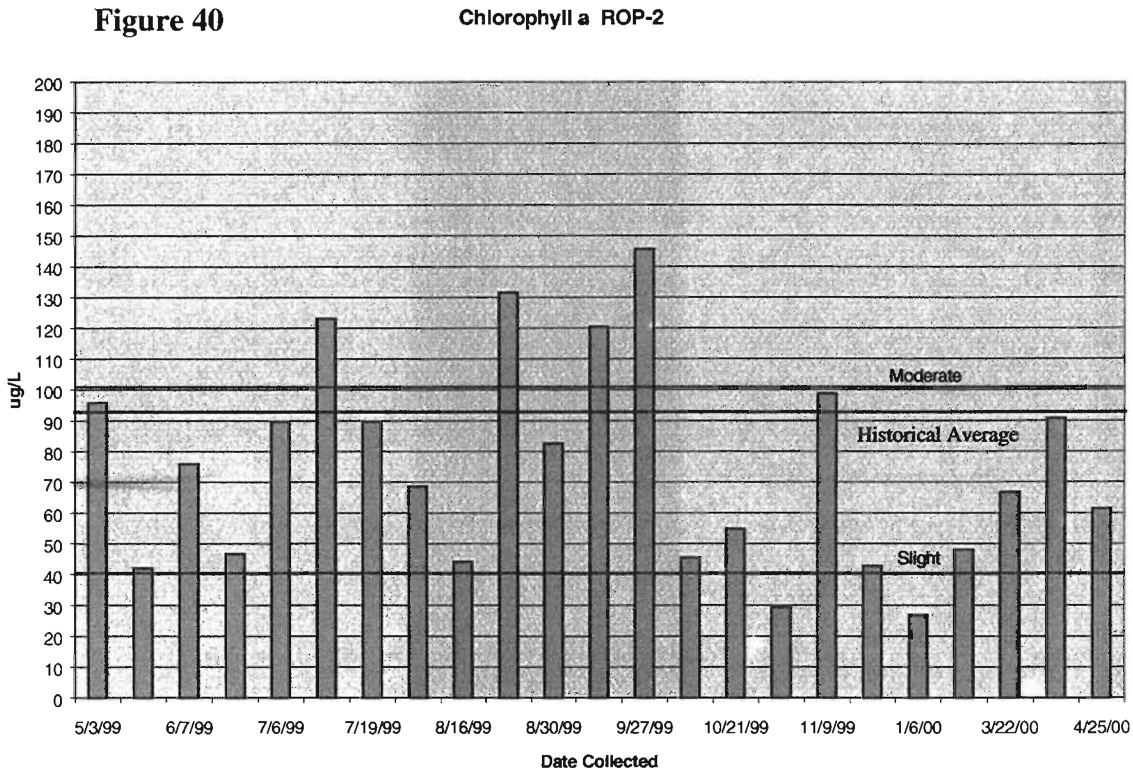


Figure 41

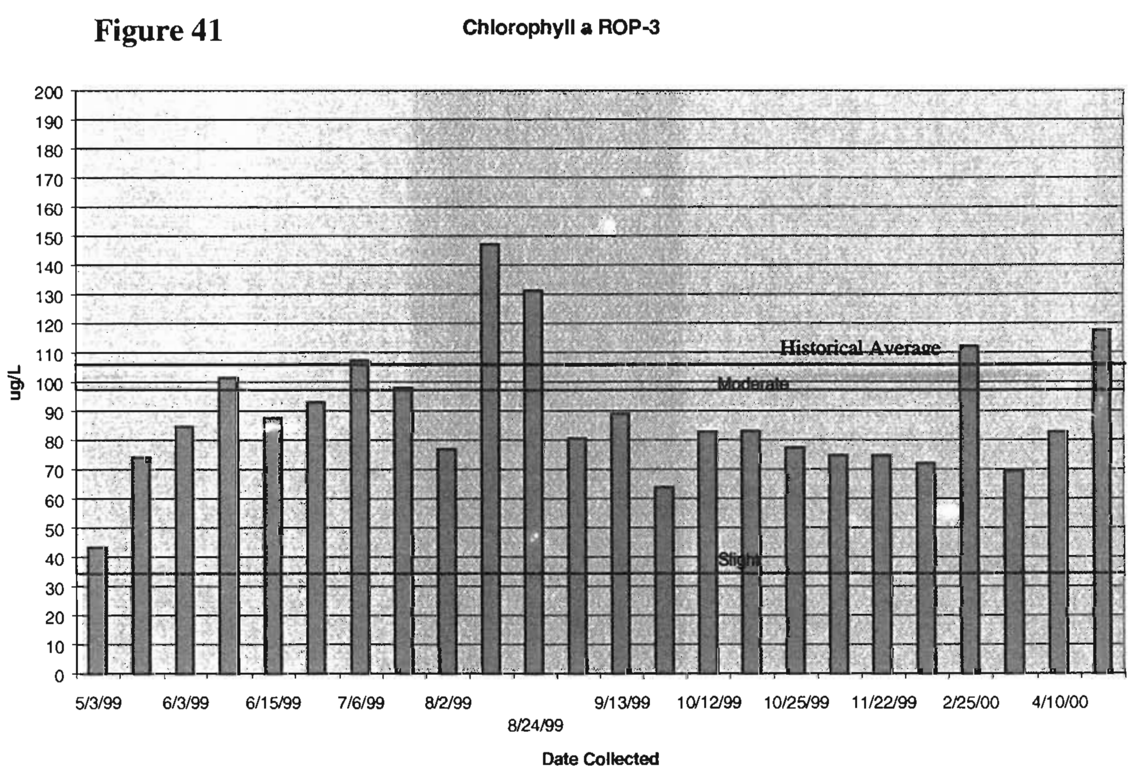


Figure 42

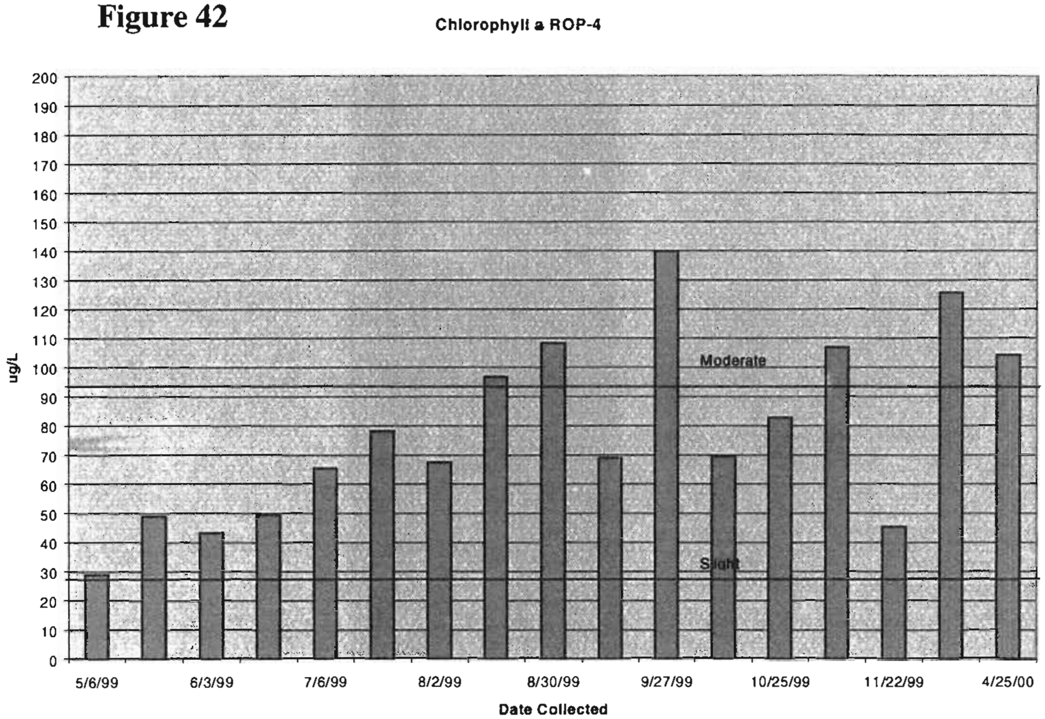


Figure 43

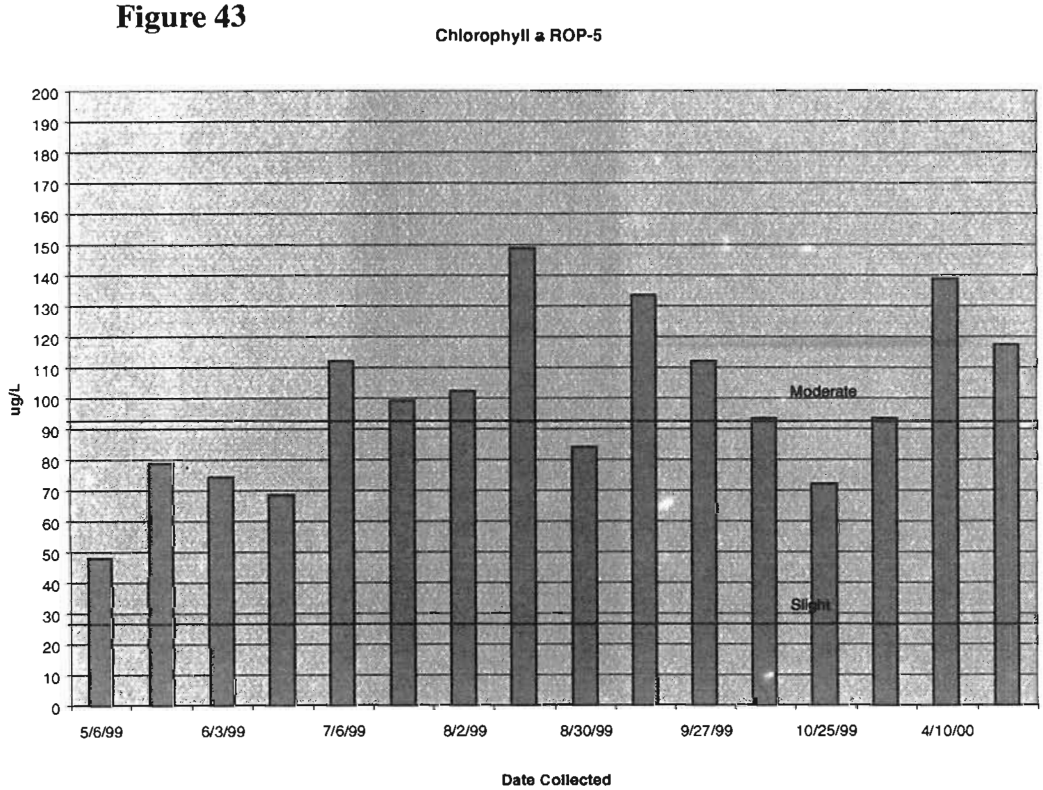


Figure 44

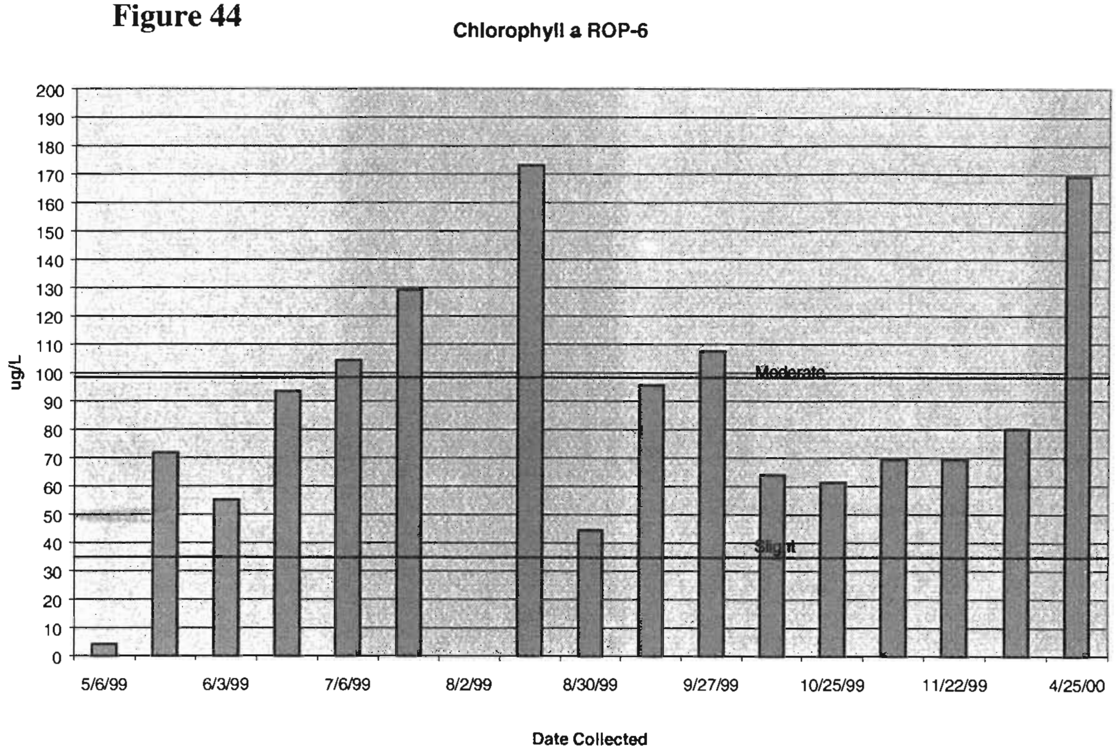
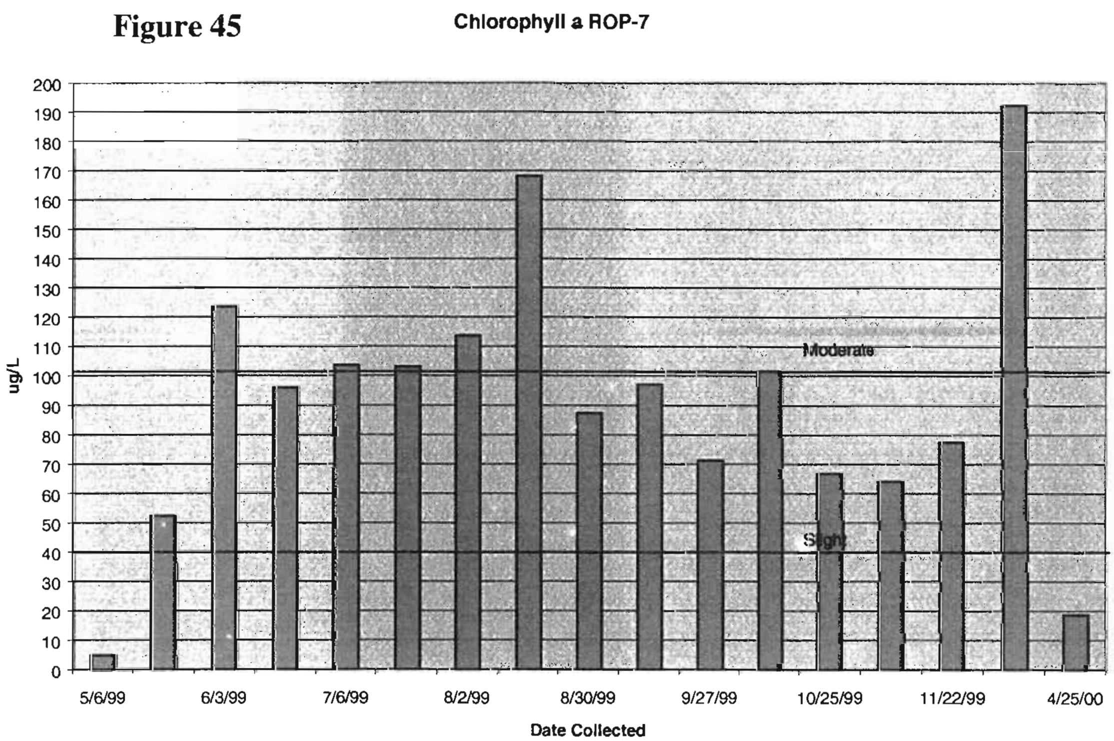


Figure 45



Fish

Fisheries are a major concern for Governor Bond Lake. Fishing is one of the main recreational activities that take place on the lake. Governor Bond Lake is known for its good fishing. Sports fishers come from a large area for the bass, bluegill, crappie and catfish. Maintaining quality-fishing stocks is an important component for overall lake management. The Illinois Department of Natural Resources has done a very good job managing the fisheries for Governor Bond Lake. Charlie Marbut is the IDNR Fisheries Manager. Water quality can have a direct impact on the fish population in the lake. Concerns that were mentioned in the 1999 Governor Bond Lake Resource Plan included highly turbid waters, algae blooms, low dissolved oxygen levels, lack of aquatic vegetation, sedimentation depleting spawning grounds and the overall turbidity and sedimentation in the upper half of the lake resulting in a shift from game fish to rough fish (GBLRP 1999).

As part of the Clean Lakes requirement Charlie Marbut of the ILDNR conducted a fish flesh analysis. Fish were sampled using Electro fishing and gill nets. All samples were within the regulatory limits for the specific compounds analyzed (Table 22). The IDNR in cooperation with the City sets fishing regulations including number and size limits in addition to developing a lake management plan which involves conducting regular fish surveys.

The current size and limit regulations are found in Table 20.

Table 20 Fish Size and Limit Regulations

Fish	Limit	Size
Bass	3	15 inches
Crappie	25	None
Channel Catfish	6	None

The 2000 survey (IDNR LMP 2000), which includes data through 1999, is as follows:

Bluegill

Angling for bluegill was excellent from 1990 to 1994. The quality and condition of the fish were excellent. The 96 survey indicates a decline in quality and numbers of large bluegill. The 1997 survey indicates an improvement in the bluegill fishery, and the 1999 survey depicted the best bluegill population this lake has ever had. 697 fish per hour were collected in 1999, and 55% were larger than 6.0 inches, but only 2% were larger than 7.0 inches. Flesh condition (Wr) was good at 104. Bluegill fishing should continue to improve in 2000.

Channel Catfish

A total of 64 catfish were collected, ranging in length from 8 to 30 inches. 44% of the channel catfish collected were between 13 and 17 inches, 47% were 18 inches or larger. Average flesh condition (Wr) was good at 91. However channel catfish less than 18.0

inches in length had an average Wr of 87, compared to 96 for fish 18.0 inches and larger. Due to the increase in numbers of channel catfish, and no fin clips were collected, the regulations on troutline and jugs will be removed. 1999 was the last year NVCC will be stocked from the state hatchery. The City of Greenville will continue stocking NVCC by purchasing fish from a private dealer.

Largemouth Bass

The largemouth bass population has been on a gradual increase since 1986, and the 1999 survey indicates continued improvement. The CPUE objective (68/hour) was exceeded in 99 as 86 fish/hr were collected. The numbers of bass collected less than 8.0 inches was good indicating good reproduction. 32% were between 8.0 and 11.9 inches, 17% were 12.0-14.9 inches, and 36% were equal to or larger than 15.0 inches. From the anglers perspective, the current bass population is the best it has been in many years, with over one-third of the bass collected in 1999 being 15.0 inches or larger. The city continues to purchase 6-8" bass annually from a private dealer.

White Crappie

The crappie population peaked in 1998 as anglers harvested large numbers of crappie larger than 9 inches. A 25 per day limit was submitted in 1999 and went into affect on April 1, 2000. A city ordinance of 25 fish per day was enforced during 1999. Flesh condition (Wr) was good at 96. 44% of the crappie collected were 9.0 inches or larger. 2000 should provide good angling for crappie and with good numbers of fish 6 to 7 inches, the population should remain stable for several years.

Black Crappie

A total of 73 fish were collected. The peak of the population was 6.0 to 8.0 inches (86%). Only 5% were 9.0 inches or larger. Flesh condition (Wr) was good at 91.

Gizzard Shad

This species remains abundant and available for the predator fish. CPUE was 2061 fish per hour, the objective is 150/hr. 33% of the shad collected were smaller than 4.0 inches. 60% were between 4.0 and 5.9 inches, and 1% were larger than 8.0 inches. The abundance of shad smaller than 4.0 inches provides excellent forage for the mid size and smaller predators. Flesh condition (Wr) was fair at 88. The majority of the shad populations are available for forage for the predator fishes. The heavy algae blooms experienced in the lake prior to 1998 have seemed to diminish. Wr values have historically been less than desired for shad in this lake.

Table 21 **IDNR Governor Bond Lake Management Plan Status Report**

Fisheries Manager: Charlie Marbut

Type of Fish		LMP Goals	1996	1997	1999
Bluegill	PSD	20-40	24	38	57
	RSD-7	10-15	0	8	10
	Wr	90-110	83	90	104
	CPUE (#/Hr)		230	711	697
Large mouth bass	PSD	40-70	62	57	68
	RSD-18	5	4	0	6
	8.0-11.9	30	48	45	38
	12-14.9	32	24	36	20
	> 15.0	38	27	19	42
	Wr	90-110	94	93	99
	CPUE (#/Hr)	68	42	154	86
	< 8.0	18	3	8	13
	8-11.9	20	19	38	28
	12-14.9	18	10	32	15
	> 15.0	12	11	16	30
White Crappie	PSD	40-60	92	75	59
	RSD- <9.0	50	72	48	57
	9.0-10.9	40	48	33	38
	> 11.0	10	14	11	6
	Wr	90-110	96	94	96
	CPUE (#/Hr)		40	67	39
Gizzard Shad	PSD	30-60	0	3	1
	Wr	90-110	86	78	88
	CPUE (#/Hr)	150	189	959	2061

Table 22 Fish Tissue Samples from Governor Bond Lake

Collected by: DNR	C. MARBUT	ELECTRO FISHING & GILL NETS				
Date: 9/2/1999						
SPECIES		LARGEMOUTH BASS	CARP SMALL	CARP LARGE	CHANNEL CATFISH SMALL	CHANNEL CATFISH LARGE
# of Fish		5	5	5	3	5
ALDRIN		.01K	.01K	.01K	.01K	.01K
TOTAL CHLORDANE		.02K	.02K	.02K	0.03	0.12
TOTAL DDT AND ANALOGS		.01K	.01K	.01K	.01K	.01K
DIELDRIN		.01K	.01K	.01K	.01K	0.03
TOTAL PCBS		0.1K	0.1K	0.1K	0.1K	0.1K
HEPTACHLOR		.01K	.01K	.01K	.01K	.01K
HEPTACHLOR EPOXIDE		.01K	.01K	.01K	.01K	.01K
TOXAPHENE		1.0K	1.0K	1.0K	1.0K	1.0K
METHOXYCHLOR		.05K	.05K	.05K	.05K	.05K
HEXACHLOROBENZENE		.01K	.01K	.01K	.01K	.01K
GAMMA-BHC (LINDANE)		.01K	.01K	.01K	.01K	.01K
ALPHA-BHC		.01K	.01K	.01K	.01K	.01K
MIREX		.01K	.01K	.01K	.01K	.01K
ENDRIN		.01K	.01K	.01K	.01K	.01K
LIPID CONTENT %		1	1.6	0.93	1.5	5.7
# OF INDIV. IN SAMPLE		5	5	5	3	5
SAMPLE WEIGHT LBS		2.44A	2.76A	3.70A	3.08A	8.24A
FISH SPECIES (NUM)		31	12	12	16	16
FISH SPECIES-ALPHA		LMB	C	C	CHC	CHC
ANATOMY (NUMERIC)		86	86	86	86	86
ANALYZING AGENCY		1	1	1	1	1
LENGTH OF FISH INCH		16.5A	17.9A	20.2A	21.4A	27.4A
	ALL CHEMICALS IN UG/G		NOTE: K = LESS THAN VALUE			

Macrophyte Survey

Macrophytes are an important indicator of the quality of a lake. The IEPA uses macrophytes as one factor in determining aquatic life and recreational use impairment indices (ALI, RUI). If there is an overabundance of macrophytes, lake usage can be impaired. Factors such as water depth, turbidity and climate influence macrophyte growth. The amount of aquatic or semi-aquatic macrophytes located on Governor Bond Lake would be considered slight to minimal. This is most likely a result of high turbidity and steep banks. According to IEPA water quality reports the macrophytes on the lake would result in a minimal impact rating for both the ALI and RUI. It therefore can be said that macrophytes on the lake do not significantly contribute to its overall impairment. It is important, however, to understand the types and locations of macrophytes. They can play many important roles including providing fish habitat, sediment stops, oxygen source and pollution filters.

ZIES did an extensive macrophyte survey during July and August 2000. This survey consisted of collecting and mapping macrophytes throughout the lake. Nine areas with significant macrophyte growth were identified. These areas were labeled A-I. Plants in these areas were identified by both their scientific and common name (Steyermark 1999). The density of each type of plant was identified as sparse, moderate or dense. This information was used to generate a map and table (Figure 46 and Table 23).

The water level on Governor Bond Lake between July and August averaged three inches above pool. The average secchi transparency at site ROP-1 was 20.5 inches, at site ROP-2 was 19 inches, and at site ROP-3 was 10 inches. The majority of Governor Bond Lake has very steep banks due to the fact that it is a man-made reservoir. The turbidity of the water blocks light and limits the depth at which plants can grow. However, several significant areas of aquatic macrophytes were discovered. The dominant species around the majority of the lake was Common Water Willow (*Justicia americana*). It was found in the majority of the main lake body, along the shoreline and in several of the coves. There were, however, significant wetland areas in the arms of the lake with high levels of sedimentation. The locations of the largest number of aquatics were found in these areas near the feeder streams: The southeastern tips of the lake near the nature preserve (G,H,I), Kingsbury Branch (E) and Dry Branch (D). In these areas, more thorough surveys were done because of the larger variety of species. The area near the nature preserve (G,H,I) was dominated by Reed Canary Grass (*Phalaris arundinacea*) with some areas of Coontail (*Ceratophyllum demersum*) and Duckweed (*Lemna minor*). The other side of Woburn Road (Kingsbury Branch, E) is an area of extremely shallow water that was only accessible when the lake was at high pool. This area was dominated by Common Cattail (*Typha latifolia*) and reed canary grass (*Phalaris arundianaceae*) but also had several other species including Coontail (*Ceratophyllum demersum*) and Duckweed (*Lemna minor*). The Dry Branch site (D) also had extremely shallow water levels and a large amount of silt. There was an island just beyond the stream that was dominated by willow trees and would flood during high pool. Common Water Willow (*Justicia americana*) dominated the periphery of this island. The Dry Branch area was dominated by Reed Canary Grass (*Phalaris arundinaceae*). Other species in this area included Common Cattail (*Typha latifolia*), Common Arrowhead (*Sagitaria latifolia*), Lesser Duckweed (*Lemna minor*), Floating Primrose Willow (*Jussiea repens*), Rose Mallow (*Hibiscus lasiocarpus*) and False Nettle (*Boehmeria cylindrica*)

The Macrophyte survey was completed in August. The majority of plants were pressed and cataloged as a reference for future studies.

Table 23 Aquatic and Semi-Aquatic Flora Found at Governor Bond Lake

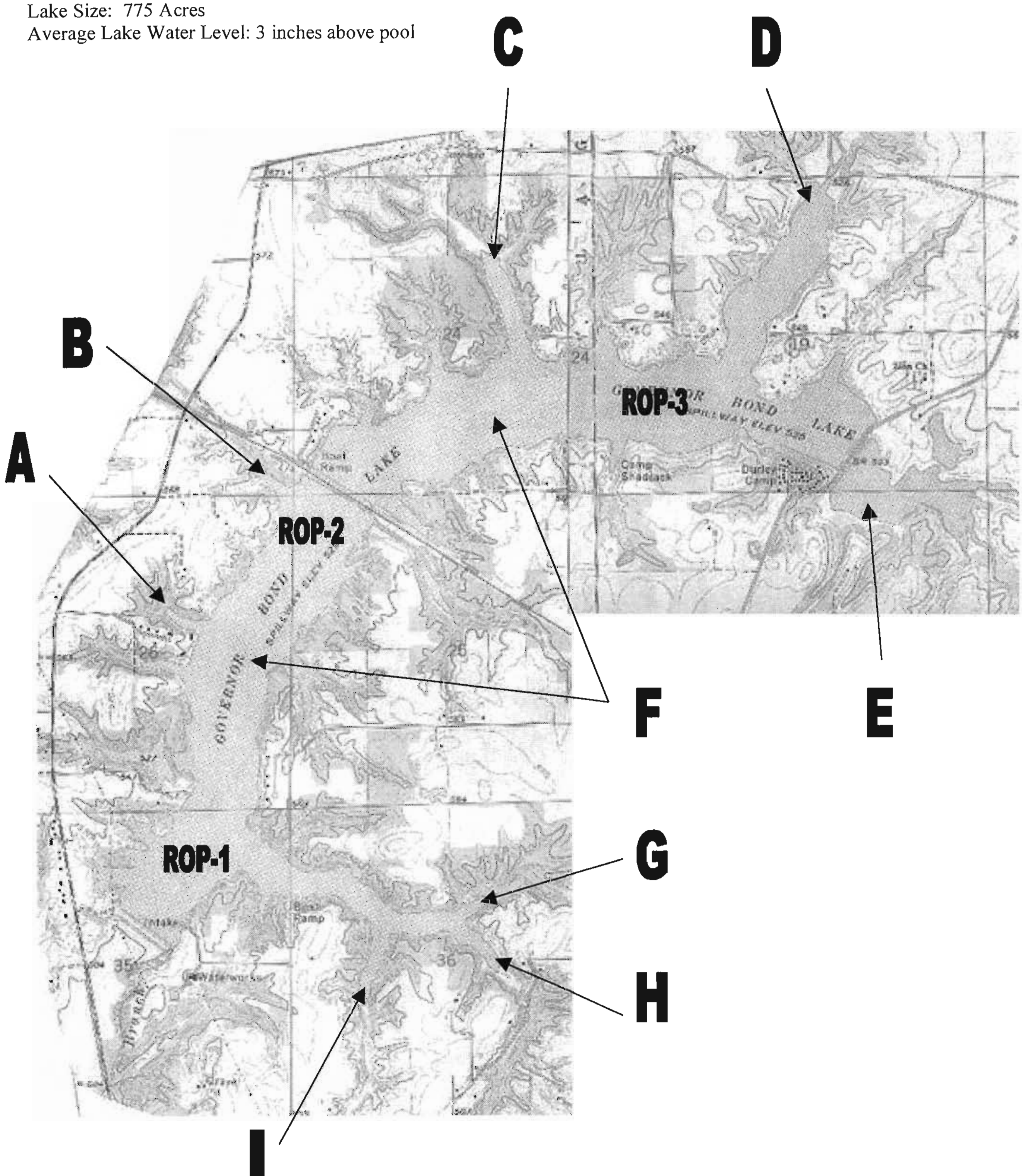
Scientific Name	Common Name	Location(s)	Density
Alisma subcordatum	Southern Water Plantain	D	sparse
Asclepias incarnata	Swamp Milkweed	D,G,H	sparse
Asclepias syriaca	Common Milkweed	G,	sparse
Bacopa rotundifolia	Water Hyssop	D,E,G	sparse
Boehmeria cylindrica	False Nettle	D,E,H	sparse - moderate
Carex decomposita	NA	D	sparse
Carex lurida	NA	G,H	sparse
Ceratophyllum demersum	Coontail	E,H,I	sparse
Cinna arundinacea	Wood Reed Grass	E	dense
Convolulus sepium	Wild Morning Glory	G	sparse
Cuscuta cuspidata	Dodder	A	moderate
Cynanchum laeve	Angle-Pod	E	sparse
Cyperus esculentus	Yellow Nutgrass	A	sparse
Eliocharis erythropoda	NA	E,G	moderate
Elymus Virginica	Virginia Wild Rye	E	sparse
Eupatorium coelestinum	Wild Ageratum	G	sparse
Hibiscus lasiocarpus	Rose Mallow	D, E	moderate
Impatiens capensis	Spotted Touch-me-not	E,G,H	moderate
Iris virginica L. var. shrevei	Southern Blue Flag	D	sparse
Jussiaea repens	Floating Primrose Willow	D,H	dense
Justicia americana	Common Water Willow	A-I	moderate - dense
Lactuca floridana	NA	E	sparse
Leersia spp.	Cut Grass	A	dense
Lemna minor	Lesser Duckweed	D,E,H,I	sparse - moderate
Lippia lanceolata	Fog fruit	A	sparse
Lobelia cardinalis	Cardinal Flower	D	sparse
Lycopus americanus	American Bugle Weed	H	sparse
Mimulus alatus	Monkey Flower	D,G	sparse
Phalaris arundinaceae	Reed Canary Grass	D,E,G,H,I	dense
Phragmites australis	Common Reed	B	dense
Polygonum coccineum	Shoestring Smartweed	D	sparse
Polygonum hydropoperoides	Wild Water Pepper	E	sparse
Polygonum lapathifolium	NA	D	sparse
Polygonum punctatum	Water Smartweed	G	sparse
Potamogeton spp.	Pondweed	E	sparse
Rudbeckia laciniata	Wild Goldenglow	D,E	sparse
Sagitaria latifolia	Common Arrowhead	D,E,H	moderate
Schoenoplectus tabernaemontani	Great Bulrush	D,E,G,H	sparse

Table 23 Continued

Scientific Name	Common Name	Location(s)	Density
Teucrium canadense	Wood Sage	E	sparse
Typha angustifolia	Narrow-leaved Catail	G,H	moderate
Typha latifolia	Common Catail	A,D,E,G,H	dense
Verbena hastata	Blue Vervain	D	sparse
Veronia noveboracensis	Ironweed	G	sparse

Figure 46 Macrophyte Survey Governor Bond Lake

Lake Name: Governor Bond Lake
County Name: Bond County
Dates Surveyed: July and August 2000
Sampler's Names: Eric Ahern and Joe Niemeth
Lake Size: 775 Acres
Average Lake Water Level: 3 inches above pool



Bacteriology

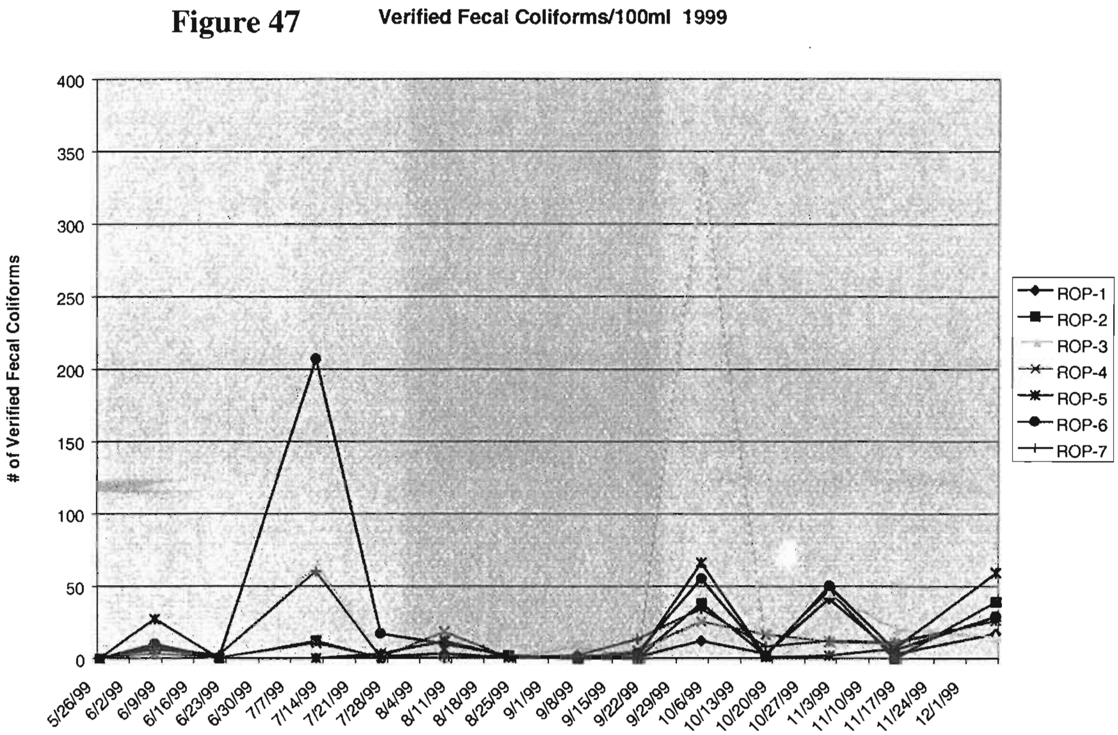
Bacteriological samples were taken to check for coliforms and streptococcus bacteria (Figures 47 and 48). These parameters are indicators of possible human and animal waste contamination. It is important for drinking and recreational waters to be free from pathogenic organisms. High levels of coliforms and streptococcus are often a result of leaching of septic systems, feedlot runoff, large waterfowl populations, cattle grazing and run-off from wildlife areas. The Illinois standards for fecal coliforms state that they shall not exceed a geometric mean of 200 per 100 ml nor shall more than 10% of at least five samples during any 30-day period exceed 400 per 100 ml in protected waters. Protected waters are areas that support primary contact or flow through or are adjacent to parks or residential areas (IPCB Part 302.209). The IEPA 305(b) water quality report sets a guideline of non-support for swimming when the geometric mean of all fecal coliforms samples is greater than or equal to 200 per100ml or 25% of all samples exceeds 400 per 100 ml. Testing for the presence of *Escherichi coli* and or fecal *Streptococcus* were also performed to more accurately determine fecal contamination. Both of these bacteria are found in the gastrointestinal tract of warm-blooded animals.

The bacteriological analyses of this project were conducted in accordance with Standard Methods for the Examination of Water and Wastewater (American Public Health Association, 1995) at Greenville College Laboratories. Samples were collected at all seven lake sites ROP-1 through ROP-7 by ZIES staff and Greenville College Students.

There were no dates throughout the year that the fecal coliforms exceeded 400 per 100 ml at any of the sites. There were several dates that the fecal coliforms were greater than 200 per 100ml. There were a few dates with more than average streptococcus counts. On most dates these corresponded with the high fecal coliform counts. The data is presented in the following graphs (Figures 47 and 48).

Bacteriological analyses of water from the streams after rain events indicated large amounts of fecal coliforms were entering the tributaries after rain events from all of the tributary sites.

Figure 47


Verified Fecal Coliforms/100ml 1999
# of Verified Fecal Coliforms
400
350
300
250
200
150
100
50
0
5/26/99
6/2/99
6/9/99
6/16/99
6/23/99
6/30/99
7/7/99
7/14/99
7/21/99
7/28/99
8/4/99
8/11/99
8/18/99
8/25/99
9/1/99
9/8/99
9/15/99
9/22/99
9/29/99
10/6/99
10/13/99
10/20/99
10/27/99
11/3/99
11/10/99
11/17/99
11/24/99
12/1/99
ROP-1
ROP-2
ROP-3
ROP-4
ROP-5
ROP-6
ROP-7

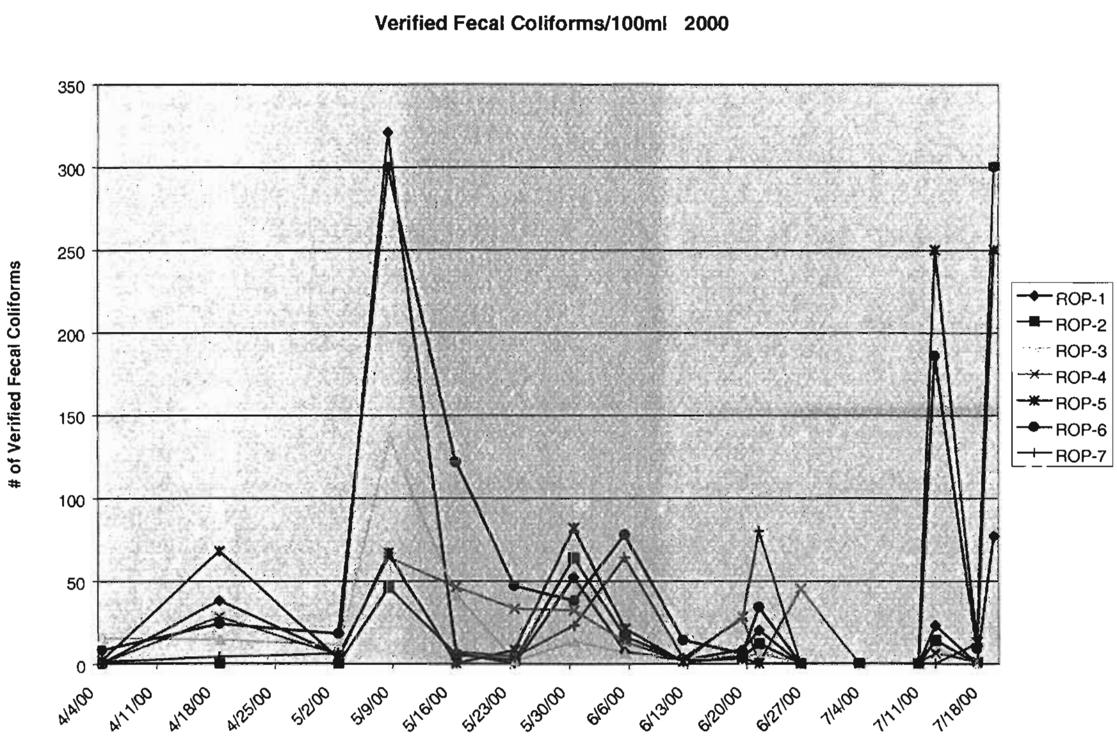
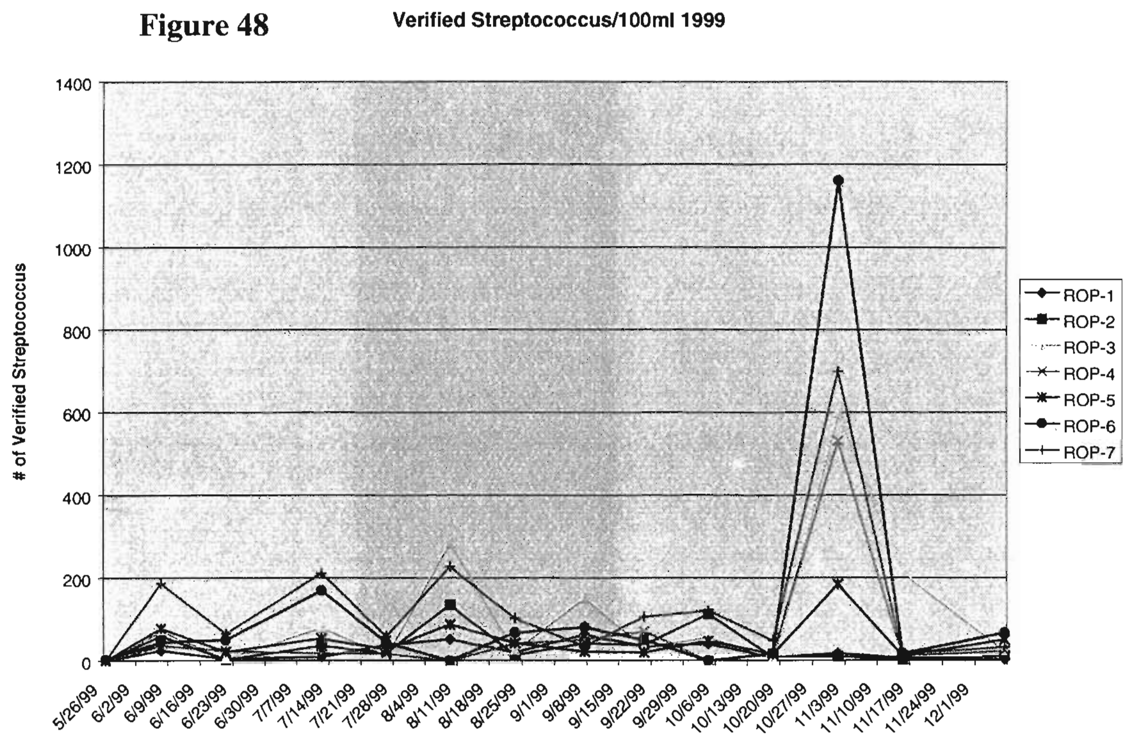
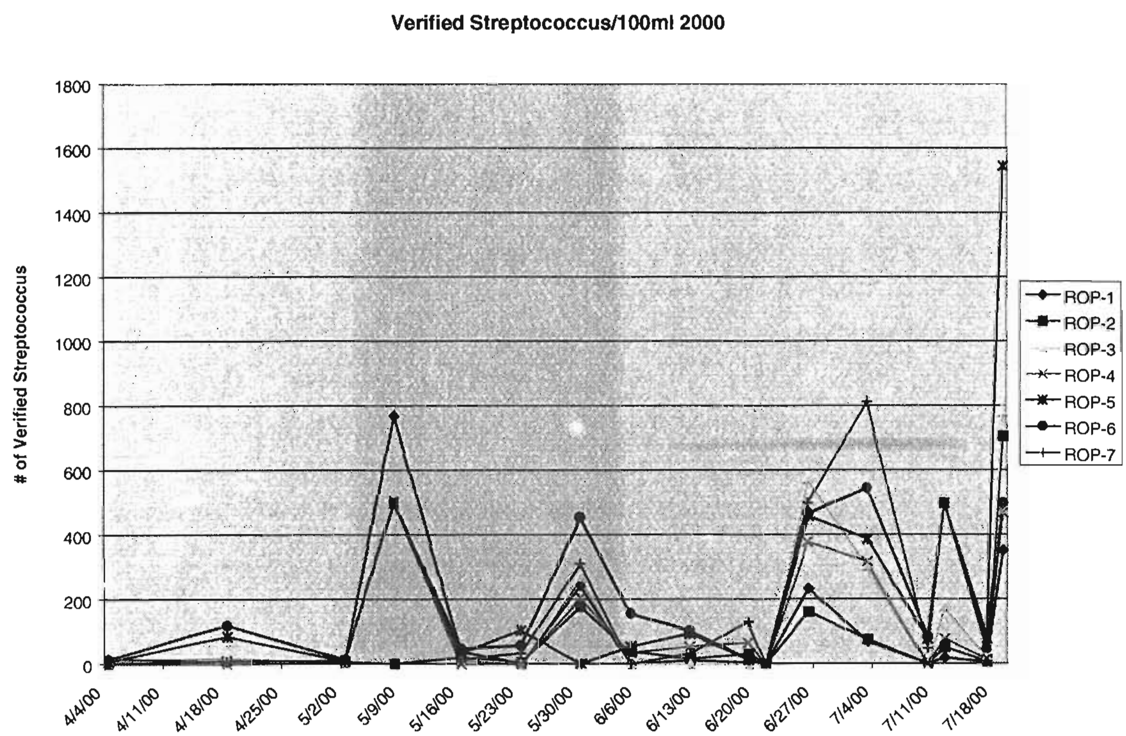

Verified Fecal Coliforms/100ml 2000
# of Verified Fecal Coliforms
350
300
250
200
150
100
50
0
4/4/00
4/11/00
4/18/00
4/25/00
5/2/00
5/9/00
5/16/00
5/23/00
5/30/00
6/6/00
6/13/00
6/20/00
6/27/00
7/4/00
7/11/00
7/18/00
ROP-1
ROP-2
ROP-3
ROP-4
ROP-5
ROP-6
ROP-7

Figure 48



Verified Streptococcus/100ml 1999
# of Verified Streptococcus
1400
1200
1000
800
600
400
200
0
5/26/99
6/2/99
6/9/99
6/16/99
6/23/99
6/30/99
7/7/99
7/14/99
7/21/99
7/28/99
8/4/99
8/11/99
8/18/99
8/25/99
9/1/99
9/8/99
9/15/99
9/22/99
9/29/99
10/6/99
10/13/99
10/20/99
10/27/99
11/3/99
11/10/99
11/17/99
11/24/99
12/1/99
ROP-1
ROP-2
ROP-3
ROP-4
ROP-5
ROP-6
ROP-7



Verified Streptococcus/100ml 2000
# of Verified Streptococcus
1800
1600
1400
1200
1000
800
600
400
200
0
4/4/00
4/11/00
4/18/00
4/25/00
5/2/00
5/9/00
5/16/00
5/23/00
5/30/00
6/6/00
6/13/00
6/20/00
6/27/00
7/4/00
7/11/00
7/18/00
ROP-1
ROP-2
ROP-3
ROP-4
ROP-5
ROP-6
ROP-7

Waterfowl and Bird Survey

To develop an understanding of the numbers and types of birds and waterfowl using the lake ZIES staff recorded bird observations while taking water samples throughout the lake. In addition to these direct observations, interviews with residents gave an idea about the number and types of birds using the lake. This information was used to compile a table of the types of birds that would be directly on or near the water (Table 23). Birds can contribute significant amount of pollution to a lake through fecal matter if they are found in large numbers throughout the year. Mallard ducks were most commonly found on the lake in large numbers during the fall and spring. Other birds observed in large numbers included Canada Goose and Double-Crested Cormorants. There were never large enough numbers of waterfowl observed to have a major impact in the water quality, although birds most likely play a small role in water pollution and nutrient loading to the lake. A graph was made with the largest number of birds seen on any given day (Figure 49). Daily nutrient loads where calculated using methodology described by Manny (Table 10) (Manny 1994).

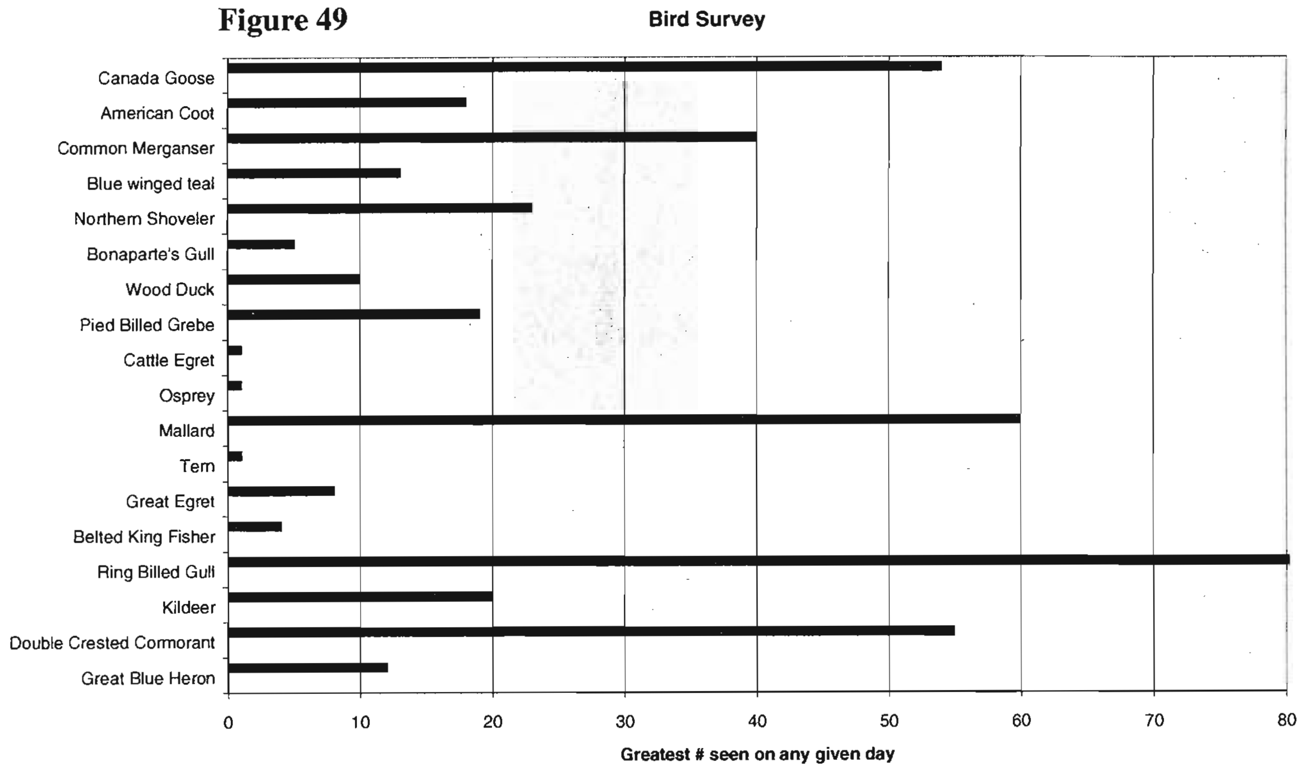
Endangered Birds in Illinois

According to the Natural Heritage Database there is a recorded siting of a Black Crowned Night Heron (*Nycticorax nycticorax*) that was spotted in the eastern end of the lake. This is an endangered bird in Illinois. During the bird survey there were no direct observations of this bird. It is, however, possible that it does exist but was not observed because it usually feeds at night. The habitat at the eastern end of the lake would be ideal for the bird and there are a number of Great Blue Herons with which *N. nycticorax* could be found nesting. Another endangered bird in Illinois is the Osprey (*Pandion haliaetus*), which was observed a few times at the southwestern end of the lake. There had been no previously recorded observations of this bird in Bond County. No nesting site was found but the bird was often seen on city property near the water treatment plant. This is a forested area that is not developed.

Table 24 Bird Count Estimates

Common Name	Scientific Name	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Canada Goose	*Branta canadensis*	0	0	0	0	0	0	0	54	0	10	0	0
Blue winged teal	*Anas discors*	0	0	0	0	0	0	0	0	0	0	0	13
Mallard	*Anas platyrhynchus*	4	0	2	2	2	50	60	52	0	60	50	0
Northern Shoveler	*Anas elypeata*	0	0	0	0	0	0	0	0	0	0	0	23
Wood Duck	*Aix sponsa*	0	0	0	0	0	1	0	0	0	0	0	0
American Coot	*Fulica amiricana*	6	6	0	0	0	25	9	0	0	0	5	18
Common Merganser	*Mergus merganser*	0	0	0	0	0	0	0	0	0	40	0	0
Cattle Egret	*Bubulcus ibis*	0	0	0	0	1	0	0	0	0	0	0	0
Great Blue Heron	*Ardea herodias*	12	12	10	10	10	12	11	7	0	0	8	10
Great Egret	*Casmerodius albus*	5	5	3	0	4	0	0	0	0	0	0	0
Bonaparte's Gull	*Larus philadelphia*	0	0	0	0	0	0	0	30	0	40	0	5
Caspian Tern	*Hydroprogne caspia*	0	0	0	0	0	0	0	0	0	0	0	0
Ring Billed Gull	*Larus delawarensis*	0	0	13	24	0	0	0	0	0	250	0	0
Double Crested Cormorant	*Phalacrocorax auritus*	6	10	9	25	25	55	13	0	0	0	0	10
Osprey	*Pandion haliaetus*	0	0	0	1	0	0	0	0	0	0	0	1

Figure 49



Bird Survey
Canada Goose
American Coot
Common Merganser
Blue winged teal
Northern Shoveler
Bonaparte's Gull
Wood Duck
Pied Billed Grebe
Cattle Egret
Osprey
Mallard
Tern
Great Egret
Belted King Fisher
Ring Billed Gull
Kildeer
Double Crested Cormorant
Great Blue Heron
0
10
20
30
40
50
60
70
80
Greatest # seen on any given day

ACKNOWLEDGEMENTS

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PART 2

FEASIBILITY STUDY

INTRODUCTION

This study has identified many causes of impairment for Governor Bond Lake. Restoration proposals will be directed at solving the most significant of these causes, including high sedimentation rates, excessive stream bank and shoreline erosion, high nutrient inputs from the watershed and from internal cycling, and excessive algal growth.

Recommended methods for restoring and enhancing lake water quality can be sorted into several different categories. Some structural restoration methods have been addressed in detail in the Governor Bond Lake - Preliminary Investigation Report, January 1998 (SWCD & NRCS for the Governor Bond Lake Planning Committee), a portion of which is included here in an abridged form. Many restoration methods have been described in the Governor Bond Lake Resource Plan - Action Items, July 1999 (Governor Bond Lake Planning Committee), which is attached as Appendix 1. A number of those recommendations are reiterated in the body of this report, but all of the restoration initiatives of that plan are included by reference, and will be pursued in accordance with the manner and timeline specified therein - that is, as funds and resources are available. Finally, the Total Maximum Daily Load program of the IEPA and USEPA has been issued in final draft form and contains additional details regarding the causes of impairment, restoration methods for improving lake conditions and projected water quality end points resulting from such restoration. This final draft report is also included as an appendix to this report (Appendix 2).

EXISTING LAKE QUALITY PROBLEMS AND THEIR CAUSES

Governor Bond Lake was assessed as not meeting its designated uses because it exceeds Secchi depth (lack of water clarity), TSI (Trophic State Index), siltation rates (lake storage volume loss), or NVSS (suspended sediments) designated use guidelines. In addition, Governor Bond Lake periodically has elevated levels of nutrients (phosphorus and nitrogen) which are aggravating factors for the foregoing causes.

High Nutrient Loads - *High levels of nitrogen and phosphorus from watershed inputs.* Monitoring data collected during the diagnostic phase of this study clearly indicate elevated levels of phosphorus and nitrogen entering the lake from watershed sources. While these levels are likely substantially lower than in previous years (due to the extent of conservation practices on agricultural grounds in the watershed), these additional inputs nevertheless aggravate an existing problem of high nutrient levels in the lake itself. Such nutrient inputs are likely the result of fertilizer use on both agricultural and, to a lesser degree, residential lands around the lake. Additional inputs originate in feedlots, septic systems, streambank erosion and natural processes.

High Phosphorus Levels in the Lake - *Internal cycling of phosphorus.* A significant volume of sediments and nutrients entered the lake during the first 15 to 20 years following construction. The sediments and nutrients have settled to the bottom of the lake and, under certain conditions, are resuspended in the water column. Such conditions include physical resuspension in shallower areas, such in the upper basin (above the trestle), and chemical resuspension, as is the case with phosphorus in the lower basin. In this latter circumstance, low DOs at the bottom of the lake, caused by (among other things) thermal stratification result in the chemical dissociation of phosphorus in the sediments and its resuspension in the water column. At fall and/or spring turn-over, this resuspended phosphorus becomes available to plants, particularly algae, in the lake. Because phosphorus in the limiting nutrient, the result is excessive algal growth.

Excessive Algal Growth - *Algal blooms leading to poor clarity and low DOs.* As described above, the abundance and availability of phosphorus during certain times promotes the uncontrolled growth of algae in the lake. This growth can lead to other problems such as poor water clarity, which can be hazardous for recreational use of the lake. It also promotes a cycle of lowering dissolved oxygen levels since, as the excessive algae grow they use oxygen in the euphotic zone (the area near the surface of the lake). As they die, this biomass settles to the bottom of the lake where bacterial activity consumes oxygen in the decomposition process, further lowering dissolved oxygen levels. The matter is exacerbated by the thermocline which prevents the lower regions of the lake from mixing with upper regions where DO levels are higher.

Turbid Waters - *High levels of non-volatile suspended solids (NVSS).* Clarity of lake water is generally based upon the amount of particulate matter in the water and, to a lesser degree, other factors such as color. Some of the particulate matter is combustible or volatile, such as the organic matter in the water. That component of water clarity that is associated with non-combustible particles includes suspended sediments and, to a lesser degree, other solids. Governor Bond Lake has exceedingly high levels of NVSS which are primarily associated with three sources: suspended solids coming from the watershed; suspended solids coming from shoreline erosion; and, resuspension of non-volatile solids that have settled in shallower areas, like the upper basin. The resulting poor water clarity can be hazardous for recreational use of the lake, and can impair the extent and quality of aquatic life.

High Sedimentation Rates and Lost Storage Volume - *Rate and extent of in-filling from watershed inputs.* Governor Bond Lake has lost in excess of 31% of its total storage volume since its construction. While the rate of in-filling and volume loss has likely decreased, the remaining volume must be preserved to provide for reasonable length of life for the reservoir. In addition, reducing sedimentation rates with improve water clarity and other water quality parameters such as sediment-associated nutrient inputs.

Shoreline Erosion - *Shoreline losses, in-filling of the lake, and elevated NVSS.* Governor Bond Lake is an impounded reservoir and, as such, is located on soil types that are generally ill-suited for the eroding forces of lake dynamics. The result of wave action, whether from wind fetch or recreation sources such as boats, is the constant eroding of shoreline areas around the lake. Such erosion causes increased in-filling of the lake and increases in the non-volatile component of the suspended solids in the water column. Shoreline erosion also cause the frustrating, and sometimes hazardous, loss of land-owner property adjacent to the lake.

OBJECTIVES FOR LAKE RESTORATION

An effective lake restoration and management plan must be developed with clear objectives in mind. The following objectives meet several different needs, including general uses for the lake such as aquatic life and recreational use, while also meeting specific needs such as raw water quality and quantity for drinking water. This restoration program is intended to address all water quality problems identified as part of the diagnostic study. It carries the added benefit, if fully implemented, of meeting any future Total Maximum Daily Load requirements associated with these particular causes of impairment.

- ***Objective #1 - Reduce total phosphorus loading from the watershed***
- ***Objective #2 - Reduce total phosphorus loading from internal cycling***
- ***Objective #3 - Control excessive algal growth***
- ***Objective #4 - Reduce NVSS***
- ***Objective #5 - Reduce the rate and extent of sedimentation and in-filling; restore lake volume***
- ***Objective #6 - Reduce shoreline erosion***

ALTERNATIVES FOR LAKE RESTORATION

Following are the various alternative methods proposed to address water quality problems in Governor Bond Lake. Each method identifies the objectives noted above which will be met. The table found at the end of Part 2 will identify restoration initiatives by type and, alternatively, by year of proposed implementation (Table 28). This proposed restoration program includes individual projects, such as created wetland/sedimentation systems in the watershed, which are to be implemented over the next three years. Several components of the restoration program are new, long-term policies and/or programs which are to be implemented within the next 12 to 18 months and which would be relatively permanent additions to lake management guidelines.

City / County Cooperative Agreements on Lake Development - *Helps to meet Objectives #1, #3, #4 and #5.* The City of Greenville owns Governor Bond Lake to elevation 525 MSL, while the surrounding lands are mostly privately owned and within the jurisdiction of Bond County. The following efforts will be made to improve watershed controls on development-related run-off:

- *Construction Controls.* The City of Greenville and Bond County will investigate development of mandatory guidelines requiring use of Best Management Practices, such as silt fencing, for all construction within the watershed. Construction projects which disturb one acre or more will be required to provide for silt basins to trap sediments which run-off of the site. New land-owners, or those existing land-owners beginning new construction, would be required to place rip-rap along their portion of shoreline. While the pollutant reduction associated with this effort is unknown, it is clearly an important step as development continues around the lake.

- *Septic Systems.* While not specifically identified as a source of impairment at present, the effect of septic systems adjacent to the lake is cumulative and should be carefully monitored in terms of numbers, types, and operational status. The City and County will investigate the practicality of developing an inspection process on a 3-year cycle, through the county health department, for all septic systems which provide direct effluent run-off into the lake and its perennial tributaries.

- *Modifications of the City's Lakes and Reservoirs Ordinance.* The City of Greenville has encoded its ordinances governing the use of Governor Bond Lake (Chapter 95, Appendix 3). The City of Greenville will investigate a modification to this ordinance regarding expansion of current no-wake areas from the State-mandated 150 feet to 200 feet from the shoreline. Additional No-Wake buoys will be purchased and installed on 500-foot centers along the shoreline.

  While a top priority for lake rehabilitation will be to protect the lakeshore with rip-rap, sea walls, revetments or other protection devices, there are some additional areas which would benefit from either temporary or permanent prohibition of wakes from watercraft. These areas will be identified by the City's standing Lake Committee and proposed as changes to the existing Lakes and Reservoirs Ordinance. All coves will remain No-Wake areas.

Conservation Practices in the Watershed - *Helps to meet Objectives #1 and #3 through #5.* Use of conservation practices throughout the Governor Bond Lake watershed has historically been very successful in reducing nutrient and sediment inputs to the lake. Efforts will be made to increase these practices throughout the watershed, including:

- *Increase participation in the filter strip, riparian buffer and Conservation Reserve Programs within the watershed.* The City of Greenville will subsidize the current financial incentives available to watershed land-owners by providing restoration cost-share funds for filter strips and riparian corridors. At present, under existing federal cost-share programs of the Natural Resources Conservation Service (NRCS), up to

90% of restoration costs are covered by federal funds for filter strips (maximum of $60 to $200 per acre) and riparian corridors (maximum of $425 per acre). The City of Greenville will provide the other 10% of the restoration costs for up to 100 acres of filter strips (at a cost of $6 to $20 per acre) and 200 acres of riparian corridor (at a cost of $42.50 per acre). The current rent payments made by federal funds for the 10-year contract on such uses is adequate to provide a land-owner incentive without additional subsidy. This incentive (the additional 10% of restoration costs) will be limited to the first three years of the restoration program (2002, 2003 and 2004).

The City will further support such conservation programs by subsidizing the annual per-acre rental payments of the NRCS' Conservation Reserve Program. For the existing 1,800 acres of CRP ground, the City will supplement the rental payments for the remainder of those contracts by $20 per acre. In addition, any new CRP sign-ups during the first three years of the restoration program (2002, 2003 and 2004) will also be subsidized with an additional $20/acre/year for the 10-year contract; this will include any existing CRP contracts that come up for renewal. It is anticipated that participation in the CRP program in the watershed can be doubled from 1,800 acres to 3,600 acres in three years using this incentive.

Implementation of these measures can reduce NVSS by 38.2%, total nitrogen (TN) by 19.5% and total phosphorus (TP) by 10.6% (TMDL, 2001).

- *Continue public education for watershed stakeholders on topics such as reducing fertilizer and pesticide use.* Through the University of Illinois Agriculture Extension Office, continue the current public educational efforts of a quarterly to semi-annual newsletter to watershed stakeholders emphasizing the importance of reducing fertilizer use, inspecting septic systems, preserving filter strips/riparian corridors, etc.

- *Increase assistance to watershed landowners.* Land-owners in the watershed seeking to implement voluntary Best Management Practices (BMPs) such as detention basins, biodegradable erosion control matting (e.g. jute mesh), vegetated buffers along ditches and drainageways, etc. will be encouraged through provision by the City and NRCS of guidance documents on such practices.

- *City acquisition of critical areas of watershed drainage.* As identified by further investigations of nutrient/sediment inputs, and as willing landowners present themselves, the City will consider acquisition of lands in the watershed that, due to their unique character or location, offer critical water quality enhancement opportunities. Such lands may be used for sediment basins, created wetland areas, conservation land covers or other uses as appropriate.

- *Institute conservation practices on various City properties.* The City will evaluate the merits of conservation land uses on City owned property within the watershed, including conservation plantings of trees and warm-season grasses, shoreline protection, and other appropriate land uses.

- *Sustainable Agriculture Demonstration Project.* The City of Greenville presently owns property adjacent to the lake near its eastern end (on Kingsbury Branch). As a means of public education, and to illustrate its support of the restoration programming described herein, the City will develop a demonstration project for watershed BMPs and sustainable agriculture.

SUSTAINABLE AGRICULTURE DEMONSTRATION PROJECT

Clean Lakes studies have been completed for Lake Lou Yeager on the Shoal Creek's West Fork, and are planned for Lake Glenn Shoals and Hillsboro Lake on Shoal Creek's Middle Fork. Since the watershed of each of these public drinking water supplies is over 80% cropland, all of these studies will call for substantial investment in watershed BMPs. This project is designed to offer guidance to watershed farmers on agricultural BMPs that are easily installed and maintained and supported by state and federal cost-share programs.

The 108.3-acre property, owned by the City of Greenville, has been in agricultural production (50.5 Ac) for many years. It is also strategically located at the eastern headwater of Governor Bond Lake. A main feeder stream of the lake is Kingsbury Branch which crosses through the property, surrounded by bottomland hardwoods (57.8 Ac). This project will modify the property to reconcile land use for crop production with its important location on the edge of the City's impaired drinking water supply. Cropland will be reduced to 39 acres for traditional crops (corn, wheat and soybeans) while warm season grasses will be planted as filter strips along the streamside bottomland forest (2.7 Ac), 2 acres of wetlands and 4.1 acres of bottomland forest will be added, 2.7 acres of grassed waterways (cool season grasses and hydrophytes) will be planted and 7.8 acres of highly erodible soil will be planted in prairie grass.

Seed from this prairie will be harvested and sold every third year as an additional revenue source. Various forms of conservation tillage will be used, and crop types and treatments will be assessed such as alternatives to GMOs, alternatives to traditional herbicide applications, strip cropping, field sabbath (fields left fallow every 7th year) and other methods of reducing impacts of agricultural land use. Fence rows will be widened to 100 feet along external borders and 60 feet between fields to improve wildlife habitat.

This will significantly improve the environment without sacrificing substantial areas of productive farm ground. Much of this property, owned by the City of Greenville, is highly erodible soils and bottomland/farmed wetland. These areas will be restored to quality habitat, while the remaining farmland will continue to be productive in rotation of corn, wheat and soybeans, planted using various methods of conservation tillage. Local farmers will see in-the-field examples of quality BMPs which they can use throughout the watershed of this and other water supply reservoirs.

***Structural Best Management Practices in the Watershed** - Helps to meet Objectives #1 and #3 through #5.* A very effective means for restoring water quality in reservoirs such as Governor Bond Lake is the installation of small sedimentation basins and constructed wetlands strategically located throughout the watershed. When properly maintained, such basins can be the next line of defense for reservoir water quality, following installation of various BMPs on watershed landowners' properties.

A particularly effective BMP, and one which will be emphasized for Governor Bond Lake, is the multiple extended detention wetland systems, which effectively reduce sedimentation as well as nutrient loading. These structures have the added benefit of significantly improving habitat values along riparian corridors of tributaries and drainageways in the watershed. These systems are commonly known as stormwater wetlands, and are described in some detail below. Much of the following information is excerpted from T. Schueller et. al., Design of Stormwater Wetland Systems (1992).

Stormwater wetlands can be defined as constructed systems that are explicitly designed to mitigate the impacts of stormwater quality and quantity that are attributable to various watershed land uses. They do so by temporarily storing stormwater runoff in shallow pools that create growing conditions suitable for emergent and riparian wetland plants. The runoff storage, complex microtopography and emergent plants in the stormwater wetland together form an ideal matrix for the removal of watershed pollutants (Table 25). These wetlands usually fall into one of five basic designs, as described below.

Table 25 Projected Long Term Pollutant Removal Rates for Stormwater Wetlands in the Mid-Atlantic Region [a, c]

Pollutant	Removal Rate (%)
Total Suspended Solids	75%
Total Phosphorus	45%
Total Nitrogen	25%
Organic Carbon [b]	15%
Lead	75%
Zinc	50%
Bacteria	2 log reduction

([a]) *Removal rates apply to stormwater wetlands sized as shown in T. Schueller et. al. (1992). Removal rates for pocket wetlands may be lower. These are projected rates, and have not be confirmed by actual monitoring.*

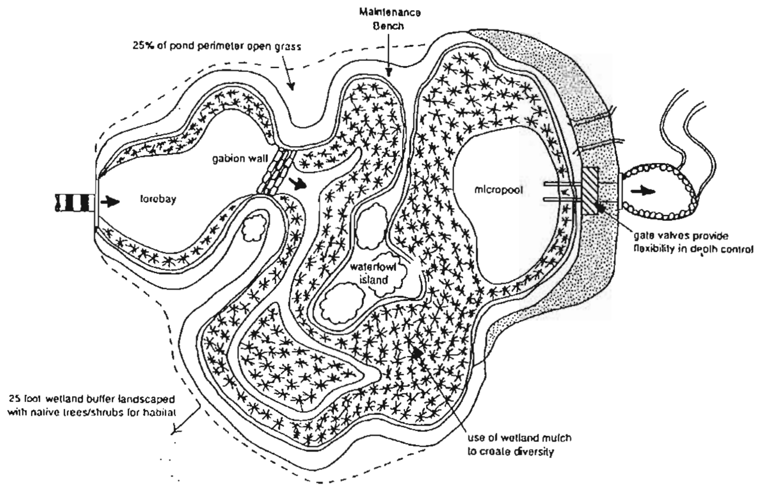
([b]) *Includes five-day, BOD, Total Organic Carbon or Chemical Oxygen Demand.*

([c]) *Phosphorus and nitrogen removal in pond/wetland systems (Design No. 2) are higher due to the effect of the pool. P removal of 65% and N removal of 40% are likely.*

Design No. 1: Shallow Marsh System

The shallow marsh design has a large surface area, and requires a reliable source of baseflow or groundwater supply to maintain the desired water elevations to support emergent wetland plants (Figure 50). Consequently, the shallow marsh system requires a lot of space and a sizeable contributing watershed area (often in excess of 25 acres) to support the shallow permanent pool.

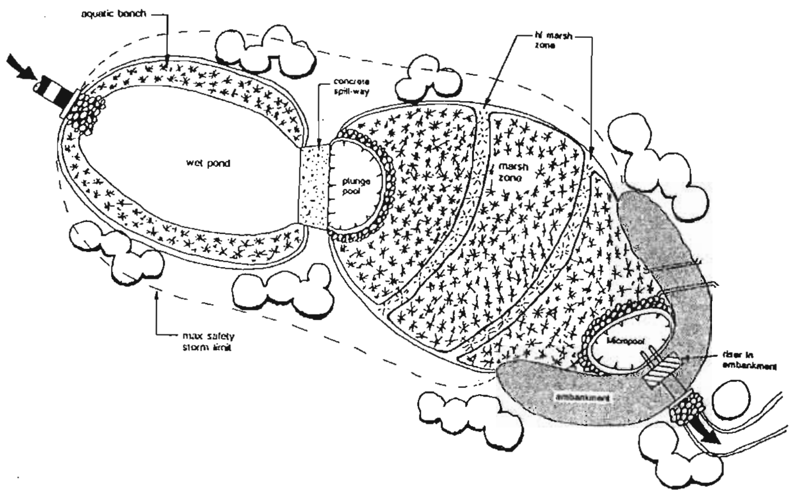
Figure 50 Shallow marsh stormwater wetland



Design No. 2: Pond/Wetland System

The pond/wetland design utilizes two separate cells for stormwater treatment (Figure 51). The first cell is a wet pond and the second cell is a shallow marsh. The multiple functions of the wet pond are to trap sediments, reduce incoming runoff velocity, and to remove pollutants. The pond/wetland system consumes less space than the shallow marsh, because the bulk of the treatment is provided by the deeper pool rather than the shallow marsh.

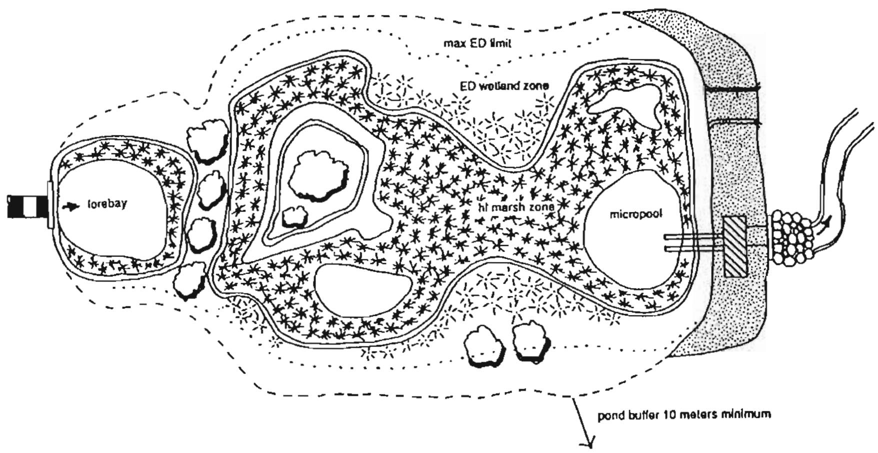
Figure 51 Pond/Wetland stormwater system.



Design No. 3: Extended Detention (ED) Wetland

In extended detention (ED) wetlands, extra runoff storage is created above the shallow marsh by temporary detention of runoff (Figure 52). The ED feature enables the wetland to consume less space, as temporary vertical storage is partially substituted for shallow marsh storage. A new growing zone is created along the gentle slopes of the wetlands that extends from the normal pool elevation to the maximum water surface elevation.

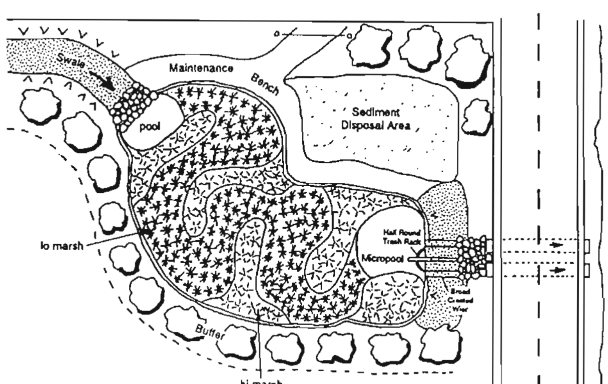
Figure 52 Extended detention stormwater wetland.



Design No. 4: Pocket Wetlands

Pocket wetlands are adapted to serve smaller sites from one to ten acres in size (Figure 53). Because of their small drainage areas, pocket wetlands usually do not have a reliable source of baseflow, and therefore exhibit widely fluctuating water levels. In most cases, water levels in the wetland are supported by excavating down to the water table. In drier areas, the pocket wetland is supported only by stormwater runoff, and during extended periods of dry weather, will not have a shallow pool at all (only saturated soils). Due to their small size and fluctuating water levels, pocket wetlands often have low plant diversity and poor wildlife habitat value.

Figure 53 Pocket stormwater wetland.



Design No. 5: Fringe Wetlands

Fringe wetlands are formed by shallow aquatic benches installed along the perimeter of the permanent pool of a wet pond. These benches are normally 10 to 15 feet in width on both sides of the normal pool (although they can be extended in width). Fringe wetlands are a very useful design feature in ponds, as they promote a more natural appearance, conceal trash and changes in water levels, reduce safety hazards, and provide some aquatic habitat. While fringe wetlands are a desirable feature in wet ponds, they provide only a minor increment of additional pollutant removal. For this reason, they are not considered further in these discussions.

COMPARISON OF STORMWATER WETLAND DESIGNS

The selection of a particular wetland design is usually dependent on three factors: contributing watershed area, available space and the desired environmental function for the wetland. The comparative attributes of each of the first four stormwater wetlands are detailed in Table 26.

Table 26 Comparative Attributes of Four Stormwater Wetland Designs

ATTRIBUTE	DESIGN NO. 1 Shallow Marsh	DESIGN NO. 2 Pond/Wetland	DESIGN NO. 3 ED Wetland	DESIGN NO. 4 Pocket Wetland
POLLUTANT REMOVAL CAPABILITY	Moderate, reliable removal of sediments & nutrients	Moderate to high, reliable removal of nutrients & sediments	Moderate, less reliable removal of nutrients	Moderate, can be subject to resuspension & groundwater displacement
LAND CONSUMPTION	High, shallow marsh storage consumes space	Moderate, as vertical pool substitutes for marsh storage	Moderate, as vertical ED substitutes for marsh storage	Moderate, but can be shoehorned in a site
WATER BALANCE	Dry weather baseflow normally recommended to maintain water elevations; groundwater not recommended as the primary source of water supply to the wetland			Water supply provided by excavation to groundwater
WETLAND AREA / WATERSHED AREA	Minimum ratio of .02	Minimum ratio of .01	Minimum ratio of .01	Minimum ratio of .01
CONTRIBUTING WATERSHED AREA	DA of 25 acres or greater with dry weather Q	DA of 25 acres or greater with dry weather Q	Minimum of 10 acres required for ED	1 to 10 acres
DEEPWATER CELLS	Forebay, channels and micropool	Pond, micropool	Forebay, micropool	Micropool if possible
OUTLET CONFIGURATION	Reversed slope pipe extending from riser, withdrawn approximately one foot below normal pool; pipe and pond drain equipped with gate valve			Broad crested wier with half round trash rack, pond drain
SEDIMENT CLEANOUT CYCLE	Forebay cleanout every 2-5 years	Cleanout of pond every 10 years	Cleanout of forebay every 2-5 years	Cleanout of wetland every 5-10 years, onsite disposal
NATIVE PLANT DIVERSITY	High, if complex microtopography is present	High, with sufficient wetland complexity and area	Moderate, fluctuating water levels impose physiological constraints	Low to moderate, due to small surface area and poor control of water levels
WILDLIFE HABITAT POTENTIAL	High, with complexity and buffer	High, with buffer, attracts waterfowl	Moderate, with buffer	Low, due to small area and low diversity

REMOVAL PATHWAYS WITHIN STORMWATER WETLANDS

The basic intent of a stormwater wetland is to create a shallow matrix of sediment, plants, water and detritus that collectively removes multiple pollutants through a series of complementary physical, chemical and biological pathways, as follows. Some of the primary removal pathways operating within stormwater wetlands are described below:

- Sedimentation
- Physical Filtration of Runoff
- Microbial Uptake/Transformation
- Uptake by Wetland Plants
- Uptake by Algae
- Extra Detention and/or Retention

Sedimentation. As with other conventional pond systems, sedimentation (or gravitational settling) is perhaps the dominant removal pathway for particulate pollutants operating within a stormwater wetland. The morphology and vegetation within stormwater wetlands create ideal settling characteristics, particularly in comparison to other pond systems. The sheetflow conditions across the wetland, slower runoff velocities and hydraulic resistance afforded by the wetland vegetation, are all very effective at promoting settling. In addition, the root network of emergent plants helps to stabilize sediments, thereby reducing the potential for their resuspension. Much of the sedimentation in wetlands (and ponds) will usually occur in the immediate vicinity of the inlet.

Adsorption to Sediment, Emergent Plants and Detritus. The second primary removal pathway is the adsorption of pollutants to the surfaces of suspended sediments, bottom sediments, wetland vegetation and organic detritus. Adsorption is a key removal pathway for phosphorus, trace metals and some hydrocarbons. The importance of adsorption as a removal pathway increases as the contact time with this complex of surfaces increases. Longer contact time in stormwater wetlands can be achieved by creating a high surface area to volume ratio. A number of techniques can be used to increase contact time:

- create a complex and variable microtopography within the stormwater wetland,
- establish dense stands of emergent wetland vegetation,
- design for sheet flow or shallow flow conditions,
- incorporate organic soils into the bottom of the wetland, and
- allow wetland detritus to accumulate within the basin.

Physical Filtration by Plants. The dense network of emergent wetland plants acts as a filter for incoming stormwater as it passes through a stormwater wetland. While physical filtration is a relatively ineffective pathway for the removal of nutrients and trace metals, it is very effective at removing trash, debris and other floatables found in urban runoff. In addition, the filtering action of the wetland plants reinforces the effectiveness of other removal pathways, such as sedimentation, adsorption and microbial removal.

Microbial Activity. The complex of surfaces within the stormwater wetlands provide favorable conditions for active microbial growth. Billions of microscopic bacteria consume carbon and nitrogen compounds within both the water column and the organic sediments of the wetland. Microbial processes are effective in removing nitrogen (via the nitrification / denitrification process) and organic matter (via aerobic decomposition). Microbial activity consumes oxygen, and often can completely deplete oxygen within the top layer marsh sediments. The combination of partially decomposed organic matter and low oxygen common to wetlands helps to immobilize many trace metals into less mobile sulfide, oxide or hydroxide compounds that are less likely to be released to the biota.

Uptake by Wetland Plants. Uptake of pollutants by emergent wetland plants is an indirect removal pathway for nutrients and metals. In nearly all cases, emergent wetland plants take up these substances through their roots, rather than from their leaves. Therefore, the influence of wetland plant uptake is primarily on pollutants that have been previously deposited in the sediments. Exceptions include some species of submerged or floating aquatic vegetation.

Although the uptake does not remove nutrients and metals from the water column, it does create new exchange sites within the sediment for future adsorption of pollutants. The nutrients and metals that are translocated to the leaves and stems are not permanently retained, but can be released to the water column when the above-ground parts dieback in the Fall.

Uptake by Algae. Uptake by planktonic or benthic algae is an important removal pathway for soluble pollutants such as phosphate and ammonia within stormwater wetlands. The large volume of standing water within stormwater wetlands is an optimum environment for the growth of algae. Free-floating algae take up the nutrients and convert them into biomass which, in turn, settle out to the wetland sediments.

Contribution of algal uptake to the nutrient removal capability of wetlands is frequently overlooked. Galli (1992) surveyed over twenty wetlands and ponds in Maryland, and found that the wetlands as a group had a higher trophic index, which is a measure of system productivity. Algal mats are often observed on the sediment surface of shallow wetlands, and these mats are thought to be effective in removing nutrients as well.

Augmented Retention or Detention. Not all the removal pathways in a stormwater wetland are related to the wetland/ plant/ sediment matrix. In many designs, up to half of the total treatment volume is devoted to a permanent pool and/or temporary extended detention. These treatment volumes can augment sedimentation and algal uptake, and can increase the total contact time within the wetland for adsorption, filtration and microbial activity. These removal pathways take on added importance during the non-growing season, when marsh removal pathways are not as effective.

PROJECTED POLLUTANT REMOVAL RATES FOR STORMWATER WETLANDS

The pollutant removal performance of nearly 25 stormwater wetland systems has been reported to date. Although the stormwater wetland systems monitored have differed greatly in their design and treatment volume, most have shown moderate to excellent pollutant removal capability under a range of environmental conditions. From a review of these studies, it is evident that:

- The removal rates for stormwater wetlands are similar to conventional ponds systems, such as dry extended detention and wet ponds. In many cases, suspended solid removal rates were higher than conventional ponds, which reflects the better settling conditions that are often found in wetland systems. Conversely, phosphorus removal rates in wetland systems were more variable and, and in some cases, slightly lower than wet ponds. The exact reason for the reduced phosphorus removal is not clear, but may reflect complex phosphorus cycling patterns often associated with wetlands. In fact, some wetlands actually exported ammonia nitrogen and phosphate at certain times of the year.

- Extended detention ponds with wetlands typically performed better than ED ponds without wetlands. Four performance studies of ED wetland systems have been reported, and these suggest a moderate to high capability to remove particulate pollutants, and a low to moderate capability to remove soluble pollutants. However, the four ED wetland systems investigated had inadequate treatment volumes (0.8 to 0.15 inches of runoff per contributing acre) which may have limited their ability to provide reliable levels of soluble pollutant removal.

- The most reliable overall performance was achieved by pond-wetland systems (Design No. 2). In these systems, the permanent pool pre-treats runoff before entering a shallow marsh. The pool also reduces runoff velocities and provides considerable pollutant removal. Of particular note has been the demonstrated capability of these systems to provide consistently higher levels of phosphorus and nitrogen removal than other stormwater wetland designs.

- The performance of pocket wetlands has never been monitored. For a number of reasons, it is quite likely that the performance of pocket wetlands will not be as reliable as other stormwater wetland designs. First, most pocket wetlands are excavated to the groundwater, which means that much of the treatment volume capacity is used up by groundwater rather than stormwater.

Second, pocket wetlands often lack forebays, are prone to resuspension, and often lack the dense vegetative cover of larger wetland designs (Galli, 1992).

- Several studies indicate that the performance of stormwater wetlands declines slightly during the non-growing season, and more strongly when the wetland plants dieback in the Fall (releasing a portion of the nutrients stored in above-ground biomass). The lower performance can be attributed to the lack of wetland structure and lower temperatures that reduce microbial and algal activity.

- Performance also declines if stormwater wetlands are covered with ice or receive snowmelt runoff. Oberts et al (1989) reports that ice and snowmelt conditions experienced in Minnesota reduced average pollutant removal by about 25 to 50%. Nevertheless, good removal rates over the entire year were still observed at the site.

- Some evidence exists that stormwater wetland performance increases as the wetland ages at least in the first several years. This is attributed to the greater density of plants and organic materials that accumulate in the wetland over time. Initially, many stormwater wetlands do not posses much organic matter because they are excavated to depleted mineral subsoils. It is not clear whether performance continue to increase over the long term (i.e., decades) as nutrient exchange sites become fixed.

- In general, it is apparent that stormwater wetlands outperform natural wetlands of similar size (Strecker et al, 1992). This undoubtedly reflects the longer detention and/or retention of runoff that is designed into constructed systems.

Based on the analysis of the performance studies and the various removal pathways in wetlands, it is expected that stormwater wetlands can reliably achieve minimum long-term removal rates, given that they are designed with the features and treatment volume specified earlier. These rates should be considered provisional until actual performance monitoring of this "second generation" of stormwater wetlands is completed.

DEEPWATER WETLAND CELLS

Deepwater cells are an integral aspect of stormwater wetland design. These cells include the sediment forebay (located near the inlet) and a micropool (situated near the outlet). The importance of these cells in the function of a stormwater wetland is described below.

Sediment Forebay. A separate-cell sediment forebay is a required design element for the shallow marsh and ED wetland systems (Design Nos. 1 and 3). Pocket wetlands frequently have no forebay, due to space constraints. While the pond/wetland system (Design No. 4) technically has no forebay, the pond cell essentially functions as one. A sediment forebay serves several useful purposes in wetland design, as it acts to:

- Reduce the incoming runoff velocities to the wetland.
- Trap coarse sediments before they enter the wetland, thereby preserving its capacity and microtopography. The sediment trapping role is particularly important as Galli (1992) has estimated that up to one foot of sediment can accumulate in stormwater wetlands within ten years.
- Spread runoff evenly over the marsh to create sheet-flow conditions.
- Extend the flow path and prevent short-circuiting.

The forebay should comprise at least ten percent of the entire treatment volume *Vt* of the wetland (with a minimum of 0.1 watershed inches), and should be 4 to 6 feet deep. Direct maintenance access to the forebay for heavy equipment must be provided, and it is preferable if the bottom of the forebay is hardened to make clean-outs easier.

The forebay should be a separate cell, which can be formed by gabions or an earthen berm. A forebay is not required for pocket wetlands due to their small size and unreliable water supply. However, a sediment disposal and stockpile area should be reserved on-site. Strecker (1992) suggests that a shallow "cattail" forebay may be a useful alternative to a deep cell forebay, if trapping of oil/grease and trash is a priority.

Micropool. The micropool is a standard design feature of the ED wetland (Design No. 3), and is also recommended for other wetland design options, as well. The purpose of the micropool is to create sufficient depth near the outlet to allow for a reverse sloped pipe to extend into the normal pool. Typically, the release from the pond is situated no more than one foot below the permanent pool. The reverse sloped pipe has been demonstrated in the field to be highly resistant to clogging, which can be a major concern given the vegetation within wetlands. Organic-rich sediments are trapped below the orifice, and debris and plant wrack float above it.

The minimum dimensions for a micropool are that it comprise ten percent of the total treatment volume (*Vt*) and that it be four to six feet in depth. The micropool should be equipped with a drain capable of de-watering the wetland within 24 hours. Typically, the pond drain is controlled by a lockable and adjustable gate valve within the riser. The drain should have an upward facing inverted elbow, so that it extends above the bottom sediments of the micropool.

The pond drain is an integral feature of the stormwater wetland as it allows the operator to manipulate water levels within the wetland (e.g., to draw-down for the planting of emergent wetlands or to clean-out sediments from the forebay).

In-lake Treatments (Algacide) - *Helps to meet Objective #3.* Much of the following information on control of algae comes from the Lake Herrick diagnostic/feasibility study.

Herbicides have been widely used to control nuisance planktonic and filamentous algae growth for many years. Various chemical compounds containing copper are most common for algae control. While planktonic algae and filamentous species *Spirogyra* are easily controlled with copper, the filamentous algae *Hydrodiction* and those in the cladophorales family—*Pithophora, Cladophora, and Rhixoclonium*—are very copper-resistant. Endothall (Hydrothol 191) is effective against *Hydrodiction.* Endothall combined with copper has been more effective against the three cladophorales species. Possibly the best control of the cladophorales can be achieved by using the adjuvant Cide-Kick with the copper. Other filamentous algae very difficult to control are *Oscillatoria* (impossible to control) and *Lnygbya.* In order to maximize copper's toxic effect on algae, chelating agents have been added. Chelated copper herbicides include Cutrine-Plus and A V-70. It has also been found that the use of Cide-Kick allows a reduction in the amount of copper needed, thus cutting costs. Oxidizing agents may be applied concurrently with the herbicide to reduce the possibility of a fish kill caused by the rapid die off of large algal populations and the consequent depletion of DO.

Research has shown that 5.4 pounds of copper sulp!.ate per acre of lake is sufficient to control problem-causing bluegreen algae (or cyanobacteria) in waters with high alkalinity, that is, waters with total alkalinities greater then 40 mg/l as $CaCO_3$. Most Illinois lakes, including Governor Bond Lake, fall in this category. This is equivalent to 1 mg/l copper sulfate ($CuSO_4 \cdot 5H_2O$) or 0.26 mg/l copper (Cu^{2+}) for top two feet of the lake surface where algal growth is highest (State Water Survey 1989). At the concentrations required for algal control, copper-based herbicides can create concentration levels of copper that can adversely affect aquatic invertebrates. *Daphnia* (Cladocera), *Gammarus* (Amphipoda), snails and clams (Mollusca), and some aquatic insects are quite sensitive to copper. The elimination or reduction in population density of algae-grazing zooplankton, such as *Daphnia*, may account for the rapid rebound of phytoplankton in a lake after a copper application. Snails and other mollusks can form an important component of the diet of some water birds and aquatic mammals.

Control of nuisance algae typically ranges from a few days to a few weeks, so repeated applications are usually necessary. For Herrick Lake, average contractor rates (including cost of the chemical and application) ranged from \$30-50/acre for copper sulfate and from \$70-90/acre for chelated copper. The relatively high cost over time and the frequency of treatment needed, coupled with the potential toxicity of copper which accumulates in the lake sediments, renders the use of copper herbicides generally infeasible for long-term algae control. Rather, long-term control can be better achieved through reduction of nutrient availability through watershed abatement measures and/or curtailing internal regeneration.

For Governor Bond Lake, the restoration program calls for the application, at \$70/acre, of copper sulphate or other algacide twice a year for the first two years of the program, then a final application (if needed) in the spring of the third year, just before dredging, an alum application and installation of an aeration system (see below). This approach should dramatically reduce the clarity of the water in the short-term, though long-term benefits will only be realized through watershed controls of nutrients.

In-lake Treatments (Alum) - *Helps to meet Objective #2.* Much of the following information on use of alum for sediment sealing and phosphorus precipitation comes from the Lake Herrick diagnostic/ feasibility study. Phosphorus precipitation removes phosphorus from lake water by adding a compound that binds with phosphorus, precipitates as a floc particle, and then settles to the lake bottom. Aluminum sulfate is often used because it retains its phosphorus-sorbing ability over a relatively wide range of environmental conditions. Dispersion of aluminum sulfate (often called alum) into a lake can result in extremely clear water within a few hours to a few days. The floc particles, which settle on the bottom, carry with them inorganic and organic particles that were suspended in water, as well as much of the lake water's phosphorus. Depending on the dosage of alum added, the consequent layer of aluminum hydroxide which settles over the lake bottom may be thick enough to form a barrier which impedes the release of sediment-bound phosphorus to the overlying lake water. Alum treatments can result in relatively long-term reductions of phosphorus in lakes where in-flowing sources of phosphorus have been well controlled, and in lakes where water depths, lake morphology, macrophyte growth, recreational uses, and lack of bottom-feeding fish minimize agitation of the delicate floc layer.

The effectiveness and potential toxicity of alum applications are influenced by the lake's water quality and morphological characteristics. Careful consideration must be given to the dose determination and application technique. As alum is added to lake water, pH and alkalinity decline. Hence, the higher a lake's alkalinity, the greater the alum dose that can be applied. However, pH must be maintained between 6 and 8 during application. Within this pH range flocculation is maximized, enabling the most efficient removal of particulate phosphorus from the water column. Below this pH range, phosphorus removal efficiency decreases. Furthermore, a decrease in pH well below 6 increases the potential for short-term dissolved aluminum (Al^{+++}) toxicity to aquatic biota; pH-depression also increases the potential for fish-kills. The concurrent use of sodium aluminate to counteract pH depression overcomes these problems (Cooke et al. 1986).

In shallow areas, such as the upper basin of Governor Bond Lake, alum applications will rarely be effective for greater than 10 years. Rather, effectiveness may more likely be seen for approximately 5 (and possibly up to 7) years. The aluminum hydroxide layer is very flocculent and therefore can be easily disturbed in shallow water depths by wind and wave action. Additionally, sloughing of bottom sediments into the lake's deepest areas would transport the aluminum hydroxide layer along with it (Garrison and Knauer 1984). At the very worst, internal loading may not be altered significantly, although temporary removal of phosphorus from the water column and an associated increase in water clarity (due to a reduction in phytoplankton) may be accomplished.

To predict long-term water quality benefits from a single alum application, a modest reduction (50 percent) in internal phosphorus loading from anoxic bottom areas can be assumed. Under these conditions, internal phosphorus loading would be reduced, and the overall effect of this reduction upon the average annual in-lake total phosphorus (TP) concentration can be calculated.

Two approaches exist for determining a proper aluminum dosage, primarily depending on the treatment objective: 1) to precipitate or remove phosphorus for the water column at a given point in time, or 2) long-term control (inactivation) of phosphorus release from the sediments. Only small amounts of aluminum are usually needed to bring about phosphorus precipitation/removal, but long-term control likely will not occur. Phosphorus inactivation typically involves application of the highest dose possible to the lake sediments, consistent with the protection of aquatic life. Application can be made either to the hypolimnion (because the target is the anoxic sediments) or the lake surface (which would also provide phosphorus removal from the water column). Due to Governor Bond Lake's high internal loading (19-23 percent of the average annual TP load) and high water column TP concentration, phosphorus precipitation / inactivation would be the procedure of choice, if selected as part of the proposed Phase 2 Restoration Project.

Eberhardt estimates an application cost of \$500/acre (includes chemical, labor, and equipment costs), while Welch and Cook estimate such costs at \$700/ha (2.47 acres) which equates to \$190,000 to treat the main body of the lake. Some application barges possess onboard computers which continuously monitor the lake water's pH and alkalinity, and automatically adjust the alum dosage (and the sodium aluminate dosage, if used) so that the lake's buffering capacity is not exceeded.

In-Lake Aeration System. Artificial circulation and hypolimnetic aeration are two methods of introducing oxygen into the lake water, but they are different from each other in objective and operation. Artificial circulation (destratification) eliminates thermal stratification or prevents its formation by injecting compressed air into the lake water from a pipe or ceramic diffuser at the lake's bottom. If the system is adequately powered, the rising column of air bubbles will produce lake-wide mixing which will eliminate temperature differences between top and bottom waters (NALMS 1990). Artificial circulation may make planktonic algal blooms less of a nuisance because of changes in the lake's water chemistry (pH, alkalinity, CO_2, iron) which can lead to a shift from blue-green to less noxious green algae (NALMS 1990).

In some cases hypolimnetic aeration has failed to result in adequate algal community shift. Failure to generate a shift in the phytoplankton community may be due to the lake's chemistry or equipment. Lorenzen and Fast (1977) found that an air flow of approximately 1.3 cubic feet per minute (cfm) per surface acre was needed to adequately mix and maintain oxygen levels in a lake. While artificial circulation injects compressed air from a diffuser located on the lake bottom, hypolimnetic aeration commonly uses an airlift device to bring hypolimnetic water up to the surface. The water becomes aerated by contact with the atmosphere, and some gases such as carbon dioxide and methane are released. The water is then returned to the hypolimnion. Destratification is not intended (NALMS 1990).

Aeration and circulation systems can both increase the oxygen concentration in the lake water. More oxygen can reduce the likelihood of fish kills, slow the rate of nutrient release from the bottom sediments, and expand the habitat available to aquatic organisms. Aeration and circulation systems in combination with algae control measures have been very effective in reducing taste and odor problems in some water supply reservoirs. Some of the effects of aeration / destratification / circulation include:

- *Dissolved Oxygen*: The most common result of destratification is an improvement in dissolved oxygen levels—and consequent benefits on warmwater fish and water supply quality.
- *Fish*: Destratification is generally considered beneficial for warm-water fish. Fish require adequate dissolved oxygen levels and cannot survive in an oxygen-deficient hypolimnion. Warm-water fish (e.g., .bass, bluegill) require a minimum dissolved oxygen concentration of 5 mg/L, and coldwater fish (e.g., trout) need 6-7 mg/L. Destratification allows warm- water fish to inhabit the entire lake, and enhances conditions for fish food organisms as well. However, because destratification warms the deep waters, some cold-water fish species may be eliminated or prevented from inhabiting that lake.
- *Water Supply Quality*: A common result of destratification is an improvement in industrial and drinking water supply quality (in fact, the first artificial circulation system was used in 1919 in a small water supply reservoir). Under anoxic (without oxygen, anaerobic) conditions, lake bottom sediments release metals (iron, manganese) and gases (hydrogen sulfide)—which can cause taste and odor problems in drinking water. When the anoxic hypolininion is eliminated, these problems are eliminated or greatly reduced as well. Water treatment costs also decrease.
- *Phytoplankton*: The effects on phytoplankton(algae) are less predictable. Destratification may reduce algae through one or more processes: 1) algal cells will be mixed to deeper, darker lake areas, decreasing the cells' time in sunlight and thereby reducing their growth rate, 2) some algae species that tend to sink quickly and need mixing currents to remain suspended (e.g., diatoms) may be favored over more buoyant species such as the more noxious blue- greens, 3) changes in the lake's water chemistry (pH, carbon dioxide, alkalinity) brought about by higher dissolved oxygen levels can lead to a shift from blue- green to less noxious green algae or diatoms, and 4) mixing of algae-eating zooplankton into deeper, darker waters reduces their chances of being eaten by sight-feeding fish; hence, if more zooplankton survive, their consumption of algal cells also may increase.

  While algal blooms have been reduced in some lake destrafication/circulation projects, in other lakes phytoplankton populations have not changed or have actually increased. For shallow lakes, it's even less likely that complete circulation would result in any of the above-mentioned benefits. This is because algae are less likely to become light-limited in shallow lakes, nor would water chemistry changes be as pronounced.
- *Phosphorus*: Destratification has the potential to reduce phosphorus (P) concentrations in some lakes. During summer stratification when the hypolimnion is oxygen-poor, P becomes more soluble (dissolvable) and is released from the bottom sediments into the hypolimnion. Because stratified lakes can sometimes partially mix, this allows greater amounts of P to "escape" into the epilimnion. These increased P levels in the lake's surface waters can potentially stimulate an algal bloom. For similar reasons, algal blooms often are seen at fall turnover. Because destratification

increases the bottom water's oxygen content, it follows that P release from the sediments should be reduced, which in turn can lead to decreased algae abundance. However, the most suitable candidates for P reduction are deep, stratified lakes where a majority of the lake's P comes from anoxic, hypolimnetic sediments (i.e., internal sources). In lakes where the majority of P comes from external sources (such as watershed runoff, the atmosphere, waterfowl, septic systems), a reduction in sediment P release may not be enough to notice a change in algae abundance.

For Governor Bond Lake, there is an apparent nutrient cycling problem in the deeper end of the lake, primarily below the railroad trestle. It is suspected this is due to large inputs of nutrients, and particularly phosphorus, during the early life of the reservoir. Based on data collected for this report, 19% of the phosphorus and 23% of nitrogen load in the lake is due to internal cycling. This problem is maintained in large part because of lake stratification in the deeper part of the lake.

It is proposed that a hypolimnetic aeration system be installed in the lower basin (below the trestle) to create DO levels sufficient to prevent the dissociation of phosphorus in the sediments. In designing the system consideration must be given to the size of the reservoir due to high friction loss and considerable air flow requirements. In relatively low to moderate water hardness situations, it is typical to use an eight-stone diffuser assembly. In harder waters a self-cleaning disk-type diffuser can be used. Depending on site elevation, length of tubing runs, and maximum lake depths it may be appropriate to specify HeavySet, self-weighted aeration tubing. For long and deep tubing runs, use of 3/4- to 1-inch polyethylene tubing is often necessary. The compressors used may range from 3/4-HP to 30-HP compressors, depending on friction loss and air flow requirements. As an example, the Lake Ogallala system in Nebraska (roughly 200 acres) used 20 eight-stone diffusers, 20 separate diffuser lines using 1" poly tubing, and two 30-HP compressors, each operating 10 diffusers. Diffuser depths ranged from 18 to 35 ft. (Tony Byrne, Plateau Ecosystems Consulting, pers. comm.).

There are no standard designs for large lakes. Rather, aeration systems should be designed on a site-specific basis and the design for this project will be based on a number of factors. These may include site elevation, electrical power availability, surface area and lake shape, average and maximum depths, general water quality, and desired turnover and oxygen input rates. Most often, for a supply reservoir like Governor Bond Lake, a two layer aeration approach is usually best for raw water quality. The other options are artificial circulation and hypolimnetic aeration. To evaluate which would be best, whether to incorporate the ability to treat individual strata via aerator injection, and to size a system, additional data/information will be needed such as:

- Stage / Volume curve or table
- Bathymetry Map
- Temperature - DO Profiles
- Depth Chemistry (TP, inorg N compounds, alkalinity, cond, Fe, Mn, S=, etc.)
- Type of treatment train (coag/floc, GAC, etc)

The installation of such a system would effectively eliminate the internal cycling of phosphorus (19% of the TP load) and nitrogen (23% of the TN load).

Streambank and Shoreline Stabilization - *Helps to meet Objective #6.* Streambank stabilization, including the use of rip-rap, bend-way weirs and bio-stabilization (willow posts, etc.) will be implemented as needed throughout the watershed, and in particular in those main feeder tributaries (Dry Branch and Kingsbury Branch) where a significant sediment load is originating. It is presently estimated that over 7,000 tons of sediment are delivered to the lake each year as a result of streambank erosion. This loading can be virtually eliminated through the use of streambank stabilization techniques and the use of sediment trapping wetland detention basins as needed in the watershed.

Shoreline stabilization is considered to be among the top priorities for Governor Bond Lake. Armoring of the lakeshore using rip-rap, cedar revetments, gabions and bio-stabilization will help to reduce the more than 6,000 tons per year of sediment currently entering the lake as a result of shoreline erosion. Specifically, areas of highest priority will be those which need reconstruction, have severe erosion (greater than 9' vertical height of bank eroded - refer to Figure 37 of Part I, page 66), and that are eroded (shoreline erosion of 1 to 9 feet in vertical height). There are 680 linear feet of reconstructed bank and 27,812 linear feet of rip-rapped shoreline at present. Restoration of Governor Bond Lake will require the reconstruction of an additional 2,720 linear feet of severely eroded shoreline, rip-rapping of 21,720 feet of eroded shoreline and stabilization of 7,750 feet of undercut bank.

It can reasonably be assumed that several areas of shoreline which are not presently showing signs of undercutting or erosion may also eventually be included in the shoreline stabilization program. Such areas are likely to be stabilized using biological means such as willow or other native plantings, cedar revetments (use of cedar trees as angles and locations such that overland/sheet and shoreline erosion are reduced), and other low cost and low maintenance methods for protecting the shoreline.

Dredging - *Helps to meet Objectives #2, #4 and #5.* Dredging removes organic and inorganic sediments that have accumulated in the lake. Dredging is often performed to make a lake deeper for boating as well as to improve fish habitat. Removal of "muck" sediments can improve recreation and water clarity, as well as aquatic plant and animal habitats. Deepening near-shore areas so that sunlight does not penetrate all the way to the bottom in the littoral zone can reduce growth of rooted plants. Removal of nutrient-rich sediments can also reduce the amount of phosphorus that is released from the sediment to the overlying lake water. Finding a socially- and environmentally-suitable disposal site for the dredged material is often a difficult problem. Dredging is an expensive restoration strategy and should always be accompanied by management efforts which reduce sedimentation rates over the long- term.

In the case of Governor Bond Lake, there are three general areas for which benefits should be evaluated related to dredging. These three general areas are the lake below the train trestle, the lake between the trestle and Woburn Road bridge, and the lake above the Woburn Road bridge.

The area below the trestle exhibits the least damage related to sedimentation. This is due anecdotally to the fact that the Woburn Road bridge and train trestle were both constructed to intentionally restrict the movement of water down the lake, resulting in sediment deposition above / upstream of these constrictions. There remains, however, significant sedimentation in the southeastern tributary which serves a relatively small watershed sub-basin of the lower portion of the lake. While lake bathymetry shows support for various recreational uses, there may be a need at some point in the future to assess benefits of dredging in several coves of this arm of the lake. For purposes of this study, however, it is proposed that no dredging need be immediately considered for the lower portion of the lake.

There has been significant sedimentation in the middle portion of the lake, that is, the portion between the train trestle and Woburn Road bridge. A fair balance in assessing the need for dredging is to assume that a mean depth of 10 feet would provide good to excellent quality in several categories of lake use including recreational (sport fishing and boating) use, water storage and water quality, the latter of these for both drinking water purposes and for general use by aquatic life. Given the control elevation of the lake and the bathymetry reported in this study, there are approximately 158 acres of lake area which could reasonably be chosen for dredging to a mean depth of 11 feet. The average depth of sediment to be removed is approximately 9 feet, resulting in a total of approximately 1.9 million cubic yards of material to be dredged and disposed of.

Finally, the area above Woburn Road bridge is approximately 38 acres in size and has almost completely filled with sediments. Much of this area is virtually impassable by boat, and it can be assumed that any storage capacity for sediments has been used and the area is perhaps even a net exporter of sediments from the Kingsbury Branch sub-basin. At present, there is no consensus on the advantages of dredging this area.

One possible scenario which needs to be further investigated in Phase II is the strategy of draining and excavating the 38 acre area above Woburn Road bridge. This process is likely to take significant periods of time for drying (on the order of hundreds of days), but the advantages of excavating and hauling dried material which has been reduced in volume by as much as 65% are obvious. In addition, such action removes the need for a dredge material confinement area in a nearby upland area. An expansion of this scenario might include the use of this area, following its excavation to a mean depth of 15 feet, as a confined disposal area for the material dredged from that portion of the lake below the Woburn Road bridge (the 200 acres noted above). The storage capacity of the area would exceed 1 million cubic yards, and so the complete dredging of those areas below the Woburn Road bridge would require a two phase program.

There are many considerations for such a program, not the least of which include: development of methods to dredge, dry, excavate and haul the sediments that are acceptable to landowners around this part of the lake; maintenance of water flow from Kingsbury Branch to the main body of the lake; and ultimate disposal areas for dredged materials.

***In-lake Sedimentation Structures** - Helps to meet Objectives #4 and #5.* The following is based on the 1998 Preliminary Investigation Report produced by the Bond County SWCD and NRCS. In-lake structural alternatives were developed and evaluated for the locally identified resource concerns. The resource planning committee, formed to develop and determine the viability of the evaluated alternatives, commissioned the study by several resource agencies including the NRCS and SWCD. Two of these structures, No. 23 and No. 24, remain under consideration as part of the Governor Bond Lake restoration program. Other methods, including those measures in the watershed which provide sediment and nutrient removal, will be implemented first and then a further evaluation will be made to determine if these additional structural measures are needed. They are described below for information purposes only at this time.

The Formulation Process. Alternative plans were formulated to specifically address water quality, including reduced water treatment costs, and improve recreational opportunities, in the watershed. In addressing the resource concerns the planning committee looked at various structures in many different locations to formulate two alternatives, which has been further expanded to include a third alternative as part of this diagnostic and feasibility study.

Description of Alternatives. The following section describes the three alternatives evaluated (the first two by the NRCS report):

- <u>Alternative #1 – No Action Plan</u>. This alternative assumed that no federal or state assisted projects other than ongoing land treatment programs (EQIP) and Conservation Reserve Program (CRP) would be instituted to address the existing problems previously described in this report.

  <u>Effects:</u> With no action the watershed will continue to deliver excessive sediment to the lake annually. Governor Bond will trap 79% this sediment as it passes through the lake. The value of Governor Bond Lake as a water supply facility will continue to decline, and its value as a recreational and fishing resource will likewise decline. Nutrients, sediment and herbicides will continue to enter the lake, which will increase water treatment costs. As the aesthetic and recreational value of the lake declines, the recreational attraction will decrease.

  The lake is presently hypereutrophic with a Trophic State Index (TSI) of 79 in the upper end and 71 in the lower end (based on 1995 data), or an overall TSI of 71.2 (TMDL Report 2001). This means that there are excess amounts of nutrients available. When large amounts of nutrients are present, excess algae is produced and the transparency of the water is reduced. This negatively effects water treatment cost and water based recreation. The Resource Planning Committee found this an unacceptable alternative.

- <u>Alternative #2</u> - If pursued, the full range of preferred build alternatives consist of four small in lake sediment retention structures, one fish hatchery pond, and two large in lake sediment retention structures. Some of these structures could function as wetlands. The structure summaries are as follows:

Structure 1 - An earthen dam with a concrete block chute principal spillway and an earth emergency spillway. An eight inch pipe would drain the sediment pool and/or aid in managing the pool area as a wetland.

Structure 8A - An earth fill dam capped with rock riprap. This structure would extend across the lake an estimated 350 feet. The trapped water behind the dam would be controlled with a pipe and valve to manage the pool as wetland.

Structure 9 - An earth dam capped with a riprap weir to be utilized as a sediment basin. A small pipe with a valve would provide drainage of the sediment pool.

Structure 10 - A pond which will be designed as an earthfill dam to create a way that it can be drained. This will let the pond function as a fish rearing site, and to be used to restock fish in the lake annually.

Structure 16A - An earthen dam capped with riprap. This structure would extend across the upper tributary branch, and be 350 feet long. The trapped water would be slowly released through a pipe to allow for the consolidation of the sediments. This site may or may not function as a wetland, depending upon its design.

Structure 23 - An earthfill dam which extends about 900 foot across the lake with a 600 foot wide shot created gabion mattress spillway. The trapped water behind the dam would be controlled with a pipe and valve to manage the sediment pool as a wetland. The road west of the existing bridge may need to be raised to allow for this construction. This structure will be a permit sized dam and will be designed to meet IDNR-OWR dam safety criteria.

Structure 24 - A sheet pile structure driven into the lake bed to form a dam which has a radius of 150 feet. This will allow for flow to continue through the bridge at approximately three (3) feet above the normal pool. This structure will be a permit sized dam and will be designed to meet IDNR-OWR dam safety criteria.

<u>Costs:</u> Total project cost is projected to be $1,141,700.00 (1995 dollars). The benefits of this alternative are summarized as follows:

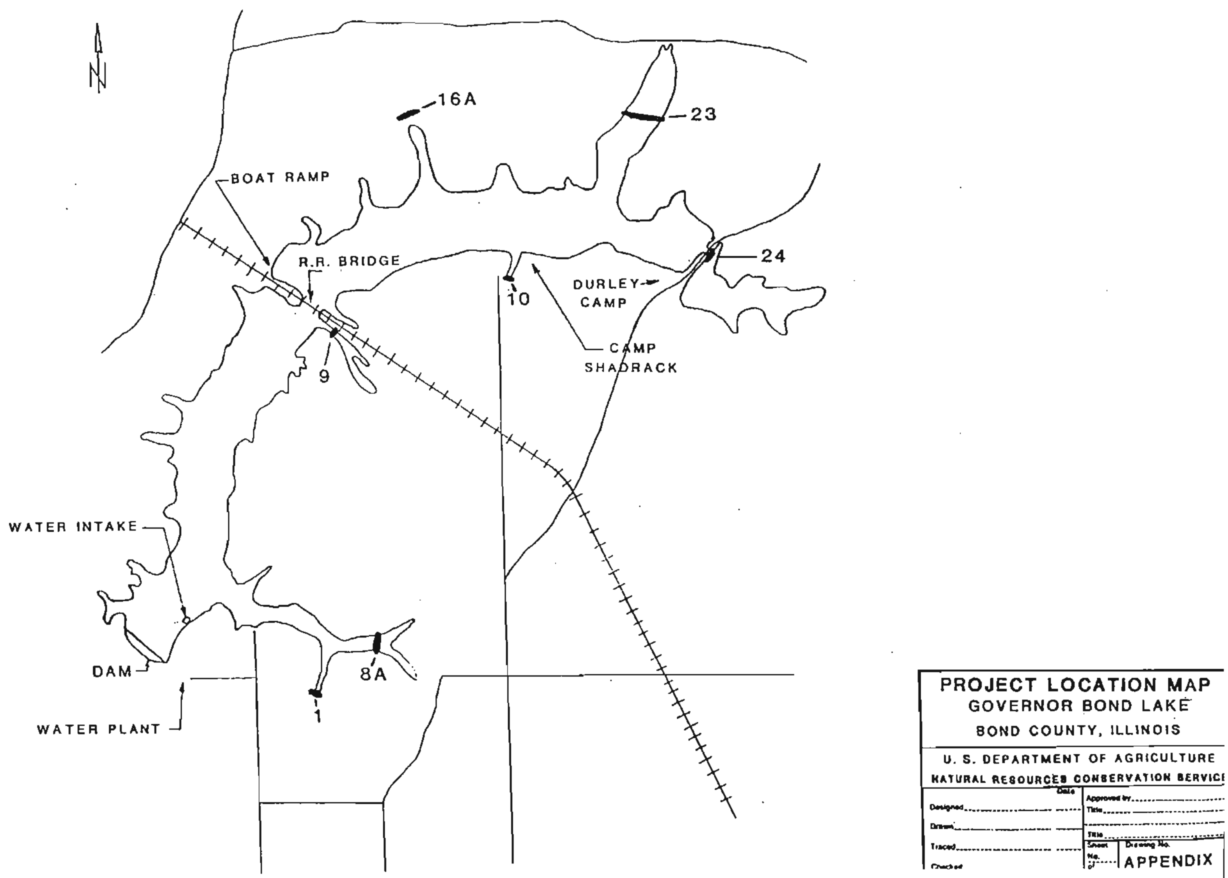
Recreation Benefits	$129,100
Water Treatment Benefits	<u>$ 28,300</u>
Total Average Annual Benefits:	$157,400

Therefore, the Cost-Benefit Ratio for this alternative is 1.82 to 1, well within guidelines for expenditure of federal funds. Table 27 provides details about each of the structures.

Table 27 Structure Data

Item	*Unit*	Str. 1	Str. 8A	Str. 9	Str. 10	Str. 16A	Str. 23	Str. 24
Structure Class		a	a	a	a	a	a	a
Total Drainage Area	*acres*	350	1420	250	120	1,100	7,892	8,593
Top of dam	*ft*	532.0	528.0			530.0	528.0	528.0
Principal Spillway elevation	*ft*	528.0	528.0			530.0	528.0	528.0
Emergency Spillway elevation	*ft*	530.0	528.0			530.0	528.0	528.0
Sediment Storage	*ac-ft*	12	59-2				281	366
Pool Area	*acres*	4.2	19.8				58.0	100.0
Maximum Water Depth	*ft*	3.5	3.5			5.5	3.5	3.5
Beneficial Use		Sediment Reduction	Sediment Reduction	Sediment Reduction	Fish Rearing		Sediment Reduction	Sediment Reduction

Figure 54 Location of various structures.



Rationale for Project Selection: This project was formulated to achieve the sponsor's goals to maintain their water supply needs, improve high quality water, improve recreational opportunities and reduce operating costs associated with water treatment costs. In the projects formulation it was determined that land treatment alone would not impact the annual sedimentation rate significantly, trapping the sediment in the upper reaches of the reservoir would be the best way to protect Governor Bond Lake. Various sites, sizes and combinations were looked at with input from local citizens and local officials. The structure sites in this plan were developed to obtain as high a trapping efficiency as possible. All measures considered were analyzed to see if each one added net benefits to the project.

- Alternative #3. (PREFERRED ALTERNATIVE). This alternative calls for the construction of Structures No. 23 and No. 24 only. This alternative remains under review and is not at present included in the restoration program for the lake. However, there remains the possibility that this alternative, that is, the construction of in-lake structures No. 23 and No. 24, could be pursued if other watershed based BMPs and programs do not accomplish the target reductions in pollutant loading.

PHASE 2 MONITORING PROGRAM

The goal of this monitoring plan is to assess the effectiveness of various BMPs for attaining in-lake water quality endpoints and designated full use support. To accurately assess the effectiveness of BMPs, including cultural programs, watershed and in-lake efforts, the monitoring will include assessment of water quality improvements associated with individual BMPs as well as general water quality in the receiving waters of the lake.

IEPA Participation. The IEPA should participate in two ways in this monitoring effort: (1) the IEPA should continue it ALMP monitoring of Governor Bond Lake on its establish 3-year cycle, beginning in 2004; the intervening years of 2002 and 2003 will be monitored by the City and its partners; and (2) the IEPA should provide matching funds as a component of the Clean Lakes Phase II grant for the first year of the monitoring program.

City of Greenville. The City of Greenville will undertake the routine monitoring of its lake to assess water quality improvements associated with implementation of its restoration program. This monitoring will include quantitative assessment of water quality in the main tributary streams of the lake (Dry Branch and Kingsbury Branch), at the outfall of each of its structural BMPs (cellular wetland / sediment basin projects), and in the lake itself (at ROP-1, 2, 3 and 7). The following general monitoring program will be established by the City, to be implemented as part of Phase 2 under the Clean Lakes Program and continued as the restoration efforts are initiated in Years 2 and 3.

Tributary Monitoring (Dry Branch and Kingsbury Branch)

- Water Quantity
  1. Stage-discharge relationship
  2. Peak values
  3. Flow characteristics
  4. Discharge modeling
- Water Quality
  1. Phosphorus (total and dissolved)
  2. Nitrate-Nitrite
  3. Ammonia
  4. Total suspended solids
  5. Non-volatile suspended solid
  6. Temperature
  7. pH
  8. Benthic macroinvertebrates
- Frequency
  1. Monthly for ambient condition
  2. Ten storm surge sampling events between May 1 and October 1

BMP Monitoring

- In-flowing Water Quality
  1. Phosphorus (total and dissolved)
  2. Nitrate-Nitrite
  3. Ammonia
  4. Total suspended solids
  5. Non-volatile suspended solid
  6. Temperature
  7. pH
- Water Quality at the Out-fall
  1. Phosphorus (total and dissolved)
  2. Nitrate-Nitrite
  3. Ammonia
  4. Total suspended solids
  5. Non-volatile suspended solid
  6. Temperature
  7. pH
- Frequency
  1. Monthly for ambient conditions
  2. Ten storm surge samping events between May 1 and October 1 (same time as trib monitoring events)

In-Lake Monitoring

- Water Quality
  1. Phosphorus (total and dissolved)
  2. Nitrate-Nitrite
  3. Ammonia

   4. Total suspended solids
   5. Non-volatile suspended solid
   6. Temperature
   7. pH
- Frequency
   1. Monthly
- Locations
   1. ROP-1 (top and bottom), 2, 3 and 7

To promote this monitoring program, the City will establish a permanent monitoring facility on the shores of Governor Bond Lake on City property consisting of a dock, storage / chemistry lab building and other such facilities as needed to undertake this effort.

Laboratory analyses will be conducted by the IEPA lab, at its discretion, or at a private laboratory. A quarterly report of activities, and a final report of findings will be submitted to by the City to the IEPA.

SOURCES OF MATCHING FUNDS

Funding sources for this program include both state and federal agencies, as well as the City of Greenville and private sources (foundations, watershed land owners, etc.). Table 28 provides details regarding the potential funding sources for this program as it is implemented over the next three years.

Clearly, the funding associated with larger projects, such as dredging and rip-rapping of the upper basin, constitutes a substantial investment by the various granting sources and may not be financially feasible. The City of Greenville is committed to pursuing every technically and financially viable project described in the this report, but accepts that without successful pursuit of PL 566 funding or other state or federal financial support, some projects may not be feasible. It is ultimately the responsibility of those agencies dictating the water quality goals to be met by the City of Greenville to financially support the measures needed.

Table 28 Restoration program summary, schedule, cost estimates and matching funds.

WATERSHED PRACTICES				
Practice	*Mechanism*	*Cost*	*Source(s)*	*Schedule*
Construction Site BMPs - silt fences around all construction; require new owners/builders to rip-rap their property; require silt basins if more than 1 Ac is to be disturbed	City / County Ordinance; administered by County	N/A other than Building Inspector's time	City / County General Fund Budget	Begin January 1, 2002, on-going
Septic Tank Inspection Program - 3-year cycle; inspect all septic tanks throughout the watershed; new septic drain-fields must be a minimum of 100 feet from lake or perennial stream	City / County Ordinance; administered by County	N/A other than County Health Inspector's time	City / County General Fund Budget	Begin January 1, 2002, on-going
NRCS Conservation Programs Subsidies - Subsidy payments to participants in NRCS conservation programs, as follows: ➢ Filter strips - add 200 Ac @ \$6/Ac to \$20/Ac for restoration, \$0 for rent ➢ Riparian Buffers - add 100 Ac @ \$42/Ac for restoration, \$0 for rent ➢ General CRP - add \$20/Ac/yr for rent as follows: ⇒ 3-year sign-up period (expect 1,800 new or re-signed CRP acres) ⇒ Include all existing contracts (1,800 acres)	City / NRCS Cooperative Agreement; administered by NRCS	Yr 1 - \$50,590 Yr 2 - \$58,570 Yr 3 - \$66,840 Yr 4 - \$61,200 Yr 5 - \$57,600 Yr 6 - \$54,000 Yr 7 - \$50,400 Yr 8 - \$46,800 Yr 9 - \$43,200 Yr 10 - \$39,600 Yr 11 - \$24,000 Yr 12 - \$12,000	City General Fund Budget (may be supplemented by IDNR C2000 or other grant programs)	Begin with City FY02, continue for 12 years
NRCS Streambank Stabilization Program - Identify and pursue stabilization of 2,640 linear feet of streams leading to the lake	NRCS Contract Private Owners	Yr 1 - \$20,000 Yr 2 - \$50,000 Yr 3 - \$50,000	IEPA Phase II (50%); NRCS grants, Sec 319, IDNR C2000	Calendar '02, '03, '04
Cellular Wetland / Basin Systems - Construct sediment basin/wetland systems to treat for nutrients, as follows: ➢ Construct one system each on Kingsbury Branch, Dry Branch ➢ Construct additional system on Kingsbury Branch ➢ Construct additional systems on tribs to Kingsbury Branch and Dry Branch	ZIES / NRCS, Contracts	Yr 1 - \$250,000 Yr 2 - \$150,000 Yr 3 - \$250,000	IEPA Phase II grant (50%); Sec 319, NRCS EQIP, NFWF, IDNR C2000	Fall grant apps (started in '01), work completed in '02, '03 & '04
Sustainable Ag / BMP Demonstration Project - Use City's 108 Ac parcel at east end of lake (Kingsbury Branch) to demonstrate Conservation Practices, Watershed BMPs and sustainable agriculture concepts	ZIES / NRCS on Greenville City Property	Yr 1 - \$25,000 Yr 2 - \$20,000 Yr 3 - \$20,000	IDNR C2000 Grant ('02), City In-kind services ('03, '04)	Spring '02, then '03 and '04

Table 28 Cont.

IN-LAKE PRACTICES				
Practice	*Mechanism*	*Cost*	*Source(s)*	*Schedule*
Lower Basin : Alum Treatment - Treat 343 Ac of lower basin with Alum (aluminum sulfate) to seal sediments	Contract	Yr 3 - $100,000	IL State grant, Sec. 319, others	Early summer of '04
Lower Basin : Algacide Treatment - Treat 343 Ac of lower basin with Algacide (copper sulfate or similar) to manage algal blooms; applications twice / yr following fall and spring turn-over, for 3 years	City staff or Contract	Yr 1 - $48,000 Yr 2 - $48,000 Yr 3 - $48,000	IEPA (50%), IDNR C2000, Sec. 319, others	Calendar '02, '03, '04
Lower Basin : Bank Stabilization / Reconstruction - Reconstruct & stabilize 4,000 linear feet of shoreline in 7 locations	Contract	Yr 3 - $250,000	PL 566 or other federal grant	FY04
Lower Basin : Rip-Rap Program - Add rip-rap to 9,000 linear feet of shoreline (excluding southeast branch)	Contract	Yr 1 - $50,000 Yr 2 - $125,000 Yr 3 - $500,000	IEPA (50%), Sec. 319, PL 566 IDNR C2000	Calendar '02, '03, '04
Lower Basin : Hypolimnetic Aeration - Install an aeration system in the lower basin (287 Ac, excl. southeast branch) as follows: ➢ 2 to 3 land based air compressors, 30hp - 60hp each ➢ 15 - 25 lines of PVC ➢ 60 - 100 fine bubble diffusers	Contract	Yr 3 - $180,000	Sec. 319, IL State grant(s)	Late summer of '04
Upper Basin : Alum Treatment - Treat 322 Ac of upper basin with Alum (aluminum sulfate) to seal sediments	Contract	Yr 3 - $90,000	Sec. 319, IL State grants	Late summer of '04
Upper Basin : Algacide Treatment - Treat 322 Ac of upper basin with Algacide (copper sulfate or similar) to manage algal blooms; applications twice / yr following fall and spring turn-over, for 3 years	City staff or Contract	Yr 1 - $46,000 Yr 2 - $46,000 Yr 3 - $46,000	IEPA (50%), Sec. 319, IDNR C2000	Calendar '02, '03, '04
Upper Basin : Dredging - Hydraulically dredge 158 Ac (1.5 million cy) to the 514 MSL contour (excl Dry Br Cove)	Contract	Yr 3 - $2.56 million	PL 566 or other federal grant	Early summer of '04
Upper Basin : Rip-Rap Program - Add rip-rap to 18,000 linear feet of shoreline (excl Dry Br Cove)	Contract	Yr 3 - $1.0 million	PL 566 or other federal grant	Calendar '04
Dry Branch Cove - Dredge 40 Ac (390,000 cy) and rip-rap OR **Dry Branch Cove** - Install structure and use as settling basin	Contract NRCS/Contract	Yr 3 - $750,000 Yr 3 - $350,000	PL 566 or other PL 566 or other	Early summer of '04 Ditto
Woburn Road Basin - Dredge 38 Ac (360,000 cy) and rip-rap OR **Woburn Road Basin** - Install structure and use for settling basin	Contract NRCS/Contract	Yr 3 - $310,000 Yr 3 - $100,000	PL 566 or other PL 566 or other	Early summer of '04 Ditto

Table 28 Cont.

GENERAL				
Practice	*Mechanism*	*Cost*	*Source(s)*	*Schedule*
Increase Patrols and Fines re: No-Wake Violations	City Lake Patrol	N/A other than Lake Patrol time	City General Fund Budget	FY02
Increase No-Wake Areas - Along shorelines, from state-mandated 150 ft to 200 ft; add No-Wake buoys along shoreline every 500 feet	City Lake Patrol	Yr 1 - $4,000 for buoys	City General Fund Budget	FY02
Maintain All Coves as No-Wake and Enforce	City Lake Patrol	N/A other than Lake Patrol time	City General Fund Budget	FY02
Prohibit Wake-creating Devices - Prohibit use of water bladders or other wake-producing devices in all watercraft	City Ordinance	N/A	N/A	Calendar '02
Monitoring Program - Begin Watershed Monitoring Program, including water quality analyses in-lake, stream sampling, and monitoring of outfall water quality from each structural BMP	Partner or Contract	Yr 1 - $87,000 Yr 2 - $33,000 Yr 3 - $33,000 Yr 4 thru Yr 10 - $35,000/yr	City General Fund, IEPA Phase II (50%), Sec. 319, etc.	FY02, then Calendar 2003 thru 2011

IMPORTANT NOTES:

The preceding tables, as well as those that follow, identify by calendar year the projects to be undertaken and potential funding sources. PROJECTS ARE LISTED IN THE YEAR IN WHICH THEY ARE TO OCCUR AND THE YEAR IN WHICH FUNDS ARE TO BE SPENT. In order to have proper funding in place for the projects associated with this program, THE GRANT APPLICATION PROCESS AND ASSOCIATED PLANNING MUST BEGIN IMMEDIATELY. Project costs have been allocated to funding sources based on:

- Funding source criteria for projects;
- Funding source annual limits on funding;
- Funding source matching funds requirements (particularly state vs. federal).

Funding sources listed are only some of the sources, both State of Illinois and Federal, that may provide underwriting of these projects. In cases where funding sources are noted as "etc." or "others" it is anticipated that separate Federal funding (congressional or other federal program) may be allocated to the project. In cases where an "IL State grant" in noted, it is anticipated that separate Illinois State money (legislative or other state program) may be allocated to the project.

Table 28 Cont.

YR 1 - 2002							
	Project Cost	*IEPA Ph II*	*NRCS EQIP*	*Sec. 319*	*PL 566*	*IDNR C2000*	*City Budget*
Construction Site BMPs	N/A						
Septic Tank Inspection Program	N/A						
NRCS Conservation Programs Subsidies	$50,590						$50,590
NRCS Streambank Stabilization Program	$20,000	$10,000	$10,000				
Cellular Wetland / Basin Systems	$250,000	$125,000	$125,000				
Sustainable Ag / BMP Demonstration Project	$25,000					$25,000	
Lower Basin : Algacide Treatment	$48,000	$48,000					
Lower Basin : Rip-Rap Program	$40,000	$20,000					$20,000
Upper Basin : Algacide Treatment	$46,000	$46,000					
Monitoring Program	$87,000	$33,000					$54,000+
Increase No-Wake Areas	$4,000	$2,000					$2,000
Total by Source:		**$284,000**	**$135,000**	**0**	**0**	**$25,000**	**$126,590**
ANNUAL TOTAL:	**$570,590**						

+ Set-up costs for Monitoring Program

YR 2 - 2003							
	Project Cost	*IL State grant*	*NRCS EQIP*	*Sec. 319*	*PL 566*	*IDNR C2000*	*City Budget*
NRCS Conservation Programs Subsidies	$58,570					$29,285	$29,285
NRCS Streambank Stabilization Program	$50,000		$15,000	$15,000		$20,000	
Cellular Wetland / Basin Systems	$150,000		$50,000	$50,000		$50,000	
Sustainable Ag / BMP Demonstration Project	$20,000					$10,000	$10,000♦
Lower Basin : Algacide Treatment	$48,000			$24,000		$24,000	
Lower Basin : Rip-Rap Program	$125,000			$50,000		$50,000	$25,000
Upper Basin : Algacide Treatment	$46,000			$23,000		$23,000	
Monitoring Program	$33,000			$16,500			$16,500
Total by Source:		**0**	**$65,000**	**$178,500**	**0**	**$206,285**	**$80,785**
ANNUAL TOTAL:	**$520,570**						

♦ In-kind services

Table 28 Cont.

YR 3 - 2004							
	Project Cost	*IL State grant*	*NRCS EQIP*	*Sec. 319*	*PL 566*	*IDNR C2000*	*City Budget*
NRCS Conservation Programs Subsidies	$66,840					$33,420	$33,420
NRCS Streambank Stabilization Program	$50,000		$15,000	$15,000		$20,000	
Cellular Wetland / Basin Systems	$250,000		$75,000	$75,000		$100,000	
Sustainable Ag / BMP Demonstration Project	$20,000					$10,000	$10,000♦
Lower Basin : Alum Treatment	$100,000	$50,000		$50,000			
Lower Basin : Algacide Treatment	$48,000	$24,000		$24,000			
Lower Basin : Bank Stabilization / Reconstruction	$250,000				$250,000		
Lower Basin : Rip-Rap Program	$500,000				$500,000		
Lower Basin : Hypolimnetic Aeration	$180,000	$90,000		$90,000			
Upper Basin : Alum Treatment	$90,000	$45,000		$45,000			
Upper Basin : Algacide Treatment	$46,000	$23,000		$23,000			
Upper Basin : Dredging	$2,560,000				$2,560,000		
Upper Basin : Rip-Rap Program	$1,000,000				$1,000,000		
Dry Branch Cove Dredging or Structure	*						
Woburn Road Basin Dredging or Structure	*						
Monitoring Program	$33,000			$16,500		$16,500	
Total by Source:		**$232,000**	**$90,000**	**$338,500**	**$4,310,000**	**$179,920**	**$43,420**
ANNUAL TOTAL:	**$5,193,840***						

♦ In-kind services

* Totals exclude costs for work in Dry Branch Cove or Woburn Road Basin - alternatives analysis is incomplete at this time

ENVIRONMENTAL EVALUATION

1. Displacement of People. There will be no persons displaced as a consequence of any activities proposed under this restoration program. The dredging efforts will primarily utilize open fields for containment and drying, while dried material will be hauled to willing land owners in the watershed.

2. Defacement of Residential Areas. There will be no defacement of residential areas as a consequence of any activities under this restoration program. All structural efforts will improve the quality of the surroundings for residential areas, including improvements to eroded properties, clarity of water and quality of septic outfalls.

3. Changes in Land Use Patterns. There will be no changes in land use patterns as a consequence of any activities under this restoration program. The rural character of the watershed of Governor Bond Lake will be maintained.

4. Impacts on Prime Agricultural Land. There will be no negative impacts to prime agricultural lands, though there are likely to be positive impacts in that dredged material high in nutrients may become available to watershed land owners.

5. Impacts on Parkland, Other Public Land, and Scenic Resources. There will be no impacts to parklands, public lands or scenic resources as a consequence of any activities under this restoration program.

6. Impacts on Historic, Architectural, Archaeological or Cultural Resources. There will be no impacts to cultural resources of any kind as a consequence of any activities under this restoration program.

7. Long Range Increases in Energy Demand. There will be no long range increases in energy demand as a consequence of any activities under this restoration program. There are likely to be periodic, short-term increases associated with construction of various watershed and in-lake BMPs.

8. Changes in Ambient Air Quality or Noise Levels. There will be no changes in ambient air quality or noise levels as a consequence of any activities under this restoration program. There are likely to be periodic, short-term increases associated with construction of various watershed and in-lake BMPs.

9. Adverse Effects of Chemical Treatment. At concentrations required for algal control, copper-based herbicides can create concentration levels of copper that can adversely affect aquatic invertebrates. *Daphnia* (Cladocera), *Gammarus* (Amphipoda), snails and clams (Mollusca), and some aquatic insects are quite sensitive to copper. The elimination or reduction in population density of algae-grazing zooplankton, such as *Daphnia*, may account for the rapid rebound of phytoplankton in a lake after a copper application. Use of algacides is proposed only temporarily, during the first two years

of the restoration program, as a means of improving water clarity and reducing DO-depleting effects of algal bloom and die-off until nutrient management efforts can be implemented.

The use of alum (aluminum sulphate) can have severe negative impacts and care must be exercised with regard to dosage. The potential or toxicity problems is directly related to the alkalinity and pH of the lake water. The pH and alkalinity of the water are likely to fall during the treatment, and so a buffered alum, which is readily available, must be considered for use if needed.

10. Compliance with Executive Order 11988 on Floodplain Management. This project complies with EO 11988 on Floodplain Management.

11. Dredging and Other Channel, Bed or Shoreline Modifications. Dredged material associated with this project will be placed and confined in an upland area. Materials to be dredged have been tested as part of this study and found to be free of hazardous or toxic materials. Channel modifications, such as streambank stabilitzation, will occur in areas which are not jurisdictional waters of the United States under Section 404 of the Clean Water Act. Shoreline stabilization will be conducted in a manner consistent with Nationwide Permits for such activities.

12. Adverse Effects on Wetlands and Related Resources. There will be no adverse effects on wetland and related resources as a consequence of any activities under this restoration program. Wetlands and wildlife habitat, riparian buffers and other such resources will be created, enhanced and improved under this program.

13. Feasible Alternatives to Proposed Project. There are no feasible alternatives to the proposed restoration program that's what this feasibility study is intended to illustrate.

14. Other Necessary Mitigative Measures. There are no other mitigative measures necessary as part of this restoration program.

CONCLUSIONS

In conclusion, the restoration program outlined above will accomplish the objectives as outlined, and will also provide the added benefit of meeting TMDL requirements for wasteload reductions. The implementation of this program will ensure the long and healthy future of Governor Bond Lake.

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PHASE 1 DIAGNOSTIC FEASIBILITY STUDY OF GOVERNOR BOND LAKE

APPENDIX 1

GOVERNOR BOND LAKE RESOURCE PLAN

GOVERNOR BOND LAKE RESOURCE PLAN

JULY 1, 1999

GOVERNOR BOND LAKE ECOSYSTEM PLAN

Introduction

This watershed management plan has been prepared at the request of the Governor Bond Lake Planning Committee and the people in the communities served by Governor Bond Lake. This report was prepared by the Bond County Soil and Water Conservation District (SWCD) with assistance from the Natural Resources Conservation Service (NRCS). Bond County SWCD and NRCS personnel also served as facilitators for planning committee meetings. Development of the Lake Planning Committee was facilitated by the SWCD to provide guidance and oversight for the planning process and the production of this report. The planning group is comprised of watershed farmers, representatives from the City of Greenville, homeowners around the lake, and Greenville Water Plant representatives. The goal of the planning committee is to develop a comprehensive plan to manage the natural resources in the watershed and therefore maintain or improve the quality of life in the Governor Bond Lake area. Inventories and recommendations have been conducted for the five major natural resource concerns: soil, water, air, plants and animals (SWAPA). Special care has been taken to recognize not only the interaction between these natural systems but the needs and relationships of humans in the system as well.

Planning Committee:

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Margaret Fertaly, Illinois Environmental Protection Agency (IEPA)
Dan Mueller, Natural Resources Conservation Service (NRCS)
Dan Feldmann, Bond County Soil & Water Conservation District (SWCD)
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Jeff Stone, Bond County Health Department
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Jeff White, Natural Resources Conservation Service (NRCS)
Marvin Brown, Natural Resources Conservation Service (NRCS)
Manny Wei, Natural Resources Conservation Service (NRCS)

Background

The dam for the 775-acre Governor Bond Lake is located in Section 35 of LaGrange Township in Bond County, approximately two miles north of Greenville (Figure 1). Including the lake's surface, the Governor Bond Lake watershed encompasses approximately 22,000 acres in Bond and Montgomery Counties (Figure 2). The maximum depth of Governor Bond Lake is 24 feet, and the average depth is 20 feet below the railroad tressel, and nine feet above the tressel. There are 19 miles of shoreline (Figure 3). Governor Bond Lake was built in 1968-70 as a water supply lake for the cities of Greenville, Mulberry Grove, Donnellson, and Smithboro. The community of Royal Lake was later added to this system. There are also some rural homes on the system, which makes a total of 7,600 water customers (Table 1).

A sediment survey was conducted in Governor Bond Lake in November 1995 by the NRCS. The report concluded that one-half of the depth had been lost in certain reaches of the upper parts of the lake, which would equal one-third of the lake's volume. The IDNR Fisheries Division points out that erosion and subsequent silt deposition are a problem in this lake, and a concern for citizens of the area. Shoreline erosion has also been identified as a problem in Governor Bond Lake.

The first meeting of the Governor Bond Lake Planning Committee was held at the U. S. Department of Agriculture (USDA) office in Greenville in 1993. At this meeting the main concerns identified were water quality, septic systems, erosion control, toxic spills / contingency plans, and recreational pollutants.

As a result of those initial planning efforts, several programs are already underway in the Governor Bond Lake watershed. Environmental Quality Improvement Program (EQIP) monies are used to encourage farmers to adopt water quality improvement practices on their farms. About 15 percent of watershed farmers have been enrolled in the Conservation Reserve Program (CRP). The "T by 2000" Illinois Department of Agriculture (IDOA) cost-share program has been promoted by Bond County SWCD, and is being used by some farmers in the watershed to reduce erosion. The IEPA has spoken to the committee about the Section 314 Clean Lakes Program.



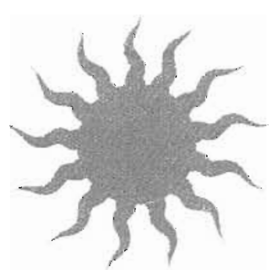


TABLE 1

Lake Characteristics	
Lake Surface Area	775 Acres
Maximum Depth	24.0 Feet
Miles of Shoreline	19 Miles
Volume of Water Storage	10,075 ac-ft
Lake Ownership	City of Greenville
Major Tributaries	Kingsbury Branch and Dry Branch
Major Outflows	Kingsbury Branch
Water Supply Usage	467,000,000 Gallons per year
Recreational usage	59,615 visitor hours

Watershed Land Use

Land use in the watershed is primarily cropland. Approximately 87 percent of the watershed is farmland. Eighty percent of the total watershed is devoted to row crop production (Table 2).

TABLE 2

Watershed Land Use

LAND USE	ACRES	PERCENTAGE OF WATERSHED
Cropland (sodic soils)	7,980	36.0%
Cropland (non-sodic soils)	9,698	44.0%
Pasture	1,350	6.1%
Forest/Wildlife	1,742	8.0%
Farmsteads/urban (other)	431	2.0%
Water	879	3.9%
Totals	22,080	100%

Population. According to the 1990 Census, the population of Greenville and Bond County is 4,806 and 14,991 respectively. Currently, the population for Greenville and Bond County has increased to 6,438 and 16,321 respectively.

Agriculture. There are 275 operating tracts that comprise 17,658 acres of cropland in the watershed. The principle crops grown are corn, soybeans and wheat. In Bond County, the overall average corn yield is 110 bushels/acre, the average soybean yield is 35 bushels/acre, and the average wheat yield is 50 bushels/acre. (Illinois Agricultural Statistics, 3 year average of 1993, 1994, and 1995 crop years.)

There are nine farms in the watershed which have livestock and are operated as feedlots or open pasture. These farms are summarized as follows:

Type	No. Farms	No. Head
Dairy	1	100
Beef	5	100
Hogs	3	300

Based on the 1992 Census of Agriculture, the market value of all agricultural products sold in Bond County was $45,000,000 of which 58 percent was from the sale of crops and 42 percent was from livestock and poultry. The average market value of agricultural products sold per farm was $71,600.

Soil

The soils in the Governor Bond Lake watershed have developed under both prairie vegetation and forested vegetation. A general description of the soils is as follows:

- Steeply Sloping Timber Soils – Steep, well-drained soil, occurring on slopes ranging form 20 to 30 percent. Often times, these are the soils that are immediately adjacent to the lake. Hickory is the typical soil type within this group. This group of soils developed on exposures of weathered glacial till with a thin loess cover less than 4 feet.
- Upland Timber Soils – Light colored, silt loam soil with moderately slow permeability. These soils occur on slopes ranging from 0 to 10 percent. They developed in loess and the underlying weathered Illinoian till. Typical soils are Atlas, Bluford, and Wyrosse.
- Prairie Soils – Nearly level, somewhat poorly drained to poorly drained soils, located in shallow depressions and on low ridges throughout the watershed. Typically the surface layer is much darker and thicker than under the timber soils. Typical soil types are Cisne and Hoyleton.
- Sodium (Natric) Soils – Of special note in this watershed are soils that have an accumulation of sodium in their subsoils much high than "normal." These soils are poorly and somewhat poorly drained and most often are located on broad upland plains and low ridges. These soils also contain high amounts of clay in their subsoils. They have a "dispersed" subsoil, due to the high sodium. This clay dispersion or "clay plugging," plus the high total clay content, causes these soils to have very slow permeability. This feature affects all use and management of these soils, from erosion to urban uses. Typical soil types are Darmstadt, Huey, and Piasa.

Kingsbury Branch has wide flat-bottomed valleys suitable for cultivation which attain widths of a quarter mile in some places. Where these valleys are deepest, their floodplains lie some 50 to 60 feet below the average upland levels. The last glacier (Illinoian) moved across a subdued land surface whose depressions were filled by the drift of the earlier glaciers. The glacial deposits in this area were laid down on a surface that apparently had about as much relief as that of the present average upland surface. One of the principle pre-glacial valleys, followed generally by the present valley of Kingsbury Branch, extends from northeast to southwest across Bond County. There are numerous places along the valleys in this area where as much as 40 to 50 feet of Illinoian drift is exposed, and along Dry Branch in the northern part of the watershed, 30 feet is exposed. The glacial deposits were mantled with an average thickness of four feet of loess.

The geological processes that have been active in this area since the glaciers melted from the mainland of North America include weathering, erosion, slope wash, and wind. Erosion has developed to the point where possibly only one-fourth of the upland area is ineffectively drained. Dry Fork Creek, the northern tributary, has not only widened the valley in this watershed but has also deepened it.

Governor Bond Lake is a relatively young lake, but siltation has significantly reduced the volume of the lake from a water supply standpoint. Also, recreational use and fish habitats have been negatively affected. Governor Bond Lake is bisected at two points: by a railroad causeway and trestle (mid-lake) and an elevated fill road (upper lake). The railroad tressel that divides the lake tends to create two lakes with different water quality characteristics. The area north of the roadway acts as a silt basin for the Kingsbury Branch inflow; the railroad trestle effectively detains water, trapping most of the soil particles before they are transported to the lower end of the lake. The upper area of the lake (above the roadway and trestle), therefore, has higher levels of turbidity.

Using the 1985 Food Security Act definition, there are 1,780 acres of highly erodible soils in the Governor Bond Lake watershed in pasture, hayland, and woodland. About 1,505 acres of the highly erodible soils are in cropland and are eroding at an average of 16 tons/acre/year. There are 5,642 acres of potentially highly erodible soils in the watershed where sheet and rill erosion generates approximately 6.5 tons/acre/year. Another 10,552 acres of cropland contribute an average annual soil loss of 2.5 tons/acre/year. The remaining 2,622 acres of watershed contains pasture, woodland, urban areas, and streams, ponds and lakes. These erosion figures are based on pre-1985 Food Security Act FSA plan applications and soil losses. The housing developments and construction activities add to the soil lost, and eroded into the lake, since all are close to the shoreline. Any erosion that takes place is discharged directly into the lake (Table 3).

TABLE 3

Sources of Sediment

Erosion Sources	Gross Erosion (Ton/yr.)	Sediment Delivery Ratio (SDR)	Gross Sedimentation (tons/yr.)
Sheet and Rill:			
Cropland	85,316	0.70	59,700
Pasture	5,400	0.75	4,050
Woodland	6,969	0.80	5,575
Other	862	0.80	690
Total Sheet & Rill	98,546		70,015
Ephemeral	11,825	0.90	10,600
Gully	11,390	0.90	10,250
Streambank	1,050	1.0	1,050
Shoreline	1,420	1.0	1,420
TOTAL	124,231		93,320
Sediment Transport Factor (STF)			x 0.35
Sediment delivered to the lake yearly			32,670 tons

For further comparisons, see Attachment #1 on erosion rates after control measures are entered.

Gully, ephemeral gully and streambank erosion has not been specifically measured at this time, but these sources of erosion could add as much as 15,768 tons of sediment to the lake each year. Although sedimentation has not yet threatened the lake as a water supply from a volume perspective, the effects of sedimentation are obvious. Boaters on Governor Bond Lake report difficulty in reaching the upper end of the lake because of sedimentation. In addition, sedimentation has caused a reduction in Governor Bond Lake's water storage capacity. The estimates from NRCS' sediment survey indicated one-half the depth has been lost in the upper part of the lake, which yields losing one-third of the lake's volume and water-holding capacity.

Water

Annual precipitation in the Governor Bond Lake area is approximately 38 inches with 58 percent occurring from April through September. In addition to the 775-acre Governor Bond Lake, there are approximately 60 smaller water impoundments in the watershed. These impoundments range in size from 0.25 acres to 3.0 acres and are typically used for recreation or livestock water. A few of the impoundments are used as domestic water supplies for individual families, but most rural residents obtain their drinking water from shallow, excavated wells. During periods of drought, such as in 1983 and 1988, both shallow wells and small impoundments are reportedly unreliable water sources. The Governor Bond Lake watershed is basically linear in shape with approximately eight miles of perennial streams and five miles of intermittent streams as tributaries.

Governor Bond Lake is the primary water source for Greenville, Mulberry Grove, Donnellson, Smithboro, and Royal Lake. Currently the lake serves approximately 7,600 water users. As a result of the excessive levels of sediments that raise the amount of treatment needed, the water usage may be placed on restricted status. This status prohibits the extension of new water lines which in turn inhibits growth in the communities served by the water plant. Poor overall raw water quality has had an impact on the use of this lake as a public water supply. The lake is also utilized heavily for recreational purposes. Permitted activities are as follows: fishing, boating, Scouts, camping, and miscellaneous visits to the lake each year.

In addition to the above user visits, the Underwater Search and Rescue Team would normally be included, but has to perform training at locations other than Governor Bond Lake due to its turbidity. Soil, organic material and pesticides which have washed into the lake since its construction in 1968 have negatively impacted all of its uses. Fishing, boating, aquatic life, and aesthetics have all been impaired, and the overall water quality degradation in Governor Bond Lake continues. The IDNR (formerly the Illinois Department of Conservation) is very interested in the water quality and habitat for fisheries. More information about fisheries is located in the "Animal" section of this report.

Another concern in the watershed is the increase in housing development around the lake. All of the homes are on aeration units or septic tanks. With the tight subsoils and drainage towards the lake, the concern is that any effluent that is discharged will eventually enter the lake. Over a period of years and from over 100 homes, this can add to the nutrient loading of the lake (see Attachment #2).

Air Quality

The air quality in the Governor Bond Lake watershed area has not been specifically inventoried nor has it been listed as a priority concern by the residents in the watershed.

Plant Inventory

The dominant plant species in the Governor Bond Lake watershed are grain and forage plants. Corn, soybeans and wheat are the primary crops produced in the watershed. Grain sorghum is also produced in the watershed.

Much of the strongly sloping agricultural lands are planted to permanent vegetative cover. Forage species are dominated by cool-season grasses and legumes. Tall fescue is the most abundant pasture grass. Various mixes of alfalfa, red clover, tall fescue, orchard grass, smooth brome grass and timothy are typical of hay crops. Sorghum-sudan grass is occasionally used as a forage crop.

There are 2,600 acres of cropland in the watershed enrolled in the Conservation Reserve Program. The acreage is planted to a mixture of cool-season grasses and legumes, trees, and wildlife food plots.

Timber in the watershed is located on either sloping ground or wet ground next to creeks. Typical species include red, white and black oaks, shagbark hickory, American elm, silver, red, and sugar maples, box elder, sycamore, hackberry, and persimmon. Eighty percent of the timber is in private ownership and is immediately adjacent to the lake or its tributaries. There are no large, contiguous tracts of timber in the watershed.

Animals

The fishery resource has been rated as a major concern in Governor Bond Lake. The upper half of the lake has higher levels of turbidity than the lower half, which result in less aquatic vegetation. In addition, high levels of turbidity also can be responsible for lower dissolved oxygen levels, decreased fish reproduction, increased fish diseases, and poor body condition of the fish; all of these can contribute to a shift in the species composition from game fish to rough fish. Fisheries Biologists of the IDNR report that there is little aquatic vegetation in the north end of the lake, and the crappie are very thin. Sediment deposition in the upper end has decreased the available fish habitat by blanketing potential spawning areas with silt. Continuing deterioration of Governor Bond Lake will impact the viability of many of the species occurring in the lake, especially of those species, such as muskie, requiring relatively clean water and high dissolved oxygen levels. As fish populations are impacted due to the deterioration in the water quality in Governor Bond Lake, the use of the lake for recreational fishing will decline. The algae bloom at the entrance of Dry Branch appears annually and contributes negatively to oxygen levels in the lake. Tiger Muskie and Hybrid Striped Bass have been added to the lake, but could not survive due to the water temperature and turbidity.

Threatened and Endangered Animals:

- The Indiana bat (*Myotis sodalis*) has been found in Bond County, but none have been specifically identified in the Governor Bond Lake area.
- A black-crowned night heron (*Nycticorax nycticorax*) was seen during an Atlas survey by IDNR in 1992 at the east end of Governor Bond Lake.

Livestock also are produced in the watershed. There are nine producers in the watershed with permanent livestock herds. Hogs and cattle represent the majority of the farm animals, but there are some sheep and exotic animals produced. The majority of hogs are produced in confinement systems with the balance being feedlot / free-range. The cattle, sheep and exotics are primarily raised in a pasture / feedlot system.

Human

There are 175 farms in the watershed, and farm sizes average 285 acres per farm (Table 4). Areas of woodland and grass are generally located on sloping areas along drainage ways. There are no documented sites of cultural significance in the Governor Bond Lake watershed; however, the Bond County area does have some recorded pre-historic and historically significant sites, so there is a potential for the existence of such sites in the watershed.

TABLE 4

Watershed Demographics

Number of farms in the project	175
Low income or minority farms	3
Type of farms	Grain and livestock
Average farm size	285 acres

The human recreational benefits of Governor Bond Lake have been discussed in the "Water" segment of this report. The lake offers diverse and unique recreation opportunities in the Governor Bond Lake area. Aesthetic enjoyment of the lake has been adversely impacted by high levels of turbidity, excessive shoreline erosion, and exposure of sediment flats in the upper end of the reservoir.

Governor Bond Lake

Resource Plan

Action Items

TITLE	NO	ITEM	** RESPONSIBILITY	START	END	OMPLETE	BUDGET IN-KIND AGENCY	IN-KIND INDIVIDUAL	FUNDING NEEDED
OBJECTIVE	1	**IMPROVE THE WATER QUALITY OF GOVERNOR BOND LAKE -- (Non-Sediment Related)**							
GOAL	1	**Determine the current level of water quality in the lake Establish a "before" or "benchmark" level for future reference**							
ACTION ITEMS	1	Research existing reports on the lake (EPA, Greenville College, IDNR, NRCS, etc.)	NRCS EI	Jun-99	Jul-99		$ 500.00	---	---
	2	List chemicals and perameters (EPA limits)	WATER	Jun-99	Jul-99		$ 100.00	---	---
	3	Farm-A-Syst Program with Mark Worth, IDOA	SWCD CES	Jun-99	Jun-01		$ 1,000.00	---	---
GOAL	2	**Address the concern of livestock waste entering the lake**							
ACTION ITEMS	1	Locate and categorize all livestock facilities in the watershed, determine animal "units" per facility	NRCS SWCD	Jun-99	Jul-99		$ 500.00	---	---
	2	Contact all livestock operations in the watershed and present information on the benefits of preparing animal waste management plans	NRCS SWCD	Jul-99	Sep-99		$ 1,000.00	$ 100.00	---
	3	Prepare animal waste plans, and nutrient management plans for all landowners in the watershed who request them.	NRCS SWCD	Aug-99	Jun-01		$ 4,000.00	$ 250.00	---
	4	Include animal waste related articles in at least every other quarterly newsletter	NRCS SWCD	Jun-99	Jun-01		$ 120.00	---	---
	5	Include animal waste construction practices in any request for cost-share moneys, or grant applications	NRCS SWCD	Jun-99	Jun-01		—	---	---

TITLE	NO	ITEM	** RESPONSIBILITY	START	END	OMPLETE	BUDGET IN-KIND AGENCY	IN-KIND INDIVIDUAL	FUNDING NEEDED
GOAL	3	**Address the concern of agricultural fertilizers, pesticides, and herbicides entering the lake**							
ACTION ITEMS									
	1	Work to reduce soil erosion on cropland, thereby reducing the amount of chemicals being transported into the lake	NRCS SWCD	Jun-99	Jun-01		---	---	---
	2	Increase the number of acres of cropland enrolled in the Conservation Reserve Program (CRP)	NRCS	Jun-99	Jun-01		$ 2,000.00	$ 250.00	—
	3	Present information to landowners about the benefits of preparing nutrient management plans for their cropland acres	NRCS SWCD	Jun-99	Jun-01		$ 2,000.00	---	---
	4	Prepare nutrient management plans for all landowners in the watershed who request them	NRCS SWCD	Jul-99	Jun-01		$ 6,000.00	$ 500.00	---
	5	Print article in newsletter with rates of applying nitrogen, plus legume credits C78according to University of Illinois	NRCS SWCD	Jun-99	Jun-01		$ 60.00	---	---
GOAL	4	**Address the concern of homeowners pollutants entering the lake**							
ACTION ITEMS	1	Develop a list of items that are classified as "Homeowners' Pollutants"	BCHD	Jun-99	Jul-99		$ 40.00	—	---
	2	Include articles in the quarterly newsletter about what items are classified as "homeowners' pollutants"	BCHD	Jun-99	Jul-01		$ 120.00	—	---
	3	Conduct an annual clean-up day for homeowners to bring listed pollutants to a central drop-off point for disposal	BCHD CES	3rd Sat. of 2000 -	April 2001		$ 600.00	---	$ 2,000.00
	4	Pursue grants for clean-up day	BCHD CES RC&D	Jun-99	Apr-01		$ 400.00	---	—

TITLE	NO	ITEM	** RESPONSIBILITY	START	END	OMPLETE	BUDGET IN-KIND AGENCY	BUDGET IN-KIND INDIVIDUAL	FUNDING NEEDED
GOAL	5	**Address the concern of the impact poor water quality would have on fish and wildlife in and around the lake**							
ACTION ITEMS	1	Include information in the quarterly newsletter about the impact that reduced water quality would have on the fish population in the lake	IDNR	Jun-99	Jun-01		$ 60.00	---	---
	2	Conduct a survey at the lake, asking anglers questions about the lake, and what they would like to see improved	IDNR CES	May-00			$ 600.00	---	$ 600.00
	3	Research existing fish counts and IDNR fish shocking records to show any changes in the lake over the years	IDNR NRCS	Jun-99	Aug-99		$ 250.00	---	---
BJECTIVE	2	**ADDRESS THE NUMBER OF SEPTIC SYSTEMS ADJACENT TO THE LAKE (WITHIN 500') AND DETERMINE AFFECT TO WATER QUALITY**							
GOAL	1	**Reduce the amount of pollutants entering the lake from old-fashioned, or poorly functioning, septic systems**							
ACTION ITEMS	1	Have all septic systems adjacent to the lake inspected annually	BCHD	Jun-99	Jun-01		$ 6,000.00	---	---
	2	Include articles in the quarterly newsletter in regards to proper septic system use and maintenance	BCHD	Jun-99	Jun-01		$ 120.00	---	---
	3	Extend outreach efforts to all septic system users in the watershed	BCHD CES	Aug-99	Jun-01		$ 800.00	---	—
GOAL	2	**Establish construction and installation requirements for new construction that is adjacent to the lake (within 500' of water)**							
ACTION ITEMS	1	Have all private sewage disposal systems meet current Illinois Department of Public Health standards, and all local ordinances	BCHD	Jun-99	Jun-01		$ 1,000.00	---	---

TITLE	NO	ITEM	** RESPONSIBILITY	START	END	OMPLETE	BUDGET IN-KIND AGENCY	IN-KIND INDIVIDUAL	FUNDING NEEDED
OBJECTIVE	3	**ELIMINATE OR REDUCE SOIL EROSION IN THE WATERSHED**							
GOAL	1	**Reduce the rate of soil erosion on cropland fields in the watershed**							
ACTION ITEMS	1	Increase acreage of no-till farming in the watershed	NRCS SWCD	Jun-99	Jun-01		$ 1,600.00	—	---
	2	Prepare conservation farm plans on 80+C152% of the cropland acres in the watershed	NRCS SWCD	Jul-99	Jun-01		$ 7,500.00	$ 750.00	---
	3	Submit an application to USDA to have the watershed designated an EQIP priority area	NRCS	Feb-00			$ 1,600.00	$ 250.00	$ 185,000.00
	4	Convert additional acres of cropland to CRP	NRCS	Jun-99	Jun-01		$ 4,000.00	$ 500.00	---
	5	Recognize landowners who are reducing soil erosion on their property	SWCD CES	Jun-99	Jun-01		$ 1,000.00	---	$ 2,000.00
	6	Increase application of best management practices (BMP's) within the watershed	NRCS SWCD	Jun-99	Jun-01		$ 1,000.00	---	$ 1,000.00
	7	Submit application for EPA 319 funding for erosion reduction practices	NRCS EI	Feb-00			$ 800.00	$ 800.00	$ 85,000.00
GOAL	2	**Reduce the rate of soil erosion on pastureland in the watershed**							
ACTION ITEMS	1	Prepare pasture management plans for 75% of the pasture acreage in the watershed	NRCS SWCD	Oct-99	Jun-01		$ 2,800.00	---	---
	2	Conduct pasture/hayland management workshop in watershed, every other year	NRCS SWCD CES	Jul-00	Jul-01		$ 1,200.00	$ 250.00	$ 750.00
	3	Include pasture management information in one of the quarterly newsletters each year	NRCS SWCD CES	Jun-99	Jun-01		$ 80.00	---	---
	4	Recommend livestock be fenced off from the lake to reduce bank erosion	NRCS	Oct-99	Jun-01		$ 1,000.00	—	---

TITLE	NO	ITEM	** RESPONSIBILITY	START	END	OMPLETE	BUDGET IN-KIND AGENCY	IN-KIND INDIVIDUAL	FUNDING NEEDED
GOAL	3	**Reduce the rate of soil erosion on woodland acreage in the watershed**							
ACTION ITEMS	1	Encourage landowners to fence off the wooded portions of their pastures, in order to exclude livestock	NRCS IDNR	Jul-99	Jun-01		$ 1,000.00	$ 250.00	$ 1,000.00
	2	Install woodland erosion control structures, to reduce gully erosion	NRCS	Oct-99	Jun-01		$ 2,000.00	$ 500.00	$ 1,000.00
	3	Recommend woodland management to landowners to further reduce erosion	NRCS IDNR	Jun-99	Jun-01		$ 1,000.00	$ 500.00	---
GOAL	4	**Reduce the rate of soil erosion disturbed areas (road ditches, construction sites, etc.)**							
ACTION ITEMS	1	Schedule a contractor meeting, every other year, to present information to contractors, road commissioners, home builders, etc.	NRCS SWCD CES	Feb-00	Feb-01		$ 600.00	$ 100.00	$ 600.00
	2	Make landowners aware of Illinois Erosion and Sediment Control Act, administered by the Soil and Water Conservation District	SWCD NRCS	Jun-99	Jun-01		$ 1,000.00	---	---
	3	Make contractors aware of Illinois Erosion and Sediment Control Act, administered by the Soil and Water Conservatin District	SWCD NRCS	Jun-99	Jun-01		$ 1,000.00	---	—
GOAL	5	**Reduce the rate of soil erosion along the shoreline of the lake**							
ACTION ITEMS	1	Install rip-rap along the shoreline to reduce erosion	CITY	Jul-99	Jun-01		$ 4,000.00	$ 500.00	$ 187,000.00
	2	Plant native vegetation into the shallow water next to the shoreline, to help reduce shoreline erosion	CITY IDNR NRCS	Oct-99	Jun-01		$ 4,000.00	$ 1,000.00	$ 5,000.00

TITLE	NO	ITEM	** RESPONSIBILITY	START	END	OMPLETE	BUDGET IN-KIND AGENCY	BUDGET IN-KIND INDIVIDUAL	FUNDING NEEDED
GOAL	5	**Continued**							
	3	Investigate additional shoreline protection practices (cabling tree tops, willow posts, wattling, etc.), and install where feasible	CITY IDNR NRCS	Jul-00	Jun-01		$ 3,000.00	$ 500.00	$ 35,000.00
GOAL	6	**Reduce the rate of soil erosion along streambanks leading into the lake**							
ACTION ITEMS	1	Promote the use of filter strips, and riparian buffers next to streams and creeks	NRCS SWCD CES	Jun-99	Jun-01		$ 1,000.00	$ 500.00	---
	2	Enroll 200 acres of cropland into the CRP Filter Strip Program, and 100 acres into the CRP Riparian Buffer Program	NRCS	Jun-99	Aug-00		$ 3,000.00	$ 500.00	---
	3	Install streambank stabilization practices along 2,640 feet of streambanks leading into Gov. Bond Lake	NRCS SWCD	Jun-99	Jun-01		$ 20,000.00	$ 500.00	$ 105,000.00
	4	Encourage livestock farmers to fence off streams and creeks from the rest of the pasture land	NRCS SWCD	Oct-99	Jun-01		$ 1,000.00	$ 250.00	---
GOAL	7	**Investigate the use of sediment basins in the watershed**							
ACTION ITEMS	1	Conduct a phase 1 Clean Lakes Program study	City EI	May-99	Aug-00		$ 24,000.00	$ 1,000.00	$ 36,000.00
OBJECTIVE	4	**ADDRESS THE CONCERN OF TOXIC SPILLS AND HAZARDOUS WASTE ENTERING THE LAKE**							
GOAL	1	**Review existing "rapid response" plans in place for Gov. Bond Lake**							
ACTION ITEMS	1	Present the current plan to the Residents' Planning Committee once a year for review	WATER	Feb-00	Feb-01		$ 1,000.00	$ 250.00	---

TITLE	NO	ITEM	** RESPONSIBILITY	START	END	OMPLETE	BUDGET IN-KIND AGENCY	IN-KIND INDIVIDUAL	FUNDING NEEDED
GOAL	2	**Reduce the possibility of a hazardous waste spill into the lake from the railroad line going over the lake**							
ACTION ITEMS	1	Contact the railroad company and request information regarding the material currently being hauled over the lake	WATER CITY	Aug-99	---		$ 1,000.00	---	---
	2	Determine inspection ownership, possibly through litigation	WATER CITY	Aug-99	---		$ 1,000.00	---	---
	3	Increase the current inspection schedule for the tracks and tresil over the lake	WATER CITY	Aug-99	Jun-01		$ 1,000.00	---	---
	4	Prepare a list of hazardous materials that should not be carried by rail over the lake, and forward that list to the railroad company	WATER	Aug-99	---		$ 1,000.00	---	---
	5	Review the plan for railroad use and materials carried over Carlyle Lake	WATER	Aug-99	Jun-01		$ 1,000.00	---	---
GOAL	3	**Reduce the possibility of hazardous waste material from a truck or automobile reaching the lake**							
ACTION ITEMS	1	Post signs along all roads in the watershed that state, "Water Supply Area--Report All Spills"	WATER NRCS	Oct-99	---		$ 500.00	$ 500.00	$ 2,000.00
GOAL	4	**Reduce the amount of "household hazardous waste" that is entering the lake**							
ACTION ITEMS	1	Sponsor a household hazardous waste clean-up day annually for landowners in the watershed	BCHD WATER CITY	3rd Sat. of 2000	April 2001		$ 1,000.00	$ 250.00	$ 1,500.00
	2	Include an article annually in the quarterly newsletter in regards to common household pollutants	BCHD	Jun-99	Jun-01		$ 100.00	---	---

TITLE	NO	ITEM	** RESPONSIBILITY	START	END	OMPLETE	BUDGET IN-KIND AGENCY	IN-KIND INDIVIDUAL	FUNDING NEEDED
GOAL	4	**Continued**							
	3	Encourage the use of natural groundcovers and other low-chemical input vegetation for new and existing homes	NRCS SWCD	Jun-99	Jun-01		$ 1,000.00	---	---
	4	Reduce pesticides, fertilizers, and other chemical yard applications	NRCS	Jun-99	Jun-01		$ 500.00	$ 250.00	$ 1,000.00
OBJECTIVE	5	**ADDRESS THE CONCERN OVER RECREATIONAL POLLUTANTS ENTERING THE LAKE**							
GOAL	1	**Identify what types of pollutants are entering the lake, and their sources**							
ACTION ITEMS	1	Prepare a list of recreational pollutants, for publication in the quarterly newsletter	IDNR WATER	Aug-99	---		$ 1,000.00	---	---
GOAL	2	**Reduce the amount of recreational pollutants that are entering the lake**							
ACTION ITEMS	1	Include articles in the newsletter regarding the use of cleaner running boat motors	IDNR	Jun-99	Jun-01		$ 1,000.00	---	---
	2	Post signs at the boat dock and any campgrounds that state, "Water Supply Lake--Report any Spills of the Following Items to the Water Plant Immediately"	WATER NRCS	Oct-99	---		$ 500.00	$ 250.00	$ 1,000.00
	3	Distribute brochures to all boat sticker applicants	CITY	Mar-00	Jun-01		$ 2,000.00	$ 250.00	$ 1,500.00
	4	Include the marina in this process	CITY NRCS	Jun-99	Jun-01		$ 500.00	---	---

TITLE	NO	ITEM	** RESPONSIBILITY	START	END	OMPLETE	BUDGET IN-KIND AGENCY	BUDGET IN-KIND INDIVIDUAL	FUNDING NEEDED
OBJECTIVE	6	**CONDUCT OUTREACH EFFORTS TO ALL LAKE USERS AND STAKEHOLDERS**							
GOAL	1	**Inform all landowners in the watershed about the efforts to improve Governor Bond Lake**							
ACTION ITEMS	1	Publish a quarterly newsletter, and distribute to all landowners	CES BCHD NRCS IDNR	Throughout	project		$ 4,000.00	$ 500.00	$ 1,000.00
	2	Supply an informational article to the Greenville Advocate six times a year, for publication in their newsletter	CES BCHD NRCS IDNR	Jun-99	Jun-01		$ 100.00	---	---
	3	Prepare six news releases a year, for use by local radio station WGEL	CES BCHD NRCS IDNR	Jun-99	Jun-01		$ 400.00	---	---
GOAL	2	**Inform all lake users about the efforts to improve Governor Bond Lake**							
ACTION ITEMS	1	Prepare a flyer about the lake improvement activities, to be handed out to people as they purchase boat stickers, and other recreationalpermits	NRCS CES BCHD IDNR	Feb-00	---		$ 1,000.00	$ 250.00	$ 2,000.00
	2	Pursue grants to cover the cost of publication	RC&D CITY	Jun-99	Jun-00		$ 1,000.00	---	—

TITLE	NO	ITEM	** RESPONSIBILITY	START	END	OMPLETE	BUDGET IN-KIND AGENCY	IN-KIND INDIVIDUAL	FUNDING NEEDED
GOAL	3	**Reassure all municipal water supply customers that the water provided to the public is clean and drinkable**							
ACTION ITEMS	1	Twice a year, include information about water quality with monthly water bill	CITY	Jun-99	Jun-01		$ 100.00	---	---
	2	Submit articles to the local newspaper about the condition of the water supply three times a year	WATER NRCS	Jun-99	Jun-01		$ 500.00	---	---
	3	Provide public tours of the water plant	CITY WATER	Sep-99	Jun-01		$ 500.00	---	---
	4	Provide information about clean water at the annual ski show	CITY SKI WATER	Jun-99	Jun-01		$ 250.00	---	---
		TOTALS					$ 138,400.00	$ 12,250.00	$ 656,950.00

** **RESPONSIBILITY CODES**

BCHD=Bond County Health Department
CES=Cooperative Extension Service
CITY=City of Greenville, Illinois
EI = Environmental Institute (Greenville College)
IDNR=Illinois Department of Natural Resources
NRCS = USDA NRCS office - Greenville
RC&D=USDA South Western IL Resource Conservation and Development office - Mascoutah
SWCD=Bond County Soil & Water Conservation District
WATER = Greenville Water Plant

PHASE 1 DIAGNOSTIC FEASIBILITY STUDY OF GOVERNOR BOND LAKE

APPENDIX 2

TMDL FOR GOVERNOR BOND LAKE

GOVERNOR BOND LAKE
GREENVILLE, ILLINOIS
TOTAL MAXIMUM DAILY LOADS

Prepared for

Illinois Environmental Protection Agency

June 14, 2001

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CONTENTS (Continued)

FIGURES

TABLES

Table **Page**

EXECUTIVE SUMMARY

Governor Bond Lake in Greenville, Illinois is listed as impaired for recreation, swimming and overall use. Main causes contributing to impairment are identified as nutrients, siltation, suspended solids, and excessive algal growth/chlorophyll-a. This TMDL addresses the nutrient and sediment reductions needed for Governor Bond Lake to comply with Illinois guidelines for nutrients, siltation, suspended solids, and chlorophyll-a concentrations. The specific problems and control action plans associated with nutrient and sediment loads are highlighted below.

Problem No. 1: Nutrients

Excessive nutrient loading to Governor Bond Lake has resulted in nuisance algal blooms, and consequently, impaired recreation and overall uses. Because there are no point source dischargers in the watershed, nutrient loads are coming from nonpoint sources, such as farming activities, feedlots, septic systems, streambank erosion, and natural processes. Elevated total phosphorus (TP) concentration, a surrogate for nutrients in general, has been measured in both the lake and associated tributaries. Internal cycling (re-release of previously settled out TP) is also implicated as a source of TP. Excessive chlorophyll-a, a surrogate measure of algal growth, has been measured in the lake. Several BMPs will result in nutrient load reductions and consequently, reduced algal growth. Some BMPS include: construction of multi-celled wetlands/extended sedimentation ponds, filter strips, tillage and nutrient management plans, construction erosion control permits, septic tank setback, sediment sealing, destratifiers, and/or aerators, to name a few. Additionally, continued and increased enrollment in CRP, stream bank stabilization projects, septic system maintenance, tillage and nutrient management education, feedlot management, and other on-going programs will further help reduce nutrient loads to Governor Bond Lake.

Problem No. 2: Sediment

Sediment loads to Governor Bond Lake have resulted in lake siltation (in-filling) and elevated non-volatile suspended solids (NVSS) concentrations. About one-half of the sediment load to Governor Bond Lake is from land surface erosion, and the rest is from shoreline and stream bank erosion. High sediment loads from tributaries and high NVSS in the lake have been measured. Practices that reduce erosion will reduce both sediment transport and NVSS concentrations. Most BMPs designed to reduce nutrient transport will also be effective at reducing sediment loads. Stream bank fencing, rip-rap, and aquascaping are some additional BMPs that can be used to reduce sediment transport to acceptable loads.

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act (CWA) provides authority for completing Total Maximum Daily Loads (TMDLs) to achieve state water quality standards and/or designated uses.

A TMDL is a calculation of the maximum amount of pollutant that a water body can receive and still meet water quality standards and/or designated uses. It is the sum of the loads of a single pollutant from all contributing point and nonpoint sources. TMDLs must include the following eight elements to be approved by the U.S. Environmental Protection Agency (EPA):

The TMDL must:

1. be designed to implement applicable water quality criteria,
2. include a total allowable load as well as individual waste load allocations,
3. consider the impacts of background pollutant contributions,
4. consider critical environmental conditions,
5. consider seasonal environmental variations,
6. include a margin of safety,
7. provide opportunity for public participation, and
8. have a reasonable assurance that the TMDL can be met

In general, the TMDL is developed according to the following relationship:

$$TMDL = WLA + LA + MOS \quad [1]$$

Where:

TMDL =	Total Maximum Daily Load (may be seasonal, for critical conditions, or other constraints)
WLA =	Waste Load Allocation (point source)
LA =	Load Allocation (nonpoint source)
MOS =	Margin of Safety (may be implicit and factored into conservative WLA and LA, or explicit)

This document provides the information used to develop TMDLs for Governor Bond Lake in Greenville, Illinois. The priority ranking for Governor Bond Lake TMDL development is No. 85 (1998 Illinois 303 (d) list).

Governor Bond Lake (Illinois water body ID numbers ILROP1-1998 and ILROP2-1998) was listed in the Illinois Water Quality Report 2000 (305(b) Report) as impaired for failure to meet its designated uses of recreation, swimming and overall use. Causes contributing to use impairment are nutrients (nitrogen and phosphorus), siltation, suspended solids, and algae growth. Causes contributing to impairment were determined using water quality standards (narrative and numeric) and Illinois Water Quality Report 2000 water quality criteria and guidelines. The applicable general use water quality standards are specified in Title 35 of the Illinois Administrative Code, Subtitle C, Part 302. The applicable listing guidelines developed by the Illinois EPA for narrative standards are specified in the Illinois Water Quality Report 2000 (IEPA/BOW/00-005). This TMDL document addresses all currently identified impairments to Governor Bond Lake.

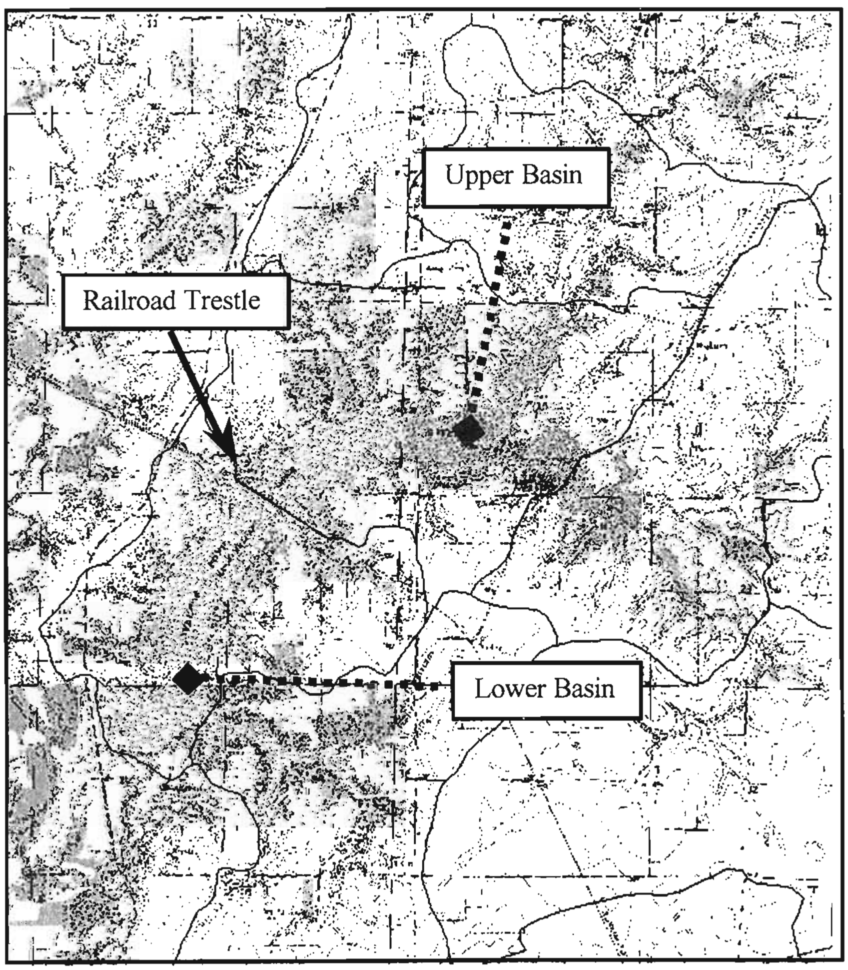
2.0 BACKGROUND INFORMATION

2.1 GENERAL CHARACTERISTICS

Governor Bond Lake was built in 1968 to 1970 as a water supply reservoir for the cities of Greenville, Mulberry Grove, Donnellson, and Smithboro. Currently, this lake also supports Royal Lakes and several rural customers for a total customer base of about 7,264 (Source Water Assessment Program Fact Sheet, 2000). The city of Greenville manages this reservoir and operates the surface water supply intake (Illinois Environmental Protection Agency [IEPA] #60096), which has three intake ports at varying depths. Governor Bond Lake is also heavily used for recreation. Permitted activities include fishing, boating, Scouts activities, and camping.

Governor Bond Lake has been effectively divided into two basins by a railroad trestle bisecting the lake (Figure 1-1). The two basins have significantly different physical and chemical properties that have affected recreational use and aquatic life support in each basin. TMDL assessment, however, is performed for whole lake systems.

Figure 1-1 Governor Bond Lake Basins



A partial shoreline survey completed in 1998 by Bond County indicates that shoreline erosion ranges from none (< 1 ft) to severe (up to 30-feet height of eroded bank), and highly eroded areas are associated with unprotected lake bank protrusions. Bank erosion was evident along approximately 1.25 miles of the surveyed shoreline.

Table 2-1 lists the general characteristics and Table 2-2 summarizes water quality characteristics of Governor Bond Lake as assessed in 1998 (based on 1996 data) and in 1999 (based on 1999 provisional Clean Lakes Program and IEPA data).

Table 2-1. General Governor Bond Lake Watershed Characteristics

Lake Surface Area	775 acres
Watershed Area	22,520 ac (re-projected SWAP geographic information system [GIS] data using in TMDL determinations); other organizations using different methods have measured slightly different areas (less than 2 percent difference)
Lake Depth	Mean depth = 13 ft (9 ft north basin, 20 ft south basin); Maximum depth = 24.5 ft
Lake Perimeter	31.39 miles
Lake Volume	9,900 acre-ft
Lake Retention Time	0.608 year
Major Inflows	Kingsbury Branch; Dry Branch
Major Outflows	Kingsbury Branch
Tributaries	8 miles of perennial, 5 miles of intermittent

SWAP = Source Water Assessment Program

Table 2-2. Governor Bond Lake Mean Concentration of Water Quality Constituents

Parameter	Upper Basin		Lower Basin	
	1996	1999	1996	1999
Chlorophyll-*a*, µg/L	36.3 (0.39)	90.2 (0.07)	19.7 (0.17)	78.0 (0.09)
Total Phosphorus, µg/L	208 (0.36)	149 (0.15)	115 (0.24)	84.2 (0.29)
Total Nitrogen, µg/L	1,446 (0.25)	731 (0.09)	1,248 (0.13)	828 (0.14)
Non-Volatile Suspended Solids, mg/L	38 (0.63)	21.8 (0.13)	27.1 (0.22)	13.0 (0.12)

Where:
µg/L = micrograms per liter = parts per billion
mg/L = milligrams per liter = parts per million
Value in parentheses = coefficient of variation

2.1.1 Lake Dissolved Oxygen Dynamics

Dissolved oxygen (DO) profiles show that anoxic (free oxygen depleted) conditions are observed at the bottom of both the lower basin and mid-basin sites sometime during the summer in all years monitored. Surface DO generally remains above six mg/L. The upper basin appears to be well mixed and DO remains at about six mg/L for all depths on most sampling dates. However, semi-monthly measurements would likely not detect episodic DO depletions. In 1993, DO fluctuated at the upper basin site, possibly attributable in part to July tributary inflows affecting lake mixing processes.

Lake mixing dynamics can greatly affect water quality in terms of chemical (nutrient) availability; the concentrations, location, and forms in which the chemical(s) are present. Phosphorus that settles out of the water column to the lake bottom is particulate-phosphorus and bound to the lake bottom sediment. This phosphorus generally is not available for aquatic plant growth and is not a water quality problem. However, if anoxic conditions occur at the lake bottom, it can result in re-release of the bound phosphorus. If there is no subsequent mixing of the water column, the dissolved phosphorus, resulting from the anoxic conditions, will remain at the lake bottom. If there is mixing (e.g., wind action or fish activity), this dissolved phosphorus is brought up to the surface where it is available for algal uptake and growth.

Anoxic conditions also can be created if there is highly active decomposition at the lake bottom in nutrient rich waters during warm weather, which accelerates decomposition rates. During active decomposition, DO is simply being used up faster than it can be replenished.

Anoxic conditions can also be created when lakes stratify. When a lake is stratified, new DO is prevented from being replenished because of lack of mixing. In typical midwestern lakes, lake stratification is a process based on formation of temperature differences in deep water bodies. Surface water gains (or loses) heat faster than wind action and temperature diffusion can mix the heat to lower depths. Warm water is less dense than cold water, so the warm surface layer "floats" on top of the colder, denser, deep water. Once this situation has occurred, the layers of water are essentially separated; there is a thermal resistance to mixing of water and chemicals. The surface layer is mixed, but does not mix with the lower, undisturbed layers. Over time, however, wind action and heat gain slowly catch up and the surface layer is slowly mixed deeper and deeper into the water column, until the thermal resistance to mixing the entire lake is removed. When this happens, the whole lake is able to mix again, resulting in "turnover." If this turnover happens during times of the year when aquatic plants such as algae are not actively growing (e.g., late fall), then the dissolved phosphorus released as a result of anoxic conditions does not contribute to water quality problems. If this happens during the active growing season, then the dissolved phosphorus can accelerate aquatic plant growth, resulting in nuisance algal blooms.

2.1.2 Limiting Nutrients

Total phosphorus (TP) is an essential, and often limiting, nutrient for plant growth. Therefore, TP often contributes to lake eutrophication (fertility) and algal blooms. Analysis of current and historical data shows that TP is slowly decreasing over time but it still exceeds both the Illinois Water Quality Standards (< 0.05 mg/L for reservoirs > 20 acres) and Illinois Water Quality Report 2000 guidelines (< 0.05 mg/L for non-impairment) at all sites.

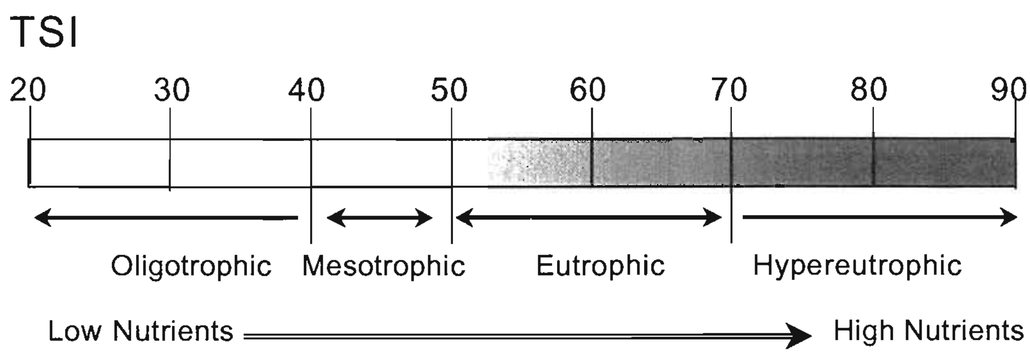
Nitrogen is another essential nutrient for plant growth; however, it is often so abundant that lack of nitrogen often does not limit algae growth, especially in water systems with low retention times (fast flowing systems). Some species of algae can also "fix" their own atmospheric nitrogen, so they do not need another source. With abundant nitrogen availability, any addition of the limiting nutrient (e.g., TP) results in rapid growth.

2.1.3 Trophic Status: Fertility Status

Trophic status often is used to describe the nutrient enrichment status of a lake ecosystem. Higher trophic status is equated with more nutrient availability and higher productivity. Generally, mesotrophic to eutrophic lakes are considered to be the best for supporting a variety of uses including fishing, aquatic life support, swimming, boating, and others. Excessive nutrient load to lakes can result in nuisance algal blooms and excessive turbidity. Very low nutrient status also can limit support of aquatic life by lack of a sufficient nutrient supply.

Carlson Trophic State Indexes (TSIs) use measured parameters as indicators of trophic status. These TSIs are based on TP concentration (TSI-TP), Chlorophyll-a concentration (TSI-Chla), or Secchi depth (TSI-SD). The individual indices are often averaged for an overall TSI. However, in general, TSI-TP is considered the best indicator of *potential* trophic status. The following diagram depicts the relationship between TSI, trophic status, and nutrient status according to IEPA guidelines.

Figure 2-1 Trophic State Index Relationship to Lake Fertility



Governor Bond Lake is considered to be eutrophic to hypereutrophic (fertile to highly fertile); Trophic State Indexes (TSI) are $\geq 50 < 70$ for eutrophic lakes and ≥ 70 for hypereutrophic lakes. The 1998 Illinois 305(b) Report mean TSI-SD = 75.2, TSI-TP = 73.8, and TSI-Chla = 59.6, with the average TSI = 69.6. In 1999, these values were similar with TSI values as follows: TSI-SD = 73.7, TSI-TP = 67.6, and TSI-Chla = 72.4, with and overall TSI of 71.2.

2.1.4 Hydrology

Governor Bond Lake is a constructed reservoir on the Kingsbury Branch within the Shoal River Watershed HUC (07140203). As a Public Water Supply system, outflow is controlled by a rectangular dam (40 ft high and 1,200 ft long) with a gravity driven maximum discharge of 15,568 cfs. Normal

reservoir storage as-built (original volume) is 9,900 acre-ft and maximum storage is 22,400 acre-ft (BASINS data set). Siltation of the reservoir has resulted in current storage volume of 6,324 acre-ft (Illinois State Natural History Erosion Inventory, 1990) to 4,874 acre-ft (NRCS Sediment Survey, 1995) or a reduction in storage capacity of 36 to 51 percent. Water supply withdrawals average 1.27 million gallons per day (MGD) (Source Water Assessment Program, 2000).
Withdrawals remain fairly constant throughout the monitoring season and are listed below (gallons):

Table 2-3. Monitoring Season Withdrawals from Governor Bond Lake

Month	Volume (gals)
Apr-99	37,506,000
May-99	41,231,000
Jun-99	38,234,000
Jul-99	41,059,000
Aug-99	41,781,000
Sep-99	40,435,000
Oct-99	41,783,000

Source: city of Greenville

No U.S. Geological Survey (USGS) gauging stations are located along this section of the Kingsbury Branch. However, because a low-head rectangular dam controls outflow, daily lake levels can be used to determine discharge rates with a broad-crested weir equation. Staff gage readings were recorded daily in 1999 as part of the Clean Lakes Program study and were used to approximate discharge rates using the weir equation. During dry conditions (mid to late summer and winter), no discharge occurs; water levels are below the dam height.

Bottom seepage rates are unknown and are therefore assumed to be negligible. Model analysis supports this assumption because no significant water balance residuals occurred implying seepage loss or gain.

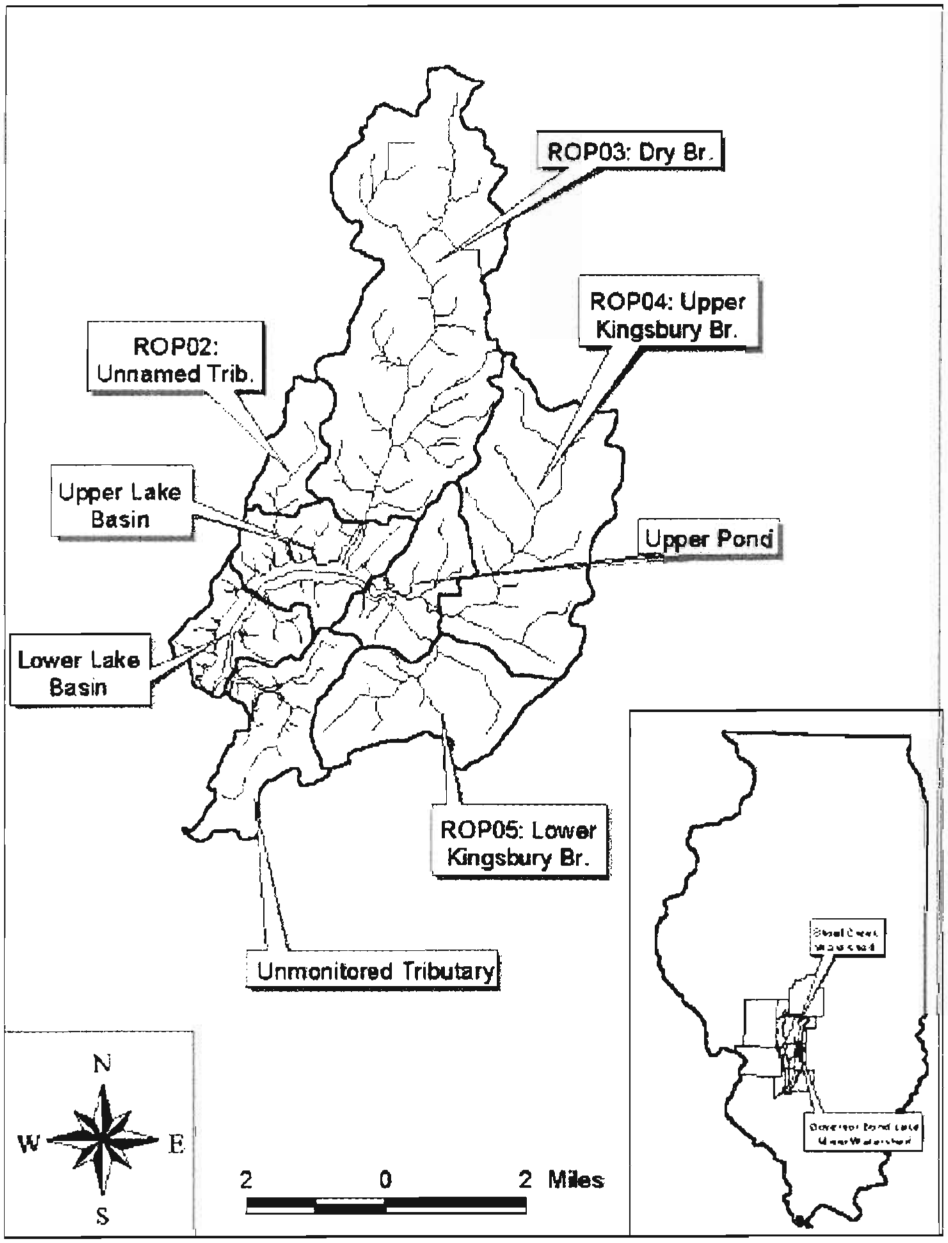
Average annual precipitation at the Greenville station (ID 113693) is approximately 39.2 inches (standard deviation 6.3 inches) for the past 13 years of record (1987 through 1999; there were some missing values in the years from 1989 through 1992). Most of the precipitation (55 percent) occurs between April and September (monitoring season) (Midwestern Regional Climate Center, Champaign, IL).

2.2 WATER BODY SETTING AND LAND USE

2.2.1 Water Body Setting: Watershed Characteristics

Governor Bond Lake is located approximately 1.5 miles north of the city of Greenville in Bond County, Illinois (Figure 2-2). Its outlet dam is located in Section 35 of LaGrange Township. The lake's watershed is located mainly within Bond County but also extends into the southeastern portion of Montgomery County.

Figure 2-2. Governor Bond Lake Location and Modeled Subwatersheds



Soils within the watershed are primarily silt loams formed under either native forest or prairie vegetation, in loess deposits overlying glacial tills. Forest soils are found on the uplands and on slopes with drainage characteristics depending upon landscape position. Prairie soils are generally somewhat poorly to poorly drained and are found in the low areas and depressions. The underlying glacial tills in this watershed tend to be less permeable and often create an impediment to downward drainage. Water infiltrating through the surface loess encounters the less permeable glacial till and either starts ponding there, if topography is fairly flat, or starts moving laterally along the interface towards streams and lakes, if topography is sloped. Upland soils in this watershed are generally poorly- to somewhat poorly-drained; however, flooding is rarely a problem, because landscape geomorphic processes have resulted in an extensive drainage network over time.

2.2.2 Land Use

Land use within the watershed is primarily row-crop agricultural followed by forest and pasture (GBL Committee, 1999; Source Water Protection Program, 2000). The major row crops grown in this region are corn, soybeans and wheat. Some grain sorghum also is produced in this watershed. Much of the strongly sloping agricultural lands are planted to permanent vegetative cover, and forested lands occur along major streams and tributaries. About 2,800 acres of land in the watershed are enrolled in the Conservation Reserve Program (CRP), planted to a mixture of cool season grasses and legumes. This acreage is variable with new enrollments and turnover occurring each October.

Land use distribution used for modeling the watershed is summarized in Table 2-4. Land use used in modeling is a combination of land use data from NRCS data as presented in the Governor Bond Lake Resource Plan (1999), GIS data from the Source Water Assessment Program (2000), and GIS data from the BASINS model data set (1999). Differences may exist between the total area used in modeling and those from other sources, because different methods were used to calculate land uses. These differences are minimal (less than 2 percent).

Table 2-4. Land Use Distribution Used for Modeling the Governor Bond Lake Watershed

Land Use	Acres	Percent of Total
Cropland	12,580	55.8 percent (15.7 percent of Cropland
Grass/Pasture	6,270	27.8
Forest	2,250	10.0
Urban	80	0.4
Transportation	40	0.2
Water/Wetlands	1,300	5.8
Total	22,520	100

Nine farms in the watershed are feedlot or open pasture livestock operations. Six farms are approximately 100-head cattle (dairy and beef) operations, and three farms are approximately 300-head hog operations (GBL Committee, 1999).

2.3 POPULATION CHARACTERISTICS, WILDLIFE RESOURCES, AND OTHER RELEVANT INFORMATION

2.3.1 Population Characteristics

Current population of the city of Greenville and Bond County are 6,955 and 17,633, respectively (U.S. Census 2000). There are 175 farms in the Governor Bond Lake watershed and farm sizes average 285 acres per farm. Although most of the area is in rural agriculture, 118 houses comprise lakeshore developments.

According to the Governor Bond Lake Resource Plan (GBL Committee, 1999), there are no documented sites of cultural significance in the Governor Bond Lake watershed. However, the Bond County area does have some recorded pre-historic and historically significant sites. Consequently, a potential remains for the existence of such sites in this watershed, especially since many historical sites are located close to watercourses.

2.3.2 Biotic Resources

2.3.2.1 Aquatic Vegetation

The Governor Bond Lake Resource Plan (GBL Committee, 1999) notes that Illinois Department of Natural Resources (IDNR) Fisheries Biologists report little aquatic vegetation in the northern end of the lake. Some cattails are found at the tributary inlets/backwater areas and some water willow grows very close to the edges (ZEIS, 2001). Because Governor Bond Lake is a reservoir, its steep sides inhibit aquatic macrophyte (rooted aquatic plants) growth, and consequently, results in reduced cover for young fish. The upper basin is shallower and has aquatic macrophytes growing within the tributary inlets that may somewhat compensate for the other negative fish habitat characteristics of the upper basin.

2.3.2.2. Fisheries

According to the IDNR (2000), Governor Bond Lake historically has been an excellent channel catfish fishery that has been annually stocked by the state hatchery. A survey conducted in 1994 through 1995 noted that the population declined, resulting in fishing limits placed on harvesting of young and reproducing catfish. Since then, catfish population has improved and regulations on trotline and jugs have been removed. The city of Greenville took over channel catfish stocking in 2000. Bluegill population in Governor Bond Lake has been excellent since 1990. There was a decline in populations according to the 1996 survey, but current populations are within lake management plans goals. Largemouth bass population in Governor Bond Lake has been gradually increasing since 1986 and continued improvement is forecast. Largemouth Bass six to eight inches in size are stocked by the city of Greenville. White crappie population in Governor Bond Lake peaked in 1998 and should remain stable for several years. Current populations are well within Lake Management Plan goals. Gizzard shad population in Governor Bond Lake has been well within Lake Management Plan goals since 1992, except for 1994 when there was a slight reduction in populations. Goals for small and medium predators were exceeded by more than 10 times in 1999 and the majority of the population is within the size class available. Stocking of tiger muskie and hybrid striped bass has historically been unsuccessful, presumably due to high temperatures, high turbidity and low dissolved oxygen (IDNR, 2000).

2.3.2.3 Terrestrial Vegetation

As mentioned earlier, most of the vegetation in this watershed is row crop agriculture (corn and soybeans with some grain sorghum) and pasture/CRP (cool season grasses and legumes). Most of the forest land is confined to riparian areas and is composed of red, white and black oaks; shagbark hickory; American elm; silver, red, and sugar maples; box elder; sycamore; hackberry; and persimmon. Nearly 80 percent of the timber is owned by private parties and is immediately adjacent to the lake or its tributaries.

No threatened or endangered plant species have been identified in the Governor Bond Lake watershed, however several have been found in the overall Bond County area (ZEIS, 2001).

2.3.2.4 Terrestrial Fauna

The IDNR performed a Natural Heritage Database search for presence of endangered or threatened species, Illinois Natural Area Inventory sites, or dedicated Illinois Nature Preserves within the Governor Bond Lake watershed in 1998. A species record for the Black-Crowned Night Heron was found for the eastern end of the lake, which was recorded during an Atlas survey by IDNR in 1992. Therefore, any activities and methods recommended in the feasibility study for Phase II, and consequently for TMDL implementation, should avoid adverse impact to this species and its habitat.

As part of the Clean Lakes Program Phase I Study, a bird survey was conducted from July 18, 1999, through May 8, 2000 (ZEIS, 2001). Fourteen counts were acquired between July 18,1999, and November 11,1999, and seven counts were performed from April 3, 2000, through May 8, 2000. Seventeen species were identified with maximum number per day ranging from one (tern, osprey, and cattle egret) to over 50 (mallard and double crested cormorant). No Black-crowned night heron were identified.

About 1,600 hogs and cattle are present in the watershed, as well as some livestock sheep and exotic animals. The majority of hogs are raised in confined feedlot systems, however some are produced in a combination of feedlot and free-range systems. The cattle, sheep, and exotic animals are raised in mostly open-pasture and feedlot systems.

2.4 PRESENT AND FUTURE GROWTH TRENDS

Growth between 1990 and 1999 reflected a 33 percent increase in the city of Greenville population and 9 percent increase in Bond County population (GBL Committee 1999). If trends continue through 2010, the city of Greenville population will increase to 8,560.

The current rate of new housing development is about eight houses per year, reflecting a 33 percent increase in development rate since 1995[1]. Projected development around Governor Bond Lake for 2010 would be an additional 102 houses, bringing the total to 220, or 95 percent of full development. Maximum development (number of sites available for development) is 232 sites[2] and would be reached in less than 15 years.

No sediment or erosion control practices are currently part of the permitting process for construction activities[3]. Bare soil surfaces associated with construction can result in more than 20 tons per acre per

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[1] Personal communication, Mary Cross, City of Greenville, 2000.
[2] Personal communication, Crystal Lingley, Bond County Health Department, 2001.
[3] Personal communication, Dan Mueller, NRCS, 2000.

year soil loss. This, coupled with development in close proximity to Governor Bond Lake, means that eroded soils are more likely to be discharged directly into Governor Bond Lake.

2.5 DESCRIPTION OF POINT AND NONPOINT SOURCES

This section provides an inventory and description of potential sources of pollutants associated with the water quality impairment, noted in the preceding section for both point and nonpoint sources within the watershed. Loads were determined through modeling efforts and analysis of monitored data.

2.5.1 Point Sources

There is only one minor point source discharger in the Governor Bond Lake watershed, the Gateway Retreat Center, which discharges into a roadway ditch leading to the lake. Flow rate for this discharger is 0.0160 MGD for 2 to 3 months each year. This discharger has no permitted limits and is only required to report quantities discharged.

Reported total potential point source load per year to Governor Bond Lake is 7.5 lbs of BOD (3.4 kg), 5.4 lbs of total suspended solids (2.5 kg), and 1.6 lbs of Ammonia (0.7 kg) (Discharge Monitoring Reports 1998 to 2000, IEPA).

2.5.2 Nonpoint Sources

The majority of non-point source sediment and nutrient loads are from row-crop agriculture. Other sources include pastures, construction sites, and shoreline and gully erosion. Nutrient load sources also include on-site septic systems and animal feedlots.

Watershed topography is fairly flat, but many soils are not very permeable. Low permeability results in water, nutrients, and fine sediment washing off of the surface into streams during storm events. Water that does not infiltrate will quickly reach the stream system. The resulting high-energy, sudden peak flows can severely erode stream banks and carry large sediment loads to the lake. Areas with topsoils that are permeable, on the other hand, often have an impermeable layer below. Consequently, excess nutrients may be washed into the soil and travel horizontally along the impermeable layer to lakes and streams. Due to these runoff and transport characteristics, both surface and subsurface nutrient contributions in this watershed can be high: modeled surface runoff concentration N is >8.0 mg/L and subsurface groundwater N is > 3.0 mg/L).

Areas around tributary inlets, in particular Dry Branch Creek, experience a large amount of backwater effect and may act similar to wetlands. While these quiet water areas can trap sediment and nutrients, periodic drying and flushing of these resources can also result in phosphorus re-release and flushing.

Fields that are cropped or pastured all the way to stream banks can contribute both sediment and nutrients to water bodies. Lack of buffer/filter strips results in inadequate trapping of particulates, uptake of dissolved nutrients, and infiltration of water and nutrients. Grazed pasturelands are often bisected by tributaries. Livestock passage through and within tributaries stirs up previously deposited sediment, destroys stream banks and riparian vegetation, and contributes to accelerated stream bank erosion.

Siltation of Governor Bond Lake has been significant due to both eroded sediment transport and lakeshore erosion. As-built lake volume (1970) is reported as 9,900 acre-ft. Sediment/erosion surveys were conducted in 1990 by the Illinois Natural History Survey (INHS), in 1995 by the NRCS, and in 1999 by the Zahniser Institute for Environmental Studies (Clean Lakes Program). The INHS determined the lake volume to be 6,324 ac-ft, and the NRCS measured a lake volume of 5,026 acre-ft five years later. These volumes are not necessarily comparable due to different methods used, however, they do provide an estimate of lake in-filling since completion. Approximately one-third to one-half of the entire lake volume has been lost due to siltation. This is a large reduction in storage capacity that has affected aquatic life and recreation. However, it has not yet threatened the lake's designated use as a water supply. Eventually, decreasing storage volume may affect public water supply support, as local population increases.

Nonpoint source loads were determined by modeling watershed processes using measured and defined watershed characteristics. A suite of models was chosen for their ability to describe the system, model pollutants of concern, and make full use of available data while minimizing assumptions and default conditions. Details of this process are included in the associated document, Governor Bond Lake Load Assessment Modeling Technical Memorandum (2001) (Appendix A).

The model FLUX (a stream loading computation model) was used to calculate annual flow-weighted average nutrient (total and dissolved nitrogen and phosphorus) and non-volatile suspended solids (NVSS) loads from each of four subwatersheds whose tributaries were sampled and monitored under the 1999 Clean Lakes Program water quality monitoring program. Resulting values were then used to calibrate the runoff and sediment nutrient concentrations of the watershed model, GWLF (Generalized Watershed Loading Function). GWLF incorporates watershed characteristic data (e.g., soils information, land use, cropping factors, septic systems, and others), Universal Soil Loss Equation (USLE) processes, and other processes to model sediment and nutrient transport for a watershed. GWLF is a steady-state model that uses daily climate data and provides monthly or annual loading rates. The model was run for 13 years (1987 though 1999) and loads were assessed for a dry year (1989), a wet year (1993), a normal year (1996), and the calibration year (1999). Table 2-5 lists the nonpoint source loads from each subwatershed for dry, wet, normal, and calibration year climatic conditions.

Table 2-5 Nonpoint Source Loads

Contributor	Nonpoint Source Load			Contributor	Nonpoint Source Load		
	TP	TN	Sediment		TP	TN	Sediment
	kg/yr	kg/yr	Mg/yr		kg/yr	kg/yr	Mg/yr
1989: Dry Year				**1996: Normal Year**			
Dry Br.	1,600	18,868	8,867	Dry Br.	3,139	26,552	11,762
Kingsbury Br.s	7,905	72,987	7,366	Kingsbury Br.s	11,429	99,455	9,771
Direct Watersheds	1,734	9,789	3,816	Direct Watersheds	2,840	13,283	8,617
Other	1,307	7,873	3,444	Other	1,860	9,989	4,565
Atmospheric	106	1,705	-	Atmospheric	106	1,705	-
Internal	2,353	-	-	Internal	17,730	-	-
Total	13,405	92,354	23,493	Total	33,965	124,432	34,715
1993: Wet Year				**1999: Wet-Normal Year**			
Dry Br.	2,876	29,061	10,984	Dry Br.	3,139	20,300	8,988
Kingsbury Br.s	12,405	106,597	9,125	Kingsbury Br.s	9,530	76,481	7,466
Direct Watersheds	2,848	13,491	10,065	Direct Watersheds	2,522	10,633	6,700
Other	2,177	12,036	4,263	Other	1,641	10,324	3,489
Atmospheric	106	1,705	-	Atmospheric	106	1,705	-
Internal	32,732	-	-	Internal	5,114	-	-
Total	50,268	133,829	34,437	Total	18,913	99,143	26,643

Where:
Other = two unnamed minor tributaries
Mg/yr = Megagrams per year or metric tons per year
TN = total nitrogen
TP = total phosphorus

Atmospheric deposition of nitrogen is 1705 kilograms per year (kg/yr) (Pucket, 1993) and phosphorus is 106.2 kg/yr (Litke, 1999). For model purposes, 50 percent of each pollutant was assumed to be in the dissolved form and 50 percent in the particulate form. No information was available on the exact proportion in each form for these pollutants; therefore it was assumed that they were in the same proportion as the model default parameters.

Decisions and assumptions in the modeling process were conservative to err on the side of caution. Because only four of the eight subwatersheds delineated for modeling were monitored, averages of the calibrated parameters were used for the remaining subwatersheds. It should also be noted that missing discharge measurements, movement of staff gages, and non-ideal conditions for tributary flow measurements result in differences between modeled and measured flow situations. However, because the GWLF watershed model is, to a large extent, process-based, loads will be reasonably modeled even without calibration.

For modeling septic systems, it was assumed that each system served three people for nutrient loading functions. The model does not separate drainfield versus aeration on-site septic systems, thus aeration systems were modeled as ponded systems. Ponded systems are handled by assuming surface discharge to the water body in the same month. Only septic systems surrounding Governor Bond Lake were included, since septic system contributions in other parts of the watershed will be accounted for in GWLF groundwater flow concentrations.

An additional 25,700 tons per year (28,300 megagrams per year) could be contributed by gully, ephemeral gully, and stream bank erosion (State Soil Scientist Roger Windhorn, Draft Governor Bond

Lake Ecosystem Management Plan, 1998). An additional 404 tons/yr (445 Mg/yr) can be attributed to shoreline erosion (ZIES, 2001). These values effectively double the sediment load to Governor Bond Lake compared to sheet and rill erosion.

2.6 DESCRIPTION OF NATURAL BACKGROUND LOADS FOR POLLUTANTS OF CONCERN

Certain levels of many constituents occur naturally in waters; these levels define background loads. Governor Bond Lake, however, is a constructed reservoir; physical modifications have changed watershed characteristics. Furthermore, background conditions would apply to a flowing stream, rather than the reservoir that is Governor Bond Lake. Assessment of all background loads separate from load allocations is not possible. Consequently, nonpoint source runoff background loads are included as part of the load allocations presented in Section 5.0.

Atmospheric deposition at a minimum can be considered background sources of the nutrients nitrogen and phosphorus. These deposition rates are 1,705 kg/yr total nitrogen (Pucket, 1993) and 106.2 kg/yr phosphorous (Litke, 1999).

2.7 ANALYTICAL BASIS FOR EXPRESSING THE TMDL THROUGH SURROGATE MEASURES

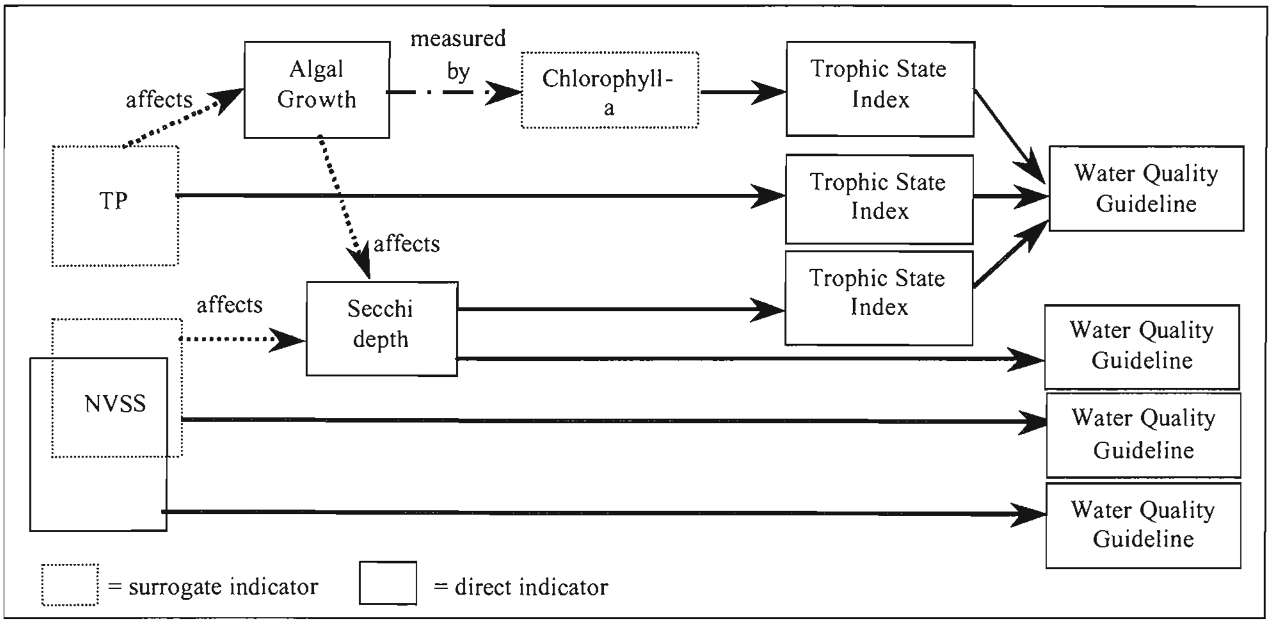
The use of surrogate measures as indicators of impairment is necessary in many cases because it is not possible or reasonable to directly assess the cause contributing to impairment. Specific causes considered to contribute to failure to meet these guidelines are nutrients, excessive algal growth, excessive sediment inputs, and siltation rate.

Algal growth is directly related to nutrient abundance and light availability for photosynthesis. For nutrients, algal growth was found to be dependent only on the nutrient phosphorus (TP) and not the nutrient nitrogen (TN) in Governor Bond Lake; in the lake eutrophication and nutrient cycling model, BATHTUB, algal growth was best simulated by the sub-model incorporating only TP, light, and reservoir flushing rate. Consequently, TP can be considered the surrogate indicator for the whole nutrient TMDL, as well as a surrogate indicator of algal growth. Chlorophyll-a is a plant pigment and its abundance in water is highly correlated with the amount of algae present.

Sediment is measured by determining all suspended solids in the water column and subtracting those that are volatile (organic material such as algal biomass). This suspended sediment is the Non-Volatile Suspended Solids (NVSS). NVSS and basin retention factors are used as surrogate measures for short-term lake siltation rates. Some of the sediment will settle out; the resulting NVSS will be only a fraction of what entered the lake. The estimated amount of sediment retained in the basin is a reasonable indicator of volume loss per year; however, detailed bathymetry measurements should be completed on a longer term (e.g., 5-year) basis in order to compare estimated siltation rates with actual lake volume loss.

Figure 2-3 depicts some of the relationships between indicators, surrogate indicators, and water quality guidelines.

Figure 2-3. Relationship Between Surrogate Indicators and Water Quality Guidelines



3.0 DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS AND NUMERIC WATER QUALITY TARGET GOALS

All waters of Illinois are assigned one of the following four designations: General Use Waters, Public and Food Processing Water Supplies, Lake Michigan, or Secondary Contact and Indigenous Aquatic Life Waters. Illinois waters must meet General Use water quality standards unless they are subject to another specific designation (Illinois Adm. Code 35, subtitle C Section 302.201). The General Use standards will protect the State's water for aquatic life (except as provided in Section 302.213), wildlife, agricultural use, secondary contact use, and most industrial uses, and ensure the aesthetic quality of the state's aquatic environment. Primary contact uses are protected for all General Use waters whose physical configuration permits such use. Public Water Supply standards are cumulative with the general use standards.

Impairment assessment is based on the guidelines outlined in the Illinois Water Quality Report 2000 (IEPA 2000) and water quality standards promulgated through Illinois Adm. Code 35, Subtitle C. TMDLs will be developed for all causes contributing to impairment.

Table 3-1. Governor Bond Lake Designated Use Impairments (305(b) list).

Designated Use	Support Status
Overall Use	Partial Support
Recreation	Partial Support
Aquatic Life	Full
Fish Consumption	Full
Swimming	Partial Support
Drinking Water Supply	Full

Source: Illinois Water Quality Report 2000

3.1 APPLICABLE ILLINOIS WATER QUALITY STANDARDS

Governor Bond Lake was assessed as not meeting its designated uses because it exceeds Secchi depth (lack of water clarity), TSI (Trophic State Index), siltation rate (lake storage volume loss), or NVSSs (suspended sediments) designated use guidelines, or for a combination of these factors. The applicable listing criteria developed by the Illinois EPA for narrative standards are specified in the Illinois Water Quality Report 2000 (IEPA/BOW/00-005). Applicable General Use water quality standards are specified in Title 35 of the Illinois Adm. Code, Subtitle C, Part 302. Quantitative standards are identified in the table below.

Table 3-2. Illinois Water Quality Standards for Causes Contributing to Impairment of Governor Bond Lake.

Parameter	Description of Water Quality Standards
Nitrogen	Total Ammonia-N shall in no case exceed 15 mg/L (standard). Unionized-Ammonia shall not exceed the acute and chronic standard provided in Section 302.212, Ill. Admin. Code (standard): Apr - Oct Acute 0.33 mg/L Chronic 0.057 mg/L Nov-Mar Acute 0.14 mg/L Chronic 0.025 mg/L For Drinking Water Supply, ≤ 20 percent of samples ≥ 10.0 ppm Nitrate-N with mean < 5.0 ppm (standard)
Phosphorus	Phosphorus as P shall not exceed 0.05 mg/L in any reservoir or lake with surface area of 8.1 hectares (20 acres) or more, or in any stream at the point where it enters any such reservoir or lake.

3.2 OTHER APPLICABLE NUMERIC OR NARRATIVE WATER QUALITY STANDARDS, CRITERIA, AND GUIDELINES

Governor Bond Lake is impaired due to exceedance of narrative standards for nutrients (nitrogen and phosphorus), siltation, suspended solids, and excessive algal growth (Chlorophyll-a). The narrative standard states that:

Offensive Conditions: "Waters of the State shall be free from sludge or bottom deposits, floating debris, visible oil, plant or algal growth, color or turbidity of other than natural origin."

Criteria for determining impairment and guidances for water quality parameters values for non-impaired conditions are provided in the Illinois Water Quality Report 2000 (IEPA, 2000). The following table lists water quality parameters for full support waters. Fecal coliforms and macrophyte coverage are also considered to be potential causes contributing to impairment; however they were not measured or assessed and are therefore not included in this table.

Table 3-3. Illinois Water Quality Guidelines

Designated Use	**Water Quality Guidelines**		
Swimming	**TSI**	**Secchi Depth (m)**	
Full Support	< 55	> 0.6096	
Partial Impairment	≤ 75	< 0.6096	
Recreation	**TSI**	**NVSS (mg/L)**	
Full Support	< 60	< 3	
Full Support	≤ 55	< 7	
Aquatic Life	**TSI**	**NVSS (mg/L)**	
Full Support	< 85		
Full Support	< 90	< 20	
Additional Applicable Guidelines	**TP (mg/L)**	**Siltation (percent Orig. Vol.)**	**Chlorophyll-a (µg/L)**
Full Support	< 0.050	< 0.25	< 20
Partial Impaired	< 0.140	< 0.75	< 92
	NVSS (mg/L)		
Full Support	< 12		

Source: Illinois Water Quality Report 2000.

Evaluation of impairment is determined by both the magnitude of numeric criteria/standard/guidance exceedance and by the combined effect all exceedances. Impairment is determined by:

1.) Assigning points for various levels of pollutants or indicators of water quality based on whether impairment caused by the particular environmental indicator is considered high, moderate, or slight (IEPA, 2000)
2.) Summing points to obtain an overall use impairment rating for each designated use
3.) Assigning impairment support classifications and index based on total rating (full, partial, and non-support)
4.) Averaging all individual use impairment indices to obtain General Use assessment

Consequently, a water body can exceed a particular standard/criteria/guidance once but still be considered to fully support the designated use. If the magnitude of exceedance is within the ranges identified in the Illinois Water Quality Report 2000 (IEPA 2000) and if the combined effect of any other measures is within the ranges identified in the report, then the water body may still be considered to fully support its designated use.

3.3 TMDL ENDPOINTS

Based on the standards and guidelines presented above, target water quality values were chosen to reflect the conditions to be considered acceptable for the most sensitive designated uses. In order to meet all designated uses, the water body must meet the guidelines or standards identified for the most sensitive use. Consequently, the most stringent values will serve as the endpoints for the TMDL analysis. In this case, the Swimming use guidelines for TSI and Secchi depth, the Recreation guidelines for NVSS, and the additional applicable guidelines for chlorophyll-a, TP, and siltation rate will serve as TMDL endpoints. Compliance with the below target water quality values will result in assessment as 'full support' for all currently impaired designated uses:

Table 3-4. TMDL Endpoints

Parameter	TMDL Endpoint	Surrogate or Direct Measurement for Water Quality Guideline?
Trophic State Index (TSI)	< 55	Direct measure
Non-Volatile Suspended Solids (NVSS)	< 7 mg/L	Surrogate for siltation rate; direct measure for sediment
Secchi Depth	> 0.6096 m	Direct measure
Total Phosphorus (TP)	< 0.050 mg/L	Surrogate for nutrients
Chlorophyll-a	<0.020 mg/L	Surrogate for algal growth

4.0 LOADING CAPACITY - LINKING WATER QUALITY AND POLLUTANT SOURCES

Sediment and nutrient loads to Governor Bond Lake were modeled using the General Watershed Loading Functions (GWLF) model. GWLF is a moderately simple watershed-scale model developed for assessing point and nonpoint source sediment, nitrogen, and phosphorus loads from rural and urban watersheds. In addition to erosion and sediment transport modeling, this model can also assess loads from septic systems, an important consideration given the nature of soils in this region and the proximity of on-site septic systems to water bodies.

To model the effect of loads and load reductions on in-lake water quality, we used a eutrophication and nutrient cycling model, BATHTUB v. 5.4, developed by the US Army Corps of Engineers for modeling reservoirs. BATHTUB requires simple inputs and is suitable for modeling seasonal nutrient cycling processes, including algal growth (chlorophyll-a concentrations), Secchi depth, nutrient decay, and others. GWLF concentrations were input into BATHTUB for analysis of effects on water quality. Internal sub-models for nutrient cycling functions were selected based on calibration to 1999 water quality monitoring data (the most complete data set).

Table 4-1. Effect of Pollutant Loads on Lake Water Quality Modeled Using BATHTUB

Year/ Parameter	Current Value	Year/ Parameter	Current Value	Units
1989: Dry Year		**1996: Normal Year**		
TP Load: 13,400 kg/yr		**TP Load: 33,970 kg/yr**		
TN Load: 92,350 kg/yr		**TN Load: 124,430 kg/yr**		
TSI	82	TSI	70.8	
SD	0.36	SD	0.44	*m*
TP	129.4	TP	166.4	*ug/L*
TN	1757	TN	1340	*ug/L*
TN/TP	13.6	TN/TP	8.1	
Chla	117.9	Chla	28.9	*ug/L*
1993: Wet Year		**1999: Wet- NormalYear**		
TP Load: 50,270 kg/yr		**TP Load: 18,910 kg/yr**		
TN Load: 133,800 kg/yr		**TN Load: 99,140 kg/yr**		
TSI	77.6	TSI	73.7	
SD	0.38	SD	0.27	*m*
TP	188	TP	120.4	*ug/L*
TN	1252	TN	760	*ug/L*
TN/TP	6.7	TN/TP	6.3	
Chla	97.4	Chla	84.5	*ug/L*

TSI = mean of Chlorophyll-a and TP Trophic State Indexes
SD = Secchi Depth
TP = Total Phosphorus
TN = Total Nitrogen
Chla = Chlorophyll-a
TN/TP = TN to TP ratio; a measure of limiting nutrient
ug/L = parts per billion, or micrograms per liter

Cycling processes will not behave consistently during different climatic conditions due to temporal variability and loading history effects on water quality. Consequently, after the sub-model functions were chosen based on 1999 water quality monitoring data, their coefficients within BATHTUB were calibrated for three climate conditions (dry, wet, and normal precipitation years) where in-lake water quality data was also available. Following calibration for initial conditions, input values (nitrogen and phosphorus tributary concentrations) were adjusted to determine load reductions and corresponding nutrient concentrations that are needed to achieve the in-lake TMDL endpoints listed above (Section 3.0).

However, while BATHTUB can model nutrient cycling well, it is not as well suited for modeling sediment and siltation processes. For siltation processes, a spreadsheet model was used to determine the difference between modeled sediment concentrations in tributary inflows and sediment (NVSS) concentration in the lake water column. This difference is the amount of sediment retained in the lake. The amount of sediment retained in the lake expressed relative to inflow concentration provides the proportion of incoming sediment that is retained in the lake. The amount of sediment retained, expressed on a volume basis, provides an indication of volume loss, or siltation rate.

Table 4-2. Effect of Sediment on Lake Siltation

				Proportion of Sediment Retained in the Lake			As-Built Volume Loss				
Year	Climate Condition	Direct Inflow	Direct Inflow + Upstream	Sediment Concentration in Inflows	NVSS Concentration in the Lake	Proportion Retained*,**	Runoff Load in	Shoreline Erosion ****	Load Retained in Lake	Volume of Load Retained	As-Built Vol. Loss ***
			Hm3	*mg/L*	*mg/L*		*Mg*		*Mg*	*Acre-ft*	%
1989	Dry	17.7	26.3	0.923	0.030	0.87	22170	28300	44107	24.3	**0.246**
1993	Wet	36.3	53.6	0.560	0.021	0.82	27464	28300	45459	25.1	**0.253**
1996	Normal	36.3	53.6	0.600	0.027	0.73	29409	28300	42123	23.2	**0.235**
1999	Wet-Normal	37.2	54.4	0.452	0.019	0.78	22473	28300	39372	21.7	**0.219**

Where: Hm3 = 1,000,000 cubic meters
* Upper Pond sediment retention assumed to be 80%
** Upper Lake Basin assumed retention for years was the same as 1999 due to lack data for the previous years
***As-Built Volume = 9,900 Acre-ft
****From Zahniser Institute of Environmetal Studies 2001 Clean Lakes Program Report = estimate

Load reductions necessary to meet target NVSS goals are calculated by determining the percent reduction in in-lake concentration required to meet NVSS concentration endpoints (Table 43). These percent reductions are then applied to the total input load to determine the necessary load reductions. For example, for NVSS to be less than 3 mg/L in dry years, 90 percent (19936 Mg) of the incoming load must be removed.

Table 4-3. Sediment Pollutant Load Reductions Necessary to Meet Various Target NVSS Concentrations.

		Measured			Load Reductions Necessary to Meet Target NVSS Ranges									
Year	Climate	Input Load	Load Retained	In-Lake Concentration	NVSS < 3 mg/L		NVSS >=3 to 7 mg/L		NVSS >= 7 to 12 mg/L		NVSS >= 12 to 15 mg/L		NVSS >= 15 to 20 mg/L	
		Mg	*Mg*	*mg/L*	*Load (Mg)*	*%*	*Load (Mg)*	*%*	*Load (Mg)*	*%*	*Load (Mg)*	*%*	*Load (Mg)*	*%*
1989	Dry	22170	20922	30	19936	90	16957	76	13233	60	10254	46	7275	33
1993	Wet	27464	25613	21	23566	86	18369	67	11873	43	6676	24	1479	5
1996	Normal	29409	26954	27	26179	89	21873	74	16489	56	12183	41	7876	27
1999	Wet-Normal	22473	20779	19	18911	84	14162	63	8225	37	3476	15	0	0

5.0 LOAD ALLOCATIONS (LA) AND WASTELOAD ALLOCATIONS (WLA)

5.1 REDUCTIONS NEEDED TO SATISFY THE TMDL

The assimilative capacity of the lake was established by determining the input stream loads or concentrations that will not result in violations of the applicable standards or guidelines during either wet, dry, or normal climate conditions. The concentrations were determined using the calibrated BATHTUB model. The percent load reductions from each source necessary to meet the TMDL endpoints were the same as the percentage reduction in concentrations.

Table 5-1. Initial Values for TMDL Endpoints and Final Values Following Load Reductions

Year/ Parameter	Initial Value	After Load Reduction	Year/ Parameter	Initial Value	After Load Reduction	Units
1989: Dry Year			**1996: Normal Year**			
TSI	82	54.5	TSI	70.8	54.5	
SD	0.36	1.04	SD	0.44	0.53	*m*
TP	129.4	24.9	TP	166.4	46.6	*ug/L*
TN	1757	1757	TN	1340	1340	*ug/L*
Chla	117.9	19.2	Chla	28.9	7.62	*ug/L*
1993: Wet Year			**1999: Wet- NormalYear**			
TSI	77.6	53.5	TSI	73.7	55.7	
SD	0.38	0.99	SD	0.27	0.37	*m*
TP	188	29.4	TP	120.4	27.9	*ug/L*
TN	1252	1236	TN	760	760	*ug/L*
Chla	97.4	11.06	Chla	84.5	18.9	*ug/L*

TSI = mean of Chlorophyll-a and TP Trophic State Indexes
SD = Secchi Depth
TP = Total Phosphorous
TN = Total Nitrogen
Chla = Chlorophyll-a
ug/L = part per billion, or micrograms per liter

Initial values for all parameters exceeded TMDL endpoints except Secchi depth (SD), which sets a minimum versus maximum value. Load reductions presented further on in Section 5.3 were sufficient to reduce all values to meet TMDL endpoints, except for a SD in 1996 and 1999. Average SD for all years, however, met TMDL endpoints (0.732 m).

Regardless of total load, percent load reduction necessary to reach TMDL endpoints were similar. The algal growth model that best simulated measured chlorophyll-a concentrations is based only on TP, turbidity, and flushing rate. This implies that nitrogen is not a limiting nutrient for algal growth. Consequently, reductions in TP are sufficient to reach nutrient affected TMDL endpoints.

Particulate forms of nutrients, or nutrient bound up in dead organic material often settle to the bottom of the lake. Internal cycling is the process where these nutrients are re-released and mixed into the water column rendering the phosphorus available for plant uptake and growth. No internal nitrogen cycling was discovered, however, internal P-cycling was evident in the Upper Lake Basin in three of the years modeled (1993, 1996, and 1999) and ranged from 30 to 65 percent of total load. During the dry year (1989), internal-P cycling did not occur in the Upper Lake Basin, but did occur in the Lower Lake Basin.

5.2 SOURCES OF POLLUTANT LOAD

The sources of pollutant load to Governor Bond Lake include nonpoint source runoff, atmospheric deposition, and septic systems. Septic system loads are relatively small compared to nonpoint source runoff, and are considered part of the overall nonpoint source load. Loads from the single point source were insignificant compared to any other loads (< 0.02 percent of allowable load) and there are no measurements for pertinent TMDL parameters. Therefore, this load is not included in the load allocation. Background loads due to nonpoint source runoff, as mentioned earlier, cannot be separated from the other nonpoint source loads due to lack of sufficient information and the significant physical and cultural changes to the watershed. Consequently, only atmospheric loads will be considered as background loads.

5.3 RATIONALE FOR LOAD ALLOCATIONS AND WASTELOAD ALLOCATIONS

The load allocation is based on the evaluation of the sources of pollutants entering the lake from the watershed. The pollutant loads, namely sediment and nutrient loads, have been linked to violations of applicable standards or guidelines in the lake. The magnitudes of the loads have been determined by a reliable quantitative procedure that is based on in-lake measurements for climate conditions that cover the range of expected precipitation conditions. The load reductions necessary are based on TMDL endpoints that have been determined sufficient to be compliant with Illinois water quality guidelines for full support of designated uses. Therefore, implementation of proposed load reductions, by means of appropriate Best Management Practices (BMPs), would be expected to bring the listed lake into compliance for all its designated uses.

TMDLs are expressed as a percent reduction in load because mass-based loads are highly variable and depend upon climatic conditions; yet, the proportion of load reduction necessary to meet in-lake TMDL endpoints remains fairly consistent. This situation is likely due to the situation that higher flow years, which generate larger loads, also result in greater flushing and dilution in the lake.

The Margins of Safety (MOSs) are calculated as the sum of both the statistical variation due to variable climate conditions assessed and those due to statistical error terms in internal model calculations. Using conservative values for model inputs adds an additional non-quantifiable, implicit MOS. See Section 6.0 for more detailed discussion of MOS.

Table 5-2 TMDLs

TMDL Parameter	WLA	LA*, % Reduction	MOS**	TMDL
Nutrients: Total Phosphorus	0	91%	3%	94%
Sediment NVSS Siltation	 0 0	 87% 20%	 2% 5%	 89% 25%

* LA includes both external and internal loads if applicable
**Sum of both coefficient of variation as a function of model calculations and variable climate conditions. Coefficient of variation = standard error/mean.

The following tables detail the load allocations for determining the TMDLs. Nonpoint source current and reduced loads are mean values for all climate condition modeled. High variation in actual loads renders these values suitable for general comparisons only, and TMDLs are therefore based on percent load reduction necessary to meet target water quality goals.

Table 5-3a: Nutrients: Total Phosphorus

Source	LA, % Reduction	Current Load, kg	Load Reduction, kg
Background (atmospheric)	0	106	0
Internal Cycling	100	10,840†	10,840†
Nonpoint Source	91	18,300†	16,550†

†Mean value for all climate conditions, current load ranges from 13,400 to 50,270 kg/yr.

Table 5-3b: NVSS

Source	LA, % Reduction	Current Load, Mg	Load Reduction, Mg
Background	NA	NA	NA
Shoreline & Gully	25 reduction	28,300	7075
Nonpoint Source	65 reduction	25,380†	14,680†

NA = Not applicable; no determined background load
†Mean value for all climate conditions, current load ranges from 22,170 to 29,410 Mg/yr.

Table 5-3c: Siltation

Source	LA, % Reduction	Current Load, Mg	Load Reduction, Mg
Background	NA	NA	NA
Shoreline & Gully	10	28,300	2,830
Nonpoint Source	15	25,380†	3,810†

NA = Not applicable; no determined background load
†Mean value for all climate conditions, current load ranges from 22,170 to 29,410 Mg/yr.

6.0 MARGIN OF SAFETY

6.1 METHOD FOR CALCULATING MARGIN OF SAFETY (MOS)

The MOS is an additional factor included in the TMDL to account for scientific uncertainties, growth, and others such that applicable water quality standards/guidelines are achieved and maintained. The MOS can be included implicitly in the calculations of the WLA and LA or can be expressed explicitly as a separate value.

For the Governor Bond Lake TMDL, the MOS includes both implicit and explicit determination. Conservative input values (examples) were chosen for modeling purposes in order to implicitly include a MOS. The BATHTUB model calculated a measure of potential model error (coefficient of variation). This error term was used in combination with the coefficient of variation for percent load reductions in order to meet target water quality goals. The summation of these error terms was used to determine an additional explicit MOS. The coefficient of variation is a measure of variation in numbers relative to the mean value and can be expressed as either a fraction or percent of the mean.

6.2 RATIONALE FOR MOS

Potential sources of error are inherent in measured data, default values chosen for modeling, and model calculation procedures. The first two error sources are included in the implicit MOS, while the last error source is included in the explicit MOS.

1. Measured flow data had several potential errors; flows were determined based on staff gage depth of water flow, cross-section geometry, and float method stage-discharge relationships. Changing channel morphology during the growing season is highly likely. Stage-discharge relationships were measured at the end of the monitoring season, and are therefore only approximate for the monitored season. Bending of staff gages, limitations of float method, and changing channel morphology all contribute to measured flow errors.

2. Measured concentrations were from single grab samples, often following a precipitation event in order to capture high flow transport of pollutants. These samples may not accurately describe total loads during high flow conditions or base flow conditions. If samples happened to miss the peak loading times, loads may be under predicted. If samples were taken only during peak concentrations, loads may be over predicted.

3. Suspended sediment samples do not often characterize the entire water column, and the measurements often miss heavier particle fractions because they settle out before the subsample can be drawn out for laboratory analysis.

4. GIS analysis was used to minimize calculation errors, however, watershed characteristic data is based on several data sources, each containing inherent errors (e.g., soil survey polygons, soil survey k factors, land use type and area, etc.). Differences in calculated areas, when one data set is re-projected to be consistent with other data sets, is another source of error.

5. Model calculations use various regression and decay functions. Each submodel has errors associated with it. These are tabulated during the modeling process for an overall coefficient of variation.

7.0 SEASONAL VARIATION

It is often essential to account for seasonal variations in the concentrations of contaminants addressed in the TMDL. However, while seasonal variation is important for reservoir and lake systems, climate conditions and climate history can have a great effect on transport and transformation processes. Runoff and transport will be affected by previous year climate as well as current climate conditions. Flushing or storage in the reservoir will be affected by the climate (amount of precipitation and runoff) and amount of inputs.

Seasonal variation was addressed by using an averaging program, FLUX, to determine yearly flow-weighted average pollutant concentrations, which integrate the effects of seasonal variation and flow measured in-stream concentrations. This model can be adjusted to account for these effects by stratifying the data into related categories (e.g., early spring and late fall, high flow and low flow). The resulting average and associated error terms incorporate seasonal effects.

The Generalize Watershed Loading Function model was run for 13 continuous years, 1987 through 1999. This time frame was chosen in order to provide each simulated year (1989, 1993, 1996, and 1999) with at least three years of antecedent conditions for characterizing the build up of soil moisture, runoff, groundwater, and other transport factors.

Finally, the BATHTUB model was run for four climate conditions in order to bracket the effects of variations in climate. BATHTUB is a steady-state, equilibrium model that models both a single season or single year conditions and does not include build up and storage components. Simulations for changing watershed characteristics or climatic conditions were performed by first modeling the changed conditions in GWLF and using that program's output as input values for BATHTUB. Seasonal variation is modeled implicitly by including coefficients of variation for measured in-lake water quality parameters, which are descriptive of seasonal variations.

8.0 MONITORING PLAN

8.1 GOALS OF THE MONITORING PLAN

The goals of this monitoring plan are to assess the effectiveness of the Best Management Practices (BMPs) for attaining in-lake water quality TMDL endpoints and designated use full support. Governor Bond Lake will remain listed until it meets the standards/criteria/guidelines identified by the IEPA.

8.2 MONITORING ACTIVITIES, SCHEDULE, AND RESPONSIBILITIES

Governor Bond Lake should continue to be monitored by the Illinois EPA for in-lake water quality parameters on a three-year basis as a continuing part of the Ambient Lake Monitoring Program. Long-term trends analysis can be used to determine if water quality is improving and TMDL endpoints are being met.

Assuming implementation of the Clean Lakes Program Phase II, it is expected that additional monitoring would be part of this effort.

Tributary Monitoring. Attainment of TMDL endpoints may take time; the internal phosphorus load that may require long-term flushing to remove and BMPs within the watershed may require time to generate sufficient funds and education to implement. However, it is important to assess the effectiveness of the TMDL program in a timely manner and to make any adjustments or additions as needed. Accurate monitoring of loads entering Governor Bond Lake will provide intermediate assessment of load reduction strategies and help to identify priority areas. Stage-discharge relationships should be developed, and water quality monitoring should be conducted on the major tributaries (Dry Branch, Upper Kingsbury Branch, and Lower Kingsbury Branch) to accurately quantify BMP effects on load reductions. Previous stage discharge relationships are only approximate and apply only to the concurrently sampled water quality data.

BMPs Assessment. Monitoring studies should be conducted prior to implementation of structural BMPs and three years following implementation.

Bathymetry. Lake siltation should be assessed by detailed bathymetry according to similar methods used by the Zahniser Institute of Environmental Studies for the Clean Lakes Program Phase I efforts, (ZEIS, 2001). Differences in methodology used in previous bathymetry studies do not allow for comparison between years of lake volume changes, hence, siltation rates. New measurements should be completed in 2004-2005 to correlate lake siltation rates with surrogate measures and assess BMPs effectiveness.

A geographic information system (GIS) with updated land use, including CRP enrollment, should be developed to track quantity and effectiveness of agricultural BMPs in the watershed. This could be developed by the INHS or ZEIS in cooperation with the local NRCS.

9.0 IMPLEMENTATION ACTIVITIES

9.1 BEST MANAGEMENT PRACTICES

Best Management Practices (BMPs) fall into two categories: cultural and structural. Cultural practices rely on changing human interactions with their environment and rely on incentives, education, and/or regulations to implement (e.g., conservation tillage, nutrient management plans). Structural practices are devices that are built or created to reduce pollutant transport (e.g., terracing, constructed wetlands). These are often more expensive up front, but can be easier to implement once funding has been obtained. Benefits of structural practices are often evident in a shorter time frame.

9.1.1 Cultural BMPs

Conservation Tillage and Conservation Reserve Program (CRP):

Conservation tillage minimizes soil structural damage and increases surface residue coverage, which in turn enhance soil infiltration and water holding properties and increase surface roughness. The combined effect is less sediment and chemical transport off the field. Conservation tillage is any tillage practice that leaves at least 30 percent of the surface covered with crop residues. Drawbacks to conservation tillage may include reduced crop yield and/or costs for retooling farm equipment.

The Conservation Reserve Program pays farmers to remove erosion susceptible land and plant it to a mixture of grass and legumes for 10 to 15 years. This allows land to recover structure and infiltration properties. Continuous enrollment is also an option for land set aside for grassed waterways, filter strips around creeks and ponds, windbreaks, riparian buffers (hardwood trees in bottom lands adjacent to streams and tributaries), and shallow water areas for wildlife. Drawbacks of CRP to the farmers are minimal, since potential CRP lands are likely in less productive areas to begin with. Reduced pasture or grazing land may be considered a drawback.

Table 9-1 examines the relative modeled effect of additional conservation tillage and/or CRP land on pollutant load reductions in the Governor Bond Lake watershed. An additional scenario considered is where all potential home sites around the lake are developed without additional BMPs (Full Build Out). Effects of these factors were incorporated into GWLF model input parameters.

Table 9-1. Percent Reduction in Loads Due to Conservation Tillage and CRP.

			Double CRP Acreage (31.4%)				Double Conservation Tillage (60%)			
Year	Climate	Initial Erosion	Erosion	Sediment	TN	TP	Erosion	Sediment	TN	TP
		tons/ac	tons/ac	%	%	%	tons/ac	%	%	%
1989	dry	5.64	4.68	13.2	8.0	5.6	4.37	22.7	16.6	10.6
1993	wet	6.99	5.79	15.2	9.7	5.6	5.42	19.3	11.8	2.7
1996	normal	7.48	6.20	16.7	11.5	6.5	5.80	24.0	18.1	8.8
1999	wet-norm	5.72	4.74	18.0	12.6	6.3	4.43	27.0	20.8	10.5

			Double CRP and Cons. Tillage				100% Conservation Tillage			
Year	Climate	Initial Erosion	Erosion	Sediment	TN	TP	Erosion	Sediment	TN	TP
		tons/ac	tons/ac	%	%	%	tons/ac	%	%	%
1989	dry	5.64	3.89	34.6	15.6	12.6	2.87	51.0	18.3	16.5
1993	wet	6.99	4.81	36.1	16.0	10.7	3.55	51.1	15.6	12.3
1996	normal	7.48	5.15	37.2	18.7	11.8	3.81	51.1	18.1	13.0
1999	wet-norm	5.72	3.94	38.2	19.5	10.6	2.91	51.1	17.7	10.8

			Full Build Out			
Year	Climate	Initial Erosion	Erosion	Sediment	TN	TP
		tons/ac	tons/ac	%	%	%
1989	dry	5.64	5.708	0.0	-1.2	-1.0
1993	wet	6.99	7.070	0.0	-0.9	-0.7
1996	normal	7.48	7.571	0.0	-1.1	-0.8
1999	wet-norm	5.72	5.785	0.0	-1.6	-1.0

Conservation Tillage = No-till

Conservation tillage and CRP programs, alone, are insufficient to meet TMDL goals. Other BMPs will need to be implemented. However, effectiveness of some BMPs described below will be dependent upon maintenance (e.g., pond in-filling, clogging of filter strips with eroded sediment, etc.). Therefore, conservation tillage and CRP will greatly assist in longevity and functional efficiency of these other BMPs and should be considered a necessary part of the load reduction strategy.

Full Build Out show slightly (< 0.1 percent) negative pollutant reductions are possible due to an actual increase in nutrient pollution from the additional septic systems.

Nutrient Management:

The high surface and subsurface runoff potential makes nutrient management important in the Governor Bond Lake watershed. Nutrient management involves managing the source, rate, form, timing, and placement of nutrients. Nutrient management is a component of a conservation management system that can be used in conjunction with filter strips to reduce the amount of nutrient loads to Governor Bond Lake.

The objectives of nutrient management are to effectively and efficiently use nutrient resources (e.g., manure, commercial fertilizers) to supply plants with sufficient resources to produce food, forage, fiber, and cover while minimizing environmental degradation. Nutrient management is applicable to all lands where plant nutrients and soil amendments are applied.

Typical nutrient management components of conservation plans may include the following information:

- Field map and soil map
- Crop rotation or sequence
- Results of soil, water, plant, and organic material samples analyses
- Expected yield
- Source and form of nutrients to be applied
- Nutrient budget, including credits of nutrients available
- Recommended nutrient rates, form, timing, and method of application
- Location of designated sensitive areas
- Guidelines for operation and maintenance

General nutrient management considerations for water quality protection may include the following:

- Test soil, plants, water and organic material for nutrient content
- Set realistic yield goals
- Apply nutrients according to soil test recommendations
- Account for nutrient credits from all sources (e.g., manure, atmospheric nitrogen fixation, carry over from previous applications, etc.)
- Consider effects of drought or excess moisture on quantities of available nutrients
- Use a water budget to guide timing of nutrient applications
- Use cover and green manure crops, where possible, to recover and retain residual nitrogen and other nutrients between cropping periods
- Use split applications of nitrogen fertilizer for greater nutrient efficiency
- Incorporate nutrients to minimize losses.

Guidelines for operation and maintenance include the following:

- Review nutrient management component of the conservation plan annually and make adjustments when needed
- Calibrate application equipment to ensure uniform distribution and accurate application rates.
- Protect nutrient storage areas from weather to minimize runoff and leakage
- Observe setbacks for nutrient applications adjacent to water bodies, drainage ways, and other sensitive areas
- Maintain records of nutrient applications
- Clean up residual material from equipment and dispose of properly

A nutrient management plan also includes an assessment of the site-specific potential environmental risks. For example, a nutrient management plan should include an assessment of the potential risk for nitrogen and phosphorus to contribute to water quality impairment. Areas that might have high levels of produced or applied nutrients that may contribute to environmental degradation must be evaluated and appropriate conservation practices and management techniques must be implemented to mitigate any unacceptable risks.

Filter/Buffer Strips:

Filter strips, which are areas of grass or other permanent vegetation, can be used to maintain or improve water quality by reducing sediment, organics, nutrients, pesticides, and other contaminants from runoff. Filter strips are recommended because of their effectiveness in reducing dissolved contaminants in areas situated between cropland and water bodies. In several instances, filter strips are listed as one of the most effective BMPs in reducing ammonia and nitrogen transport to water bodies. The following case studies illustrate the effectiveness of using filter strips (USDA 1999):

- In Arkansas, two studies concluded that sediment and nutrient runoff (including nitrogen and phosphorus) from poultry and swine manured fields were significantly reduced in the first 10 feet of a tall fescue grass filter grown on a Captina silt loam soil. Further lengthening of the filter strip beyond 30 feet did not significantly reduce the contaminant load of the runoff water.

- In Montana, the trapping efficiency and nutrient uptake of four grasses were measured to treat dairy manure runoff in a filter strip. Orchardgrass and meadow bromegrass were effective at both entrapping the nutrients in the runoff and absorbing the nitrogen into the plant biomass within the upper 20 feet of the filter.

In addition to reducing the amount of nutrients, filter strips have the following benefits:

- Permanent vegetation along watercourses and drainage ways helps stabilize the adjacent area. The width of filter strips provides a distance from the edge of the watercourse so equipment does not damage the area.

- Companion legumes in filter strips have value and can be harvested or used. Alfalfa can be the companion legume and be harvested for commercial hay or used for on-site livestock.

The effectiveness of filter strips depends on many parameters; the key ones include flow velocity, vegetation, and width. For preliminary design purposes, the width required for different field slopes may be estimated from Table 9-2.

Table 9-2. Filter Strip Width on Land Slopes to Achieve Minimum Flow Through Times of 15 and 30 Minutes, Respectively, for a 0.5-inch Rainfall.

	Filter Strip Width (feet)					
Percent Slope	**0.5%**	**1.0%**	**2.0%**	**3.0%**	**4.0%**	**$\geq$ 5.0%**
15-min Flow Through	36	54	72	90	108	117
30-min Flow Through	72	108	144	180	216	234

Source: NRCS 1999

Lawn management:

Homeowners surrounding the lake can impact lake water quality by lawn care management practices. Mowing to the shore edge reduces native aquatic vegetation that is often helpful in providing fish habitat and shoreline stabilization. Incorrect application of pesticides and fertilizers can wash off lawns and enter directly into the lake. Timing, amount, and form of fertilizer can be adjusted to minimize potential loss to the lake.

9.1.2 Structural BMPs

Shoreline Stabilization and Aquascaping:

Governor Bond Lake is a reservoir, with naturally steep banks and high flow rates, and consequently shoreline stabilization is a difficult process. The city of Greenville has begun an extensive rip-rap and embankment program to control shoreline erosion in the lower basin. Alternative rip-rap components and energy dissipaters (e.g., native material bank revetment, deflectors) should be explored to maximize effectiveness. Regrading bank slopes to a more stable angle and establishment of vegetation can also be effective at reducing bank erosion.

There are currently no no-wake restrictions (no-wake zones) in the lower basin. No-wake zones can reduce impacts of boating on shoreline erosion by reducing the wave action that erodes shorelines.

Aquascaping, or shoreline vegetation and land management, can be effective in establishing conditions conducive to aquatic life support, reduced nutrient transport, and shoreline stabilization. Aquascaping includes planting or allowing natural aquatic macrophyte (rooted aquatic plants) growth and establishment near lakeshores. These plants acts as filter strips to remove nutrients and help dissipate erosive energy of the flowing water.

Construction Permitting:

There are no construction BMPs required as part of the permitting process; however, recently the Public Health Department established minimum lot sizes for new on-site septic systems. Minimum lot sizes provide for more area through which wastewater can infiltrate and be cleaned prior to discharge into shallow groundwater. These design requirements, however, are for human health protection and not for water quality protection. Typically, erosion control measures for new construction permits and setbacks for septic fields from water bodies are often required.

A recent city of Greenville inspection showed that most on-site septic systems (100/108) are functioning appropriately and new systems being built are primarily aeration systems (GBL Committee, 1999). Aeration systems generally include a holding tank that is periodically pumped, an aeration chamber that supplies compressed air and mixes waste material to increase decomposition, and a clarifying chamber to remove particulates (Doley and Kerns, 1996). Systems surveyed included all privately owned septic systems in subdivisions around Governor Bond Lake. Recommendations for remediation were provided to owners of failed systems.

Septic Systems:

Septic systems near the lake and tributaries can contribute nutrient and fecal coliform pollution. Like livestock manure, human effluent is rich in nutrients, oxygen-demanding waste materials, and fecal coliforms. Typical septic systems include a settling chamber where the large solids settle out and a drainfield, where liquid waste is dispersed over a large area and slowly percolates through soil. The settling tanks need to be pumped periodically (every three to five years, depending on size and load) or they will contribute to failure of the system. Drainfields can also get clogged over time, which prevents effective polishing of the liquid waste.

Septic systems should be sited far enough away from the lakeshore to allow for sufficient filtering of nutrients and fecals by soil and for uptake of nutrients by plants, prior to discharge into the lake. In areas where soils are not sufficient for septic systems (e.g., shallow depth to groundwater, infiltration too slow), aeration or mounded systems can be installed. Aeration systems generally discharge the liquid effluent at the surface, therefore, discharge should be at a point sufficiently far from the lakeshore such that there is plenty of time for nutrients to infiltrate into the ground and be taken up by plants. All systems need to be maintained; failed systems short-circuit or bypass the treatment processes and contribute to water quality pollution.

Feedlot Runoff Containment and Wetlands

Feedlot and manure application regulations for protection of water quality are found in Title 35 of the Illinois Administrative Code, Subtitle E, Part 501. BMPs for manure spreading and feedlot runoff containment or diversion will help reduce loads from feedlots. Assessment of compliance with current regulations is important in minimizing feedlot impacts on water quality. Standard BMPs include lagoon, pit, diversion, manure spreading, and other practices. Slaked lime or alum manure amendments can also be added to animal manure to bind dissolved P and reduce its solubility, hence, availability for plant growth and runoff (Sharpley et al, 1999).

For smaller feedlots and other animal operations not covered under the Illinois Adm. Code, Subtitle E, feedlot wetlands may also be helpful in reducing water quality pollution.

Wetland and Extended Detention Pond Systems to Reduce Nutrient and Sediment Loads.

Construction of multi-celled extended detention ponds or wetlands can present an opportunity to improve the quality of runoff from the nonpoint sources, provided that the drainage system in the vicinity of the wetlands is modified to direct and detain the runoff in the wetland complex. The Upper Pond area, several inlets with current backwater effects, small feedlot and other animal operation drainage areas, and additional sites in the upland areas are all potential locations for this type of BMP. In particular, siting these systems in areas with animal waste runoff (e.g., the equestrian farms on the Upper Kingsbury Branch) and watershed drainage in the upper Kingsbury Branch would be most effective, since pollutant loads from this watershed are the greatest.

Nutrient removal in wetland systems occurs through settling and by biological uptake. Most aquatic and wetland plants take nutrients from the sediments through their root system rather that from the water column through the leaves. Removal rates may be quite variable throughout the year with high removal rates in the spring and summer. Removal rates, however, are sometimes low in the fall and winter because of floating, dead plant material released from the basin and complex nutrient cycling patterns often associated with wetlands. Healthy wetland detention systems can have sediment removal rates from 60 percent to 100 percent and removal rates of nutrients in the range 20 percent to 80 percent. A discussion of using wetlands to control non-point sources is presented in *Technical Memorandum, Literature Review-Wetlands as a Nonpoint Source Pollution Control Measure (*1993). Detailed procedures for constructing wetlands or enhancing existing wetlands will not be presented here, as these are site specific.

The feasibility of implementing this BMP will depend to a great extent on the cooperation of the city of Greenville and agreement from the owners of the property and adjacent properties (potential flood zone effect). The Illinois Department of Transportation may also need to be involved because of the potential effect of modified drainage patterns on highway culvert crossings and roadside ditches within IDOT's right-of-way. IDOT approval for proposed construction activity within the IDOT right-of-way will be needed.

Livestock Fencing:

Animal traffic into and out of streams contributes to bank erosion, re-suspension and mixing of settled materials, direct deposition of waste products into the waterway, and destruction of bank vegetation that is important in filtering out runoff nutrients and sediment. Fencing livestock out of these streams and providing fenced stream crossings, if necessary, are effective at reducing bank erosion and maintaining vegetative buffers along the tributaries. Areas with pastures leading right up to the stream bank should be targeted for fencing BMPs.

Internal Load Reduction BMPs:

Aeration

Internal nutrient cycling generally occurs due to re-release of previously settled out phosphorus bound to particles. Anoxic (lack of free oxygen) conditions convert bound phosphorus to dissolved phosphorus. Subsequent lake mixing can cause this dissolved phosphorus to be brought back up to the surface and made available for plant (algal) growth. Aeration systems can keep oxygen conditions from being depleted on the lake bottom and therefore very effective at preventing re-release of bound phosphorus.

Destratifiers

Destratifiers enhance lake mixing at depths in order to prevent formation of thermal stratification in deep lakes (> 15 foot depth). Thermal stratification sets up the lake with a thermal resistance to mixing, effectively separating the warmer, lighter, well-mixed surface water from the colder, denser, undisturbed deep water. If phosphorus re-release is occurring due to anoxic conditions enhanced by lake stratification, this technique reduce phosphorus re-release by keeping the lake mixed and new oxygen replenishing the depleted supplies. In shallow lakes, however, where anoxic conditions are due to episodic events (sudden senescence of a large amount of aquatic plants) or re-suspension by wind and fish, this technique will not be effective.

Sediment Sealing

Sediment sealing effectiveness tends to last about 10 years, depending upon lake and sediment chemistry and costs approximately $700/ha (1993) (Welch and Cook, 1995). The process works by binding dissolved (plant-available) phosphorus to Alum or another metal oxide that holds phosphorus tightly bound even during depleted oxygen (anoxic) conditions. Similar to public waste water and water supply treatment processes, Alum picks up the phosphorus, binds it, and settles to the bottom of the lake where the phosphorus is rendered unavailable. It is a simple and effective process, provided that the lake chemistry and physical characteristics are appropriate. Amount of sediment and water column iron, pH, and phosphorus, in addition to more detailed lake mixing information and other characteristics need to be determined prior to considering this a viable option. A diagnostic feasibility study should be completed prior to choosing this method.

Dredging

Dredging is an effective, but very costly method for reducing internal nutrient cycling (18-65 percent TP for Governor Bond Lake). Dredging to a 1-m depth can cost $20,000/ha (Welch and Cook, 1995). Effectiveness of this nutrient removal process is 100 percent and will last for at least 50 years.

Structural BMPs Summary

The following table summarizes the pollutant removal efficiencies of some structural BMPs. The values presented are averages and in most cases there is a wide range due to BMP design, siting, and watershed characteristic s.

Table 9-3 Summary of Structural BMP Average Effectiveness for Pollutant Removal

BMP	Load Reductions			Comments	Source
	TSS	TP	TN		
	%	%	%		
Extended Detention Wet Pond	80	65	55	Extended wet detention ponds are effective for sediment and nutrient removal but must be sized to hold 2.5 inches of runoff in the permanent pool (26 to 160 acre-ft for Governor Bond Lake subwatersheds).	USEPA 1993
Constructed Wetland	80	65	55	Constructed wetlands must be 1 to 3% of the watershed area to be effective (3.6 to 96 acres for Governor Bond Lake subwatersheds).	USEPA 1993
Multi-cell Detention Ponds or Wetlands	>80	>65	>55	Incremental increases in removal over Constructed Wetlands or Extended Detention Wet Ponds depending on size, number, and configuration of additional cells	USEPA 1993
Filter/Buffer Strips	75	70	60	Reports of over 90% TP removal with 60-ft buffer strips	USEPA 1993
Feedlot Wetlands	75	85	70	The upper subwatershed of the Kingsbury Branch (ROP04) is the largest nutrient contributor to Governor Bond Lake. High loads may be associated with dairy cattle operations that may be mitigated by this BMP	Simeral 1998
Stream Fencing	Considered High but No Quantification			An important BMP for filterstrip/buffer BMPs, protection and general stream bank stabilization.	
Lake Bank Stabilization	No Quantification			Rip-rap, vegetative cover, etc. will help reduce continued slumping.	

Lake Shore Aquascaping and Set-backs	No Quantification			Lakeshore setbacks for houses and septic systems, natural aquatic plants, buffers, and filterstrips all are effective at reducing bank erosion.	
Aeration System		up to 90% internal		Testing necessary to determine cause of internal cycling and best locations. Must be maintained.	
Sediment Sealing		up to 96% internal		Temporary depending upon sediment type and other conditions, one to 10 years	Welch and Cook 1995, 1999
Dredging		up to 90% internal		Long term (>10 yrs), but costly	Welch and Cook 1995, 1999

9.1.3 Existing BMPs

Riparian Buffers and Conservation Reserve Program (CRP) Land. The Governor Bond Lake watershed landscape is flat with steeply rolling land next to the tributaries. The most prevalent BMPs currently being used are filter strips and other land enrolled in the CRP program. These lands are typically removed from production agriculture and planted to a mixture of grasses and legumes for 10 to 15 years, and then returned to production. Continuous enrollment is also an option for land set aside for grassed waterways, filter strips around creeks and ponds, windbreaks, riparian buffers (hardwood trees in bottom lands adjacent to streams and tributaries), and shallow water areas for wildlife. Much of the upland soils in the Governor Bond Lake watershed are considered a "good" candidate for shallow water areas, while the lower lands near streams are "good" candidates for hardwood trees (riparian buffers) (NRCS 1983). Most of the soils are considered restricted for grassed waterways due to erosion potential, slow percolation, and high wetness. All of the soils are suitable for grass and legume establishment and growth.

A tax abatement option is available for buffer strips of at least 66-foot width next to a water body. Much of the land immediately adjacent to tributaries is steeply sloping or very wet and not suitable for row crops and is consequently used for pasture or left as wooded riparian buffers. Some pasturelands continue right up to the tributary banks.

Conservation Tillage. Conservation tillage, primarily no-till, is also practiced in the county on approximately 31 percent of the cropped acreage (Illinois Transect Survey, 2000).

Education. A newsletter produced by the University of Illinois Bond County Cooperative Extension Service is used for public education on such issues as conservation tillage, efficient application rates, filter strip program, and other practices for protecting Governor Bond Lake.

Feedlots. Feedlot and manure application regulations for protection of water quality are found in Title 35 of the Illinois Administrative Code, Subtitle E, Part 501. In spring 2001, a diary feedlot operation in the Dry Branch subwatershed completed installation of a livestock waste handling facility. In compliance with state regulations, this facility was approved by the Illinois Department of Agriculture.

Shoreline Stabilization. The city of Greenville and associated stakeholders has already rip rapped 27,800 feet of shoreline and reconstructed approximately 700 feet of eroded shoreline banks.

Except for the CRP estimate in the land use section (15.7 percent of cropland) and shoreline stabilization, effectiveness, exact acreage, and amount of each BMP are not known at this time.

9.1.4 BMP Recommendations:

Combinations of cultural and structural BMPs are possible to reduce loads to target levels (94 percent reduction in nutrients, 89 percent reduction in NVSS). It is important to include cultural BMPs in implementation, such as conservation tillage and/or CRP, because longevity and effectiveness of structural BMPs will be enhanced by cultural BMPs, even though total reductions may not be as significant.

These removal rates are based on average effectiveness of these BMPs. In this watershed, however, average rates may not be practically attainable. Consequently, additional BMPs recommended to maximize the possibility of TMDL goal attainment. Other combinations are also possible, and exact reduction rates will depend on BMP design, siting, and other watershed characteristics.

Nutrient BMPs

The combination of the following BMPs results in a reduction of 94.6 percent of TP load to the lake

- 33.5 percent reduction through aeration, sediment sealing, or system flushing (90 percent of internal load)
- 20 percent reduction of external load due to cultural practices (primarily through CRP and tillage and nutrient management practices)
- 70 percent reduction of external load due to buffer strips
- 65 percent reduction of external load due to ponds or wetlands

Additional recommended BMPs

- Septic system maintenance and design. Include sufficiently large drainfield, assure that soil filtration properties are sufficient, and add setback requirements of at least 75 feet from the shoreline to construction permits. Replace failed systems with systems that comply with new requirements.

- Lawn management. Develop lawn chemical management guidelines for homeowners near the lake. Educate homeowners on proper use of lawn chemicals and their effects on water quality.

Sediment/NVSS BMPs

The above combination of BMPs will also result in a 92 percent reduction in sediment/NVSS

- 20 percent reduction due to cultural practices
- 75 percent reduction due to buffer strips
- 80 percent reduction due to ponds or wetlands

Additional recommended BMPs

- Shoreline stabilization. Continue with rip-rap and bank stabilization. Target highly eroded areas noted in the Clean Lakes Program Phase I Study Report (ZEIS, 2001). Explore other stabilization materials and options.

- No-wake zones. Establish boating "No-wake" zones near the most eroded segments of the shoreline to minimize wave action impact on these susceptible areas.

Overall additional BMPs.

- Stream bank fencing. Keeping livestock out of tributaries will reduce both nutrient and sediment pollution.

- Construction erosion control. Include construction erosion control plans, for sites located near water bodies, in the permitting process. Reduced sediment transport will also reduce transport of associated pollutants. Although contributions from construction sites are expected to be small, their proximity to water bodies results in immediate impacts.

- Promote aquascaping and natural aquatic vegetation to reduce shoreline erosion and increase nutrient uptake.

9.2 IMPLEMENTATION APPROACHES

Section 9.1 above describes various BMPs and their potential for achieving the proposed target phosphorus, sediment, and NVSS load reductions. This section describes the manner in which the proposed BMPs could be implemented. Appendix B describes potential funding sources for implementing these BMPs. This section does not constitute a plan for implementing BMPs. Rather, this section simply documents that institutional structures are in place to support BMP implementation. The major BMPs and their implementation approaches are as follows:

Cultural BMPs (e.g., conservation tillage, nutrient management plans, lawn care management, CRP, and others)

According to the NRCS (2000)[4] 15.7 percent of the land is already enrolled in CRP. The NRCS and the University of Illinois Bond County Extension Service have already begun a program for educating watershed residents on nutrient and tillage management, septic maintenance, and other water quality issues (GBL Committee, 1999). Additional education measures are recommended and assistance given for preparing tillage and nutrient management plans. Because they are currently being implemented, there is no initial phase-in period needed to establish programs.

Structural BMPs (e.g., constructed wetlands, stormwater detention ponds, filter/buffer strips, others)

[4] Personal communication, Dan Mueller, NRCS, 2000.

As part of the Clean Lakes Program Phase II efforts, multi-celled wetlands and/or detention ponds could be sited at several locations within the watershed.

According to the NRCS (2000), through CRP, filter and buffer strips are already established along some tributaries. There is currently a property tax abatement offered to land owners who leave at least 66 ft of riparian buffer next to tributaries. It is recommended that these programs be expanded to include all land adjacent to tributaries.

The city of Greenville has already begun a shoreline stabilization program. This program should continue and be expanded to include eroded and undercut banks as identified in the Clean Lake Program Diagnostic Feasibility Study, Governor Bond Lake (ZEIS, 2001).

10. REASONABLE ASSURANCES

10.1 EVIDENCE OF BMP IMPLEMENTABILITY

The proposed BMPs are acceptable to watershed stakeholders for implementation. These BMPs are consistent with those recommended in the IEPA Clean Lakes Program Phase I Diagnostic Feasibility Study, Governor Bond Lake (ZEIS, 2001) and the Governor Bond Lake Resource Plan (Governor Bond Lake Planning Committee, 1999).

Load reduction goals for nutrients (phosphorus) are high, but not unreasonable; studies have shown reduction rates due to proposed BMPs are reasonable. Continued monitoring following TMDL implementation will determine if TMDL endpoints are being met. BMPs could be expanded to include greater areas and/or treatment if TMDL endpoints are not being met.

10.2 DESCRIPTION OF NON-REGULATORY, REGULATORY, OR INCENTIVE-BASED APPROACHES

The Federal Clean Water Act, the Illinois Environmental Protection Act, the Illinois Water Pollution Discharge Act, and regulations and guidance implementing those statutes do not provide authority for the direct regulation of nonpoint sources of pollution to surface waters. As a result, control of nonpoint sources of pollutants and sediment must be addressed through nonregulatory measures, such as economic assistance and education, or through local ordinances and permitting processes. Section 9.1 describes a number of BMPs that will result in reduction of nutrients and sediment load to Governor Bond Lake. Many of these BMPs are being implemented through voluntary and incentive-based approaches. Furthermore, Appendix B describes funding sources that could be used to further expand the BMP applications.

11. PUBLIC PARTICIPATION

IEPA policy requires full and meaningful public participation in the TMDL development process. Illinois provides for public participation consistent with its own continuing planning process and public participation requirement provided in 40 CFR § 130.7 (c) (1) (ii). Furthermore, Illinois provides for meaningful public involvement in the TMDL through a series of two public meetings and one public hearing, which allow for public comment the draft TMDL.

11.1 DESCRIPTION OF PUBLIC PARTICIPATION PROCESS

Illinois EPA published a notice of the commencement of its solicitation of comments from the public on the proposed TMDL on June xx, 2001. The public comment period ran from June xx through August xx, 2001, and included the public hearing held in Greenville on July xx, 2001. A copy of the draft TMDL was maintained for public viewing in Greenville at _______________ ,at the IEPA offices at ____________, and on the IEPA website ______________________________.

11.2 SUMMARY OF SIGNIFICANT COMMENTS AND RESPONSES

[To be added following close of the public comment period]

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GOVERNOR BOND LAKE TMDL

APPENDIX A

HYDROLOGIC AND WATER QUALITY MODELING OF GOVERNOR BOND LAKE

A. MODELING PURPOSE

To quantify nutrient and sediment loads entering Governor Bond Lake and to determine load reductions necessary to meet water quality standards and criteria or guidelines.

Governor Bond Lake has minimal time sequence data and no continuous data; therefore, not enough data exists to support dynamic modeling. Based on the contributing causes to designated use impairments that have been identified for Governor Bond Lake (primarily nutrients, sediments, and algae), the chosen model(s) must do three things:

1. Model sediment loads to the lake
2. Model nutrient loads to the lake, including septic systems
3. Model internal eutrophication/nutrient cycling

B. GENERAL MODEL DESCRIPTIONS AND APPROACH

To model sediment and nutrient loads to Governor Bond Lake, the Generalized Watershed Loading Function (GWLF v 2.0, 1992) model was used. This is a moderately simple watershed-scale model developed for assessing point and nonpoint source nitrogen and phosphorous loads from rural, urban, and mixed watersheds. In addition to erosion and sediment transport modeling, this model can also assess loads due to septic systems, an important consideration given the nature of soils in this region and the proximity of on-site septic systems to water bodies.

Once inputs into the lake were modeled using GWLF, we used BATHTUB v. 5.4 (1998), developed by the US Army Corps of Engineers to model internal reservoir processes. BATHTUB requires fairly simple inputs and can model inflow/outflows, nutrient cycling, chlorophyll-a (a measure of algal growth), Secchi depth, and oxygen demand.

Supporting models used for calibrating and determining input parameters for GWLF and BATHTUB were FLUX v. 4.5 (1995), a stream load computations model, and PROFILE v 5.0 (1998), a model for determining oxygen demand based on in-lake dissolved oxygen (DO) and temperature (T) profiles.

The entire watershed was subdivided into10 subwatersheds based on 1999 Clean Lakes Program tributary sampling sites and additional discrete units; however, for modeling purposes they were combined into one unit. Monitored data was available for four subwatersheds (ROP02 - Unnamed Tributary, ROP03 - Dry Branch, ROP04 - Upper Kingsbury Branch, and ROP05 - Lower Kingsbury Branch) that were used to calibrate the models for determining contributions from the rest of the subwatersheds. The following diagram depicts the flow paths, subwatersheds, and inflow device (basin) modeled:

Figure B-1. Governor Bond Lake Model Flow Net

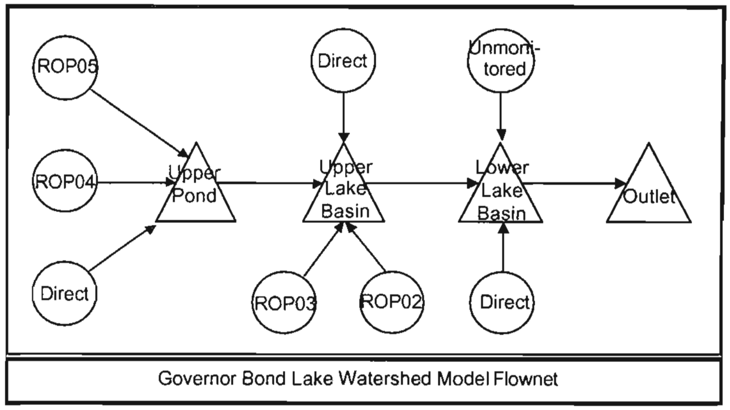
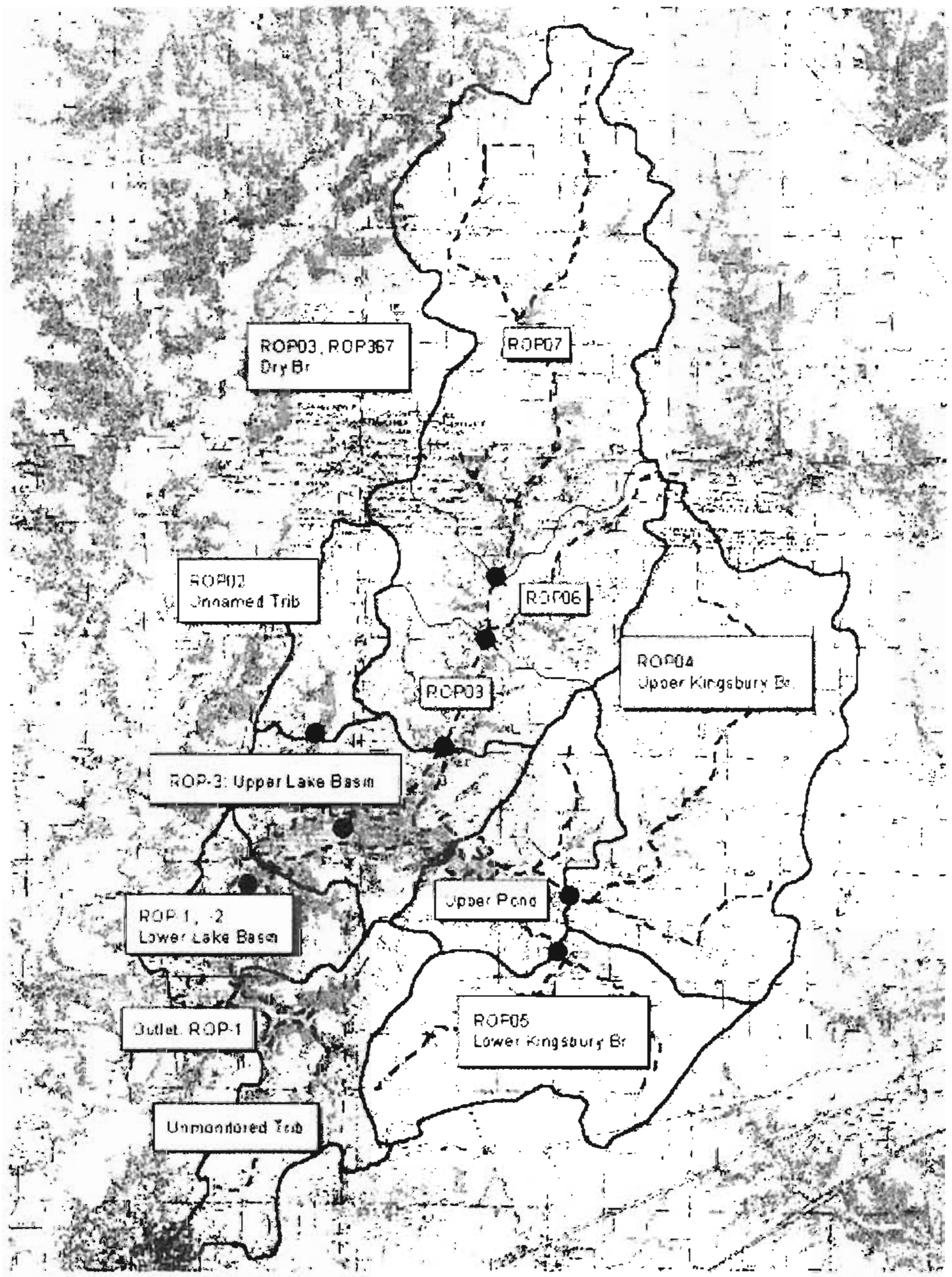


Figure B-2. Governor Bond Lake Subwatersheds and Modeled Clean Lakes Program Monitoring Sites *(red boundaries delineate modeled subwatersheds)*



C. MODELING ASSUMPTIONS AND COEFFICIENTS DETERMINATION

C.1 FLUX

FLUX was used to determine subwatershed specific flow-weighted average concentrations and loads. Daily flow data and measured concentrations from the 1999 Clean Lakes Program monitoring program (Zahniser Institute of Environmental Studies [ZEIS]) were fitted to various model regressions to determine yearly average load and concentrations. Yearly in-stream FLUX concentrations were then used to calibrate the GWLF model. By using FLUX, instead of simple mean values, variations in concentration as a function of flow and season are taken into consideration, resulting in a single yearly value that most appropriately describes the system. FLUX was also used to determine flow-weighted concentrations for the lake outflow, assuming outflow concentrations were the same as in-lake measured concentrations at site ROP-1.

Input Values

Minimum input values included daily flow and at least four water quality samples for determining flow-weighted concentrations using FLUX. Model utilities can be used to determine if sampling frequency and timing is sufficient for rigorous analysis; however, 10 samples and daily flow for an entire year are usually sufficient for reasonable (coefficient of variation < 0.3) results.

Flow Computations

In the fall of 1999, approximately 10 different flow velocity versus stream depth values were measured at Clean Lakes Program (CLP) stream sites ROP02, ROP06, ROP04, and ROP05 (ZEIS, 2001). Flow velocity was measured by recording the travel time of a floating object. A correction factor of 0.85 was applied to each velocity to account for the fact that surface flows have generally higher velocities than the whole cross-section. Prior to initiation of measurements (Spring 1999) stream cross-sections were surveyed at each sampling location. Rating curves (depth of flow versus discharge) were established for sites ROP02, ROP04, ROP05, and ROP06.

Flow was intermittent for site ROP06 during the monitoring season, consequently, the downstream site, ROP03, was used for modeling purposes. To determine flow at site ROP03, Manning's Equation was used to estimate flows at both ROP03 and ROP06. Then, flows at ROP03 were adjusted according to the relationship between Manning's predicted flow at site ROP06 and measured flow at site ROP06. Because of this artifact in calculating flows for ROP03, ROP03 flows were only used for determining yearly average in-stream concentrations and not for determining 1999 annual loads.

The 1999 monitoring program included seven tributary sites with water quality information and stream gauging. Rating curve measurements were gathered for only four sites and at the end of the monitoring season - one of these sites being an intermittent stream. Therefore water quantity calculations will be approximate at best. The tributary streambeds do not appear to be very stable; old sediment is soured out and new sediment deposited during storm events, debris is deposited or moved downstream, livestock and other animals wander in and out of the streambed, and other processes can occur. These will result in changed channel morphology and roughness and therefore flow properties will change. Flows based on velocity times cross-sectional areas will be approximate at best and established rating curves at the end of the monitoring season may not accurately reflect flows during the monitoring season. Finally, since flows were gaged using daily stream depth, backwater effects cannot be determined.

Outflow values were determined using the broad-crested weir equation for flow and monitored water quality in the lake at site ROP-1 (near the outflow). The dam length is 1200 ft, however, due to the nature of the structure (three sides of a square v. straight dam) and restricted flow around 1/3 of the length (near shore), a length of 800 ft was used for calculating actual flows.

Mannings n Equation

$$Q = \left[\frac{1.49 R^{2/3} S^{1/2}}{n} \right] A$$

Weir Equation: Broadcrested Weir

$$Q = CLH^N$$

Where:

Q = Discharge or Flow, cfs
R = Staff Gage Height or Stream Depth, ft
S = Water Surface Slope, unitless
n = Manning's Roughness Coefficient, unitless
A = Cross-sectional Area, ft^2
C = Weir Coefficient = 0.59 for depth of flow v. weir height relationship
H = Staff Gage Height or Stream Depth, ft
L = Weir Length, ft
N = 1.5 for Broadcrested Weirs

Table C-1 Stage-discharge Relationships for Sites With Measured Flow

Table A-2 lists the resulting stage-discharge relationships where Q = discharge (cfs) and H = stage height (ft).

Site	Relationship	r^2*
ROP02	$Q = 0.05068\ H^{4.803}$	0.8872
ROP04	$Q = 0.0339\ H^{5.5577}$	0.9337
ROP05	$Q = 0.269\ H^{3.1962}$	0.9977
ROP06	$Q = 11.124\ H^{2.5045}$	0.9231

FLUX Regression Model Selection

Six regression models are evaluated through FLUX for determining flow-weighted concentrations. The most appropriate regression is chosen based on balancing the following factors: low coefficients of variation (cv), lack of relationship to date or flow (no slope significance for residuals v. date or residuals v. flow), and robustness of the regression. If good fits are not possible, flow or date stratification is applied to improve the fits. Flow-weighted concentration from the best fitting regression is then used for calibrating the GWLF model. FLUX output files list the chosen regression in the header information and means and cvs for all other regressions are listed in the body.

Ortho-Phosphorous Values

Insufficient orthophosphorous (OP) values were available for FLUX flow weighted averages, therefore, the relationship between OP and Total Phosphorous (TP) (OP:TP ratio) was used to determine flow weighted average OP concentrations and loads based on FLUX TP modeled concentrations.

Table C-2. Ortho-Phosphorous to Total Phosphorous Ratios Used for Determining OP Concentrations

Site	OP:TP ratio	Comments
R0P01: Lake Outlet	0.349	Measured
R0P02: Unnamed Tributary	0.832	
R0P03: Dry Br.	0.717	
R0P04: Upper Kingsbury Br.	0.566	
R0P05: Lower Kingsbury Br.	0.643	
R0P06: Dry Br. - upper	0.717	Assume same as ROP03
R0P07: Dry Br. - upper	0.717	
Unmonitored: Unmonitored Trib.	0.643	Use ROP05, adjacent neighbor
Pond: Upper Pond	0.566	Downstream ROP04, use ROP04
Upper: Upper Lake Basin	0.650	Semi-mean ratio
Lower: Lower Lake Basin	0.650	

Annual flows are calculated and respresented in Hm3 (cubic hectameters or 1,000,000 cubic meters).

Table C-3. FLUX Concentrations Summary

Site	Flow	OP:TP	TP	OP	TN	DisN	NVSS	SedN	SedP
monitored season									
			Concentration: ppb						
ROP2		0.863	343.2	296.2	3,725	3,162	175,992		
ROP367		0.717	227.8	163.3	1,250	639	29,415		
ROP4		0.566	718.4	406.6	7,855	2,702	362,791		
ROP5		0.643	536.7	345.1	1,527	721	120,384		
	Hm3		Load: kg/ monitored season					mg/kg	mg/kg
ROP2	0.59	0.863	203.1	175.3	2,194	1,862	104,154	3,186	267
ROP367*	23.54	0.717	5,361.0	3,843.8	29,410	15,028	692,281	20,775	2,192
ROP4	4.74	0.566	3,356.6	1,899.8	37,220	12,804	1,719,133	14,203	847
ROP5	0.22	0.643	116.5	74.9	342	264	26,955	2,901	1,543

*No velocity measurements; Manning's flow adjusted for upstream site relationship

TP = Total Phosphorous
OP = Ortho Phosphorous, calcuated based on OP:TP ratios
TN = Total N
DisN = Dissolved N (NO2N+NO3N)
NVSS = Non-Volatile Suspended Solids (sediment)
SedN = Sediment N concentration = (TN-DisN)/NVSS
SedP = Sediment P concentration = (TP-DisP)/NVSS

Where:
ppb = parts per billion, or ug/L
Hm3 = cubic hectameters, or 10000000 cubic meters
kg = kilograms, or 1000 grams

C.2 GWLF

GWLF was used to model potential sediment and nutrient transport into the lake from each of the eight subwatersheds. Geographic Information System (GIS) layers were obtained from various agency sources and combined for calculating area-weighted parameters for each subwatershed. Soils information included mapping unit, hydrologic group, K-factor (erodibility), and LS (slope-length factor). Soils information was combined with land use layers to calculate area-weighted average Universal Soil Loss Equation KLSCP factor and Curve Number (CN) - two input parameters governing water and erosional transport processes in GWLF.

Table C-4 GWLF Input Parameters Overview

Parameter	Method/Value	Source
Areas	GIS Digitiazed TTEMI delineated topographs	BASINS data set, Illinois Natural History Survey datasets converted to UTM NAD 1927
Land use	GIS; BASINS, and SWAP (Source Water Assessment Program) data sets were converted to same projection and intersected to form a combined landuse layer. This increases the resolution of the BASINS layer yet separated wooded from grass/pasture of the SWAP layer. Data included cropland, grass/pasture, forest, urban, commercial, and transportation landuses and associated area for each subwatershed.	BASINS data set; Source Water Assessment Program data set
Cropping Factors (C)	Cropland = 0.43 (row crop agriculture) Grass/Pasture = 0.01 (CRP, grassland/pasture: permanent pasture, idle land, 80% groundcover as grass) Forest = 0.004 (Managed, woodland, 40-75% tree canopy)	GWLF tables Illinois Transect Survey 2000
Soils	Soil survey was digitized for Bond County and attributed with values from the soil survey. Montgomery County missing data was assumed to be include soils in the same proportion as the Bond County data. Data included soil mapping unit and area for each subwatershed.	Bond County Soil Survey TTEMI digitizing TTEMI attributing
Soil Erodibility Factor (K)	Soil survey data for the surface soil; proportion weighted averages for soil associations.	Soil Survey
Conservation Practice Factor (P)	1.0No conservation practices were modeled since CRP is the primary practice and is accounted for in the landuse categories (considered delineated as grassland/pasture)	
Slope-Length Factor (LS)	LS factors measured by NRCS for each soil mapping unit: Area weighted average for each subwatershed using GIS	NRCS
Hydrologic Group	Soil Survey data for each soil mapping unit	Soil Survey
Curve Number (CN)	Curve number is based on land use and hydrologic group. Intersected soils and landuse data was used to determine CN for each intersected area. A weighted average CN was calculated for each landuse type in each subwatershed.	Tables from GWLF manual for Hydrologic Group - Landuse relationship numbers
Soil Loss and Transport Factor (KLSCP)	Area weighted average for the entire subwatershed determined by intersecting landuse and soils data sets using GIS.	GIS Calculated

Groundwater Recession (r)	GWLF calibrated to monitored stream flows for ROP02, ROP04, ROP05; estimated for other watersheds based. Original estimate based on the following formula during hydrograph regresson: $r = \ln[flowt_1/flowt_2]/(t_2 - t_1)$ $(t_2>t_1)$/day	GWLF - monitored data calibrated
Rainfall Erosivity	Average of Zone 16 and Zone 19, Figure B-1 GWLF Manual since the watershed is near the boundary. Cool season (November though April) = 0.13 Warm season (May through October) = 0.28	GWLF Manual: (Wischmeier and Smith, 1978)
Evapotranspiration (ET)	Default ET coefficient for landuse area and Bond County Agric. Statistics cropping practices used to determine weighted average ET for each subwatershed.	GWLF Manual
Climate	Daily Temperature and Precipitation from 1987 through 1999 were reformated for use in GWLF. Leap year February 29 values were deleted because the model could only run 365-day years. The model was calibrated to 1999 data and simulated for a 13-year run. Greenville station data was used except where values were missing. In this case, neighboring station averages (Vandalia, Carlyle Reservoir, and Hillsboro) were used (all temperature and 1988 through 1992 precipitation)	Regional Climate Data Center
Nutrient Export Coefficients	FLUX calibrated for subwatersheds ROP02, ROP03, ROP04, and ROP05. Averages values from these used for the rest. Grass/Pasture was assumed to have the same nutrient concentrations as Cropland since these individual landuses could not be separated out. See text for more discussion.	GWLF/FLUX Calibrated
Nutrient Washoff Coefficients and Accum. rates	Default GWLF values for urban landuses.	GWLF Manual.
Daylight Hours	Average of Table B-9 values (GWLF Manual; Mills et. al, 1985) for 38 and 40° N (Greenville = 38° 53')	GWLF Manual
Growing season	Assumed April through October	
Sediment Delivery Ratio	Table values from GWLF manual based on size of watershed.	GWLF Manual

Septic Systems	118 septic systems are located around Governor Bond Lake. These were assumed to serve an average of 3 people per system, and exist in proportion to area of each directly contributing watershed. Of the 118 septic systems, 8 systems were considered failed. Ponded systems are used to describe systems that use surface discharge and where discharge will enter the lake within a month. In this case, aeration systems were considered ponded due to the surface discharge characteristics.	Personal Communication with City of Greenville and Bond County Health Dept.
Septic System Nutrients	Default values from GWLF were used. They were similar to literature values encountered.	GWLF Manual
Sediment Nutrients	GWLF values were calibrated using FLUX (total nutrient concentrations - dissolved concentration)/suspended sediment concentration.	GWLF/FLUX calibrated

General Modeling Conventions

For modeling purposes, all landuse areas and septic loads were multiplied by 100 in order to increase model output resolution. Consequently, all output loads (quantities, not concentrations) must be reduced by a factor of 100 for actual values.

Model simulations spanned 13 continuous years (1987 through 1999) to reduce potential errors due to artifacted antecedent conditions and to capture watershed responses to variable climate.

The growing season was assumed to be April through September and large bodies of water (Upper Pond, Upper Lake Basin, and Lower Lake Basin) were not included in the subwatershed analysis.

Calibration

GLWF input parameters were then calibrated to 1999 monitored data adjusted for nutrient transport using FLUX output. In addition to monitored tributary subwatersheds, subwatersheds included directly draining area to the northwest Upper Pond, the Upper Lake Basin, and the Lower Lake Basin, and the Unmonitored tributary in the southeast area of the watershed. GWLF loads from septic systems, groundwater interflow, and surface runoff were simulated for the years 1987 through 1999. Running model simulations for a number of years reduces potential artifacts due to antecedent conditions. GWLF derived annual loads were then used as input values for BATHTUB to model in-lake nutrient cycling processes.

Inputs

Cropping Factor

The original C used in calculations were for Cropland was 0.51. Further information obtained from the 2000 Illinois Soil Conservation Transect Survey provided more detailed cropping practices for Bond County and was used to proportionally adjust the GIS calculated weighted average Cropland landuse KSLCP for each watershed using the revised C-factor in Table B-1 (i.e., 0.43/0.51x original Cropland KLSCP).

Table C-5. Landuse Parameters Used in GIS Subwatershed Weighted Averages

Cropping Factor and Curve Number Relationships to Landuse

		Hydrologic Group Curve Number		
Landuse	**C-factor**	**1 (D)**	**2 (C)**	**3 (B)**
Cropland	0.43	91	88	81
Commercial		91	89	85
Forest	0.004	82	76	65
Grassland/Pasture	0.01	73	65	48
Transportation		98	98	98
Urban		82	76	65
Water/Wetland		98	98	98

Source: Bond County Soil Survey
Note: No Hydrologic Group A soils are present in the watershed.

Table C-6. Bond County Cropping Practice Averages: Used to Adjust Subwatershed KLSCP

	Conventional			**Mulch**			**No-till**			**Total**		
	Acres	%	C	Acres	%	C	Acres	%	C	Acres	%	wt.avgC
Corn	72538	97	0.54	424	1	0.38	1697	2	0.20	74658	44.6	0.532
Soybean	36481	64	0.48	2121	4	0.40	18240	32	0.22	56842	33.9	0.394
Small Grain	11453	32	0.38	3818	11	0.32	20786	58	0.20	36057	21.5	0.273
Totals/Means										167557	100	**0.430**

Source:
2000 Illinois Soil Conservation Transect Survey Summary, Illinois Department of Agriculture, Bureau of Land and Water Resources, Springfield, IL. September 2000

Table C-7. Soil Mapping Units and Associated Parameters From Bond County NRCS and the Bond County Soil Survey

Soil Factors Used for Determining Subwatershed Weighted Average Curve Numbers (CN) and KLSCP

Soil Mapping Unit	Hydrologic Group	K-factor	LS- factor
2	1	0.37	0.16
3A	2	0.32	0.2
3B	2	0.32	0.34
3B2	2	0.43	0.46
4B	2	0.32	0.49
4C2	2	0.32	1.39
7C3	1	0.32	0.9
8F	2	0.37	5
12	1	0.43	0.13
13A	1	0.43	0.2
13B	1	0.43	0.34
13B2	1	0.43	0.47
14B	2	0.43	0.34
14C2	2	0.43	1.3
15C2	3	0.37	1.68
48	1.5	0.37	0.13
50	2	0.28	0.16
113B2	2	0.32	0.47
120	1	0.43	0.13
218	2	0.37	0.16
242B	3	0.37	0.11
287A	2	0.37	0.25
333	2	0.37	0.16
451	2	0.32	0.12
474	1	0.37	0.16
581B2	1	0.43	0.34
583B	3	0.37	0.34
585D	3	0.32	2.4
620A	1	0.43	0.16
620B3	1	0.43	0.34
802			
862			
912A	1.55	0.3695	0.25
912B2	1.55	0.3695	0.47
914C3	0.9	0.308	0.9
946D3	1.4	0.313	2.5
991	1	0.397	0.16
DAM			

Hydrologic Groups were assigned numbers: A=4; B=3; C=2; D=1
Hydrologic Groups for associations were determined by proportion weighted average

Septic Systems

Septic system data was estimated based on near-lake housing and development information obtained from the city of Greenville[1], and failure rates from a 1999 survey (Governor Bond Lake Committee, 1998). Failed systems were assumed to operate as ponded systems (surface discharge that reaches the water body within a month of discharge) within the GWLF model. Aeration systems were also considered to respond as ponded systems since they discharge to the surface. Each household near the lake was assumed to have three people served by one septic system. The following table summarizes the per capita septic systems for both the Upper and Lower Lake Basins.

Table C-8. Estimated Number of People Served by Septic Systems Around Governor Bond Lake.

	Current	Maximum level based on number of sites available (Full Build-Out)
Total		
ponded	225 (63.4%)	441
normal	130 (36.6%)	255
Upper Basin (45% of houses)		
ponded	101	222.5
normal	58	128.5
Lower Basin (55% of houses)		
ponded	124	219
normal	72	126

Default (GWLF manual) nutrient concentrations in effluent were used and were consistent with other reported literature values: TN = 12 mg/L, Dissolved N = 2.5 mg/L, TP = 1.6 mg/L, and Dissolved P = 0.4 mg/L

Groundwater

Initial groundwater concentrations were estimated from baseflow in-stream concentrations (8/2 and 10/21 or 10/22 1999 Clean Water Partnership Monitoring Program). Groundwater concentrations were

[1] Personal communication. 2001. Crystal Lingley, Director of Environmental Health, City of Greenville

adjusted during calibration only if necessary to obtain model results consistent with in-stream water quality results.

Table C-9. Pre-Calibration GWLF Groundwater Concentrations

	Groundwater Concentration	
Site	**Dis-N**	**Dis-P**
	mg/L	*mg/L*
R0P02	4.650	0.1240
R0P03	0.155	0.1880
R0P04	0.075	0.2220
R0P05	0.135	0.0993
R0P06	0.640	0.1320
R0P07	1.950	0.0584

Evapotranspiration Coefficients

Weighted average evapotranspiration (ET) coefficients for each subwatershed were determined based on default values in the GWLF manual. ET is used to adjust potential evaporation for effects of growing plants/crops. The following tables show chosen values and resultant weighted average coefficients. Landuse and Cropland type proportion was used to determine monthly evapotranspiration.

Table C-10. Proportion-weighted Evapotranspiration Coefficients Governor Bond Lake Watershed Cropland

Evapotranspiration Factor for Agriculatural Crops (Cropland)						
% of Growing Season	Corn	Sorghum	Beans	All	Growing Season Months	Month
%	fraction of pan evaporation					
0	0.45	0.30	0.30	0.37	0.37	Nov-Apr
10	0.51	0.40	0.35	0.44		
20	0.58	0.65	0.58	0.60	0.52	May
30	0.66	0.90	1.05	0.83		
40	0.75	1.10	1.07	0.94	0.88	June
50	0.85	1.20	0.94	0.99	0.96	July
60	0.96	1.10	0.80	0.97		
70	1.08	0.95	0.66	0.95	0.96	Aug
80	1.20	0.80	0.53	0.92		
90	1.08	0.65	0.43	0.79	0.86	Sep
100	0.70	0.50	0.36	0.56		
				0.37	0.46	Oct

Calculated using 2000 Illinois Soil Conservation Transect Survey Summary for Bond County where 44.6 percent is corn, 33.9% is soybean and 21.5% of acreage is small grains. Values used for sorghum were from small grains as a close fit.

Table C-11. Overall Monthly ET for Governor Bond Lake Watershed

	Landuse ET Factor				Area Weighted ET Factor				Area Weighted ET Factor			
Month	Crop	Pasture	Forest	Water/ Wetland	ROP2	ROP3,6,7	ROP4	ROP5	Unmon	Pond	Upper	Lower
Jan	0.37	1.16	0.3	0.75	0.46	0.65	0.55	0.56	0.66	0.69	0.66	0.73
Feb	0.37	1.23	0.3	0.75	0.47	0.68	0.56	0.58	0.68	0.72	0.69	0.75
Mar	0.37	1.19	0.3	0.75	0.46	0.66	0.55	0.57	0.67	0.70	0.68	0.74
Apr	0.44	1.09	0.6	0.75	0.54	0.70	0.59	0.60	0.73	0.72	0.75	0.78
May	0.52	0.95	0.8	0.75	0.61	0.72	0.62	0.63	0.75	0.73	0.78	0.79
Jun	0.88	0.83	0.9	0.75	0.88	0.86	0.87	0.87	0.86	0.85	0.87	0.83
Jul	0.96	0.79	0.9	0.75	0.93	0.89	0.92	0.92	0.87	0.87	0.87	0.83
Aug	0.96	0.8	0.8	0.75	0.92	0.88	0.92	0.92	0.85	0.87	0.84	0.81
Sep	0.86	0.91	0.5	0.75	0.82	0.83	0.87	0.87	0.79	0.83	0.76	0.77
Oct	0.46	0.91	0.2	0.75	0.48	0.59	0.56	0.57	0.58	0.63	0.56	0.64
Nov	0.37	0.83	0.2	0.75	0.41	0.52	0.47	0.48	0.52	0.56	0.50	0.60
Dec	0.37	0.69	0.3	0.75	0.40	0.49	0.44	0.45	0.49	0.52	0.48	0.58

Daylight length and regional erodibility factors used are also included in GWLF analysis. Default values used for the region are listed in the table below (GWLF manual):

Table C-12. Daylight Hours and Erodibility GWLF Input Values for Governor Bond Lake Watershed

Month	Daylight Hours	Erodibility

Jan	9.6	0.13
Feb	10.6	0.13
Mar	11.8	0.13
Apr	13.0	0.28
May	14.0	0.28
Jun	14.6	0.28
Jul	14.5	0.28
Aug	13.5	0.28
Sep	12.2	0.28
Oct	11.0	0.13
Nov	9.9	0.13
Dec	9.3	0.13

Runoff Nutrient Concentrations

Urban, Forest, and Transportation landuses were assumed to have default runoff nutrient concentrations (GWLF manual) and atmospheric deposition rates for waterbodies (Table B-9).

Table C-13. Default Runoff Nutrient Concentrations

Landuse	Dissolved N	Dissolved P
	mg/L	*mg/L*
Forest	0.19	0.006
Urban	0.0173	0.002
Transportation	0.101	0.0019
Water	0.0184	0.00184

Source: GWLF Users Manual

Runoff nutrient concentration from Cropland and Grass/Pasture runoff was determined by calibrating GWLF output to measured in-stream concentrations for the 1999 monitoring season, where some in-stream measured data was available. Cropland and Grass/Pasture landuses dominated the subwatersheds and were assumed to have equal nutrient runoff concentrations in lieu of better data and the inability to separate nutrient concentrations associated with each landuse type. Literature for grassland or fallow lands shows that nutrient concentrations in runoff from these lands are similar to or greater than concentrations in runoff from cropland. Grassland and pasture, however, have much less runoff, so although the nutrient concentrations in runoff are the same compared to cropland, the amount of load from grassland/pasture will be much less. Actual transport rates and loads from the two different landuses will be reflected in different runoff and sediment transport properties associated with them. Runoff concentrations from cropland and grassland/pasture were adjusted until output concentrations for the monitored period were equivalent to measured concentrations (< 1% difference). If necessary, original groundwater concentrations were also adjusted during this calibration process. For non-monitored subwatersheds, average values were used. Table B-10 lists final nutrient values used.

Table C-14. Runoff Nutrient Concentrations Used in Calibrated GWLF Models.

GWLF Coefficients for unmonitored subwatersheds: Velocity Based Q Relationship Calibrated Concentrations

Cropland/Pasture							
Stream Site	**Sed N**	**Sed P**	**GW N**	**GW P**	**Dis N**	**Dis P**	**Comments**
	mg/kg	mg/kg	mg/L	mg/L	mg/L	mg/L	
ROP2	800	80	3.5	0.24	1.4	0.55	calibrated to measured instream values
ROP3	800	90	0.155	0.188	2.9	0.075	calibrated to measured instream values
ROP4	7500	450	0.155	0.222	8.9	0.816	calibrated to measured instream values
ROP5	100	1	0.135	0.0993	2.4	0.93	calibrated to measured instream values
Unmonitored	100	1	0.135	0.0993	2.4	0.93	same as 5 (neighbor)
Pond	800	85	0.148	0.187	2.233	0.593	average of 2, 3, 4, 5 - outliers
Upper Basin	800	85	0.148	0.187	2.233	0.593	average of 2, 3, 4, 5 - outliers
Lower Basin	800	85	0.148	0.187	2.233	0.593	average of 2, 3, 4, 5 - outliers

GW N = Groundwater Nitrogen
GW P = Groundwater Phosphorus
Sed N = Sediment-associated Nitrogen
Sed P = Sediment-associated Phosphorus
Dis N = Dissolved N in runoff
Dis P = Dissolved P in runoff

Table C-15. Summaries Annual GWLF Output for Each Subwatershed

ROP02: Unnamed Tributary

Ha 359.6

	PRECIP	PRECIP	PRECIP	EVAPOTRAN	GR.WAT.FLO	RUNOFF	STREAMFLOW
	m	Hm3	Hm3	Hm3	Hm3	Hm3	Hm3
1989	0.913	0.108	3.283	1.683	1.169	0.629	1.798
1993	1.294	0.252	4.653	1.518	1.766	1.054	2.819
1996	1.078	0.360	3.876	1.435	1.334	0.867	2.201
1999	1.047	0.467	3.765	1.496	1.780	0.644	2.424

		EROSION	EROSION	SEDIMENT	DIS.NITR	TOT.NITR	DIS.PHOS	TOT.PHOS
		tons/ac	tons/ac	g/L	mg/L	mg/L	mg/L	
1989	dry	0.03	4.78	0.721	2.737	3.315	0.336	0.393
1993	wet	0.08	5.93	0.569	2.683	3.139	0.341	0.387
1996	nomal	0.11	6.35	0.781	2.637	3.264	0.346	0.409
1999	cal	0.15	4.85	0.542	2.921	3.356	0.313	0.357

ROP03: Dry Branch

Ha 3175

	PRECIP	PRECIP	PRECIP	EVAPOTRAN	GR.WAT.FLO	RUNOFF	STREAMFLOW
	m	Hm3	Hm3	Hm3	Hm3	Hm3	Hm3
1989	0.913	28.988	28.988	15.780	2.635	4.477	7.112
1993	1.294	41.085	41.085	13.875	7.303	7.525	14.827
1996	1.078	34.227	34.227	13.176	8.827	6.223	15.018
1999	1.047	33.242	33.242	14.034	10.700	4.509	15.240

		EROSION	EROSION	SEDIMENT	DIS.NITR	TOT.NITR	DIS.PHOS	TOT.PHOS
		tonnes/ha	tons/ac	g/L	mg/L	mg/L	mg/L	
1989	dry	18.62	7.42	1.247	1.631	2.653	0.110	0.225
1993	wet	23.06	9.19	0.741	1.351	1.960	0.126	0.194
1996	nomal	24.70	9.84	0.783	1.128	1.768	0.137	0.209
1999	cal	18.87	7.52	0.590	0.847	1.332	0.151	0.206

ROP04: Kingsbury Branch

Ha 1925

	PRECIP	PRECIP	PRECIP	EVAPOTRAN	GR.WAT.FLO	RUNOFF	STREAMFLOW
	m	Hm3	Hm3	Hm3	Hm3	Hm3	Hm3
1989	0.913	17.575	17.575	9.240	1.444	3.484	4.928
1993	1.294	24.910	24.910	8.297	3.966	5.871	9.856
1996	1.078	20.752	20.752	7.854	4.851	4.870	9.702
1999	1.047	20.155	20.155	8.162	5.910	3.658	9.567

		EROSION	EROSION	SEDIMENT	DIS.NITR	TOT.NITR	DIS.PHOS	TOT.PHOS
		tonnes/ha	tons/ac	g/L	mg/L	mg/L	mg/L	
1989	dry	12.12	4.83	0.947	6.268	13.371	0.636	1.062
1993	wet	15.01	5.98	0.586	5.307	9.707	0.570	0.834
1996	nomal	16.07	6.40	0.638	4.486	9.272	0.515	0.802
1999	cal	12.28	4.89	0.494	3.446	7.154	0.444	0.667

ROP05: Lower Kingsbury Branch

Ha 996

	PRECIP	PRECIP	PRECIP	EVAPOTRAN	GR.WAT.FLO	RUNOFF	STREAMFLOW
	m	Hm3	Hm3	Hm3	Hm3	Hm3	Hm3
1989	0.913	9.093	9.093	4.771	0.767	1.713	2.480
1993	1.294	12.888	12.888	4.303	2.112	2.888	5.000
1996	1.078	10.737	10.737	4.074	2.570	2.390	4.970
1999	1.047	10.428	10.428	4.233	3.137	1.783	4.920

		EROSION	EROSION	SEDIMENT	DIS.NITR	TOT.NITR	DIS.PHOS	TOT.PHOS
		tonnes/ha	tons/ac	g/L	mg/L	mg/L	mg/L	
1989	dry	10.85	4.32	1.089	1.602	2.861	0.631	1.077
1993	wet	13.44	5.35	0.669	1.362	2.185	0.544	0.837
1996	nomal	14.39	5.73	0.721	1.158	1.911	0.470	0.734
1999	cal	11.00	4.38	0.556	0.905	1.634	0.379	0.640

Unmonitored Tributary

Ha 787.9

	PRECIP	PRECIP	PRECIP	EVAPOTRANS	GR.WAT.FLO	RUNOFF	STREAMFLOW
	m	Hm3	Hm3	Hm3	Hm3	Hm3	Hm3
1989	0.913	7.194	7.194	3.908	0.465	1.040	1.505
1993	1.294	10.195	10.195	3.412	1.363	1.749	3.112
1996	1.078	8.494	8.494	3.238	1.741	1.450	3.191
1999	1.047	8.249	8.249	3.451	2.175	1.087	3.262

		EROSION	EROSION	SEDIMENT	DIS.NITR	TOT.NITR	DIS.PHOS	TOT.PHOS
		tonnes/ha	tons/ac	g/L	mg/L	mg/L	mg/L	
1989	dry	10.48	4.17	1.426	0.968	1.271	0.385	0.399
1993	wet	12.98	5.17	0.854	0.834	1.024	0.340	0.349
1996	nomal	13.90	5.53	0.892	0.700	0.879	0.293	0.301
1999	cal	10.62	4.23	0.667	0.521	0.671	0.231	0.238

Pond: Upper Pond

Ha 564.7

	PRECIP	PRECIP	PRECIP	EVAPOTRANS	GR.WAT.FLO	RUNOFF	STREAMFLOW
	m	Hm3	Hm3	Hm3	Hm3	Hm3	Hm3
1989	0.913	5.156	5.156	2.840	0.491	0.678	1.169
1993	1.294	7.307	7.307	2.468	1.350	1.163	2.513
1996	1.078	6.087	6.087	2.344	1.638	0.960	2.603
1999	1.047	5.912	5.912	2.502	1.993	0.689	2.682

		EROSION	EROSION	SEDIMENT	DIS.NITR	TOT.NITR	DIS.PHOS	TOT.PHOS
		tonnes/ha	tons/ac	g/L	mg/L	mg/L	mg/L	
1989	dry	16.50	6.57	2.389	1.286	3.198	0.402	0.605
1993	wet	20.43	8.14	1.377	1.055	2.156	0.358	0.475
1996	nomal	21.88	8.71	1.424	0.870	2.009	0.323	0.444
1999	cal	16.72	6.66	1.056	0.660	1.504	0.284	0.374

Upper: Upper Lake Basin

Ha 564.1

	PRECIP	PRECIP	PRECIP	EVAPOTRANS	GR.WAT.FLO	RUNOFF	STREAMFLOW
	m	Hm3	Hm3	Hm3	Hm3	Hm3	Hm3
1989	0.913	5.150	5.150	2.821	0.530	0.536	1.066
1993	1.294	7.299	7.299	2.443	1.450	0.931	2.381
1996	1.078	6.081	6.081	2.324	1.760	0.778	2.533
1999	1.047	5.906	5.906	2.476	2.132	0.530	2.657

		EROSION	EROSION	SEDIMENT	DIS.NITR	TOT.NITR	DIS.PHOS	TOT.PHOS
		tonnes/ha	tons/ac	g/L	mg/L	mg/L	mg/L	
1989	dry	10.24	4.08	1.625	1.547	2.892	0.399	0.546
1993	wet	12.69	5.05	0.902	1.042	1.790	0.326	0.408
1996	nomal	13.58	5.41	0.908	0.897	1.646	0.302	0.384
1999	cal	10.38	4.13	0.661	0.731	1.281	0.277	0.338

Lower: Lower Lake Basin

Ha 349.3

	PRECIP	PRECIP	PRECIP	EVAPOTRANS	GR.WAT.FLO	RUNOFF	STREAMFLOW
	m	Hm3	Hm3	Hm3	Hm3	Hm3	Hm3
1989	0.913	3.189	3.189	1.778	0.339	0.272	0.611
1993	1.294	4.520	4.520	1.502	0.933	0.482	1.411
1996	1.078	3.765	3.765	1.432	1.132	0.402	1.533
1999	1.047	3.657	3.657	1.530	1.369	0.265	1.635

		EROSION	EROSION	SEDIMENT	DIS.NITR	TOT.NITR	DIS.PHOS	TOT.PHOS
		tonnes/ha	tons/ac	g/L	mg/L	mg/L	mg/L	mg/L
1989	dry	19.88	7.92	3.408	2.001	4.857	0.434	0.728
1993	wet	24.62	9.81	1.828	1.162	2.701	0.327	0.484
1996	nomal	26.37	10.50	1.802	1.030	2.534	0.308	0.464
1999	cal	20.15	8.03	1.291	0.864	1.954	0.284	0.396

Concentrations and flows adjusted for calculated loads 100 times greater than actual due to 100 multiplier used to increase model resolution.

BMPs

Since most of the conservation tillage in Bond County appears to be no-till, analysis of increased conservation tillage as a BMP assumed conversion of conventional till to no-till. Resulting C-factors were used to proportionally adjust original area-weighted Cropland KSLCP. Table B-4 shows the multiplier necessary for KLSCP factor to account for increased conservation tillage.

Table C-16. KLSCP Multipliers to Adjust Conservation Tillage Management Increases

Bond County Averages: Transect Survey 2000

Crop	Acres	Wt. C	Proportion of Conventional Tillage	Conventional Tillage C	No-Till C	Assume 40% NT	Assume 60% NT	Assume 100% NT
corn	74658	0.532	0.97	0.54	0.2	30162	25085	14932
soybeans	56842	0.394	0.64	0.48	0.22	21373	18417	12505
small grains	36057	0.273	0.32	0.38	0.2	9844	9844	7211
Fraction in conservation tillage:			0.28					
Wt. Composite C				0.43		0.3663	0.3184	0.2068
mean factor for converting initial KLSCP						0.7183	0.6243	0.4055

C.3 BATHTUB

BATHTUB is an equilibrium, in-lake eutrophication and nutrient cycling model. Input values consist of monitored tributary flow and concentrations or non-point source landuse fractions and export coefficients, in-lake water quality concentrations, and some global parameters. Internal cycling can be considered the residual between predicted in-lake concentration and measured values. Several internal sub-models are available to describe in-lake processes and coefficients can be calibrated for site-specific applications.

Although analysis of lake impairment and load reductions must be completed for the entire lake, in order to more accurately model the system and understand the processes, Governor Bond Lake was divided into three portions: the Upper Pond, Upper Lake Basin, and Lower Lake Basin. Each basin had associated tributary inputs.

Tributary output from GWLF was used as input values for BATHTUB. Directly contributing watersheds were also modeled as monitored tributaries in order to remain consistent with GWLF calculations and to simplify modeling potential BMP effects. The model was built using 1999 data; internal nutrient cycling and eutrophication models were chosen to best simulate 1999 conditions, since data was the most complete for this year.

Upper and Lower Lake Basin in-lake concentration means and coefficients of variation (cvs) were determined by analysis of STORET (1989, 1993, 1996) and 1999 IEPA and Clean Lakes Program provisional data. Two sites were available for long term analysis of the Lower Lake Basin (ROP-1 and ROP-2). Concentrations at these sites were averaged to determine overall Lower Lake Basin water quality parameters. Upper Lake Basin values were used for the Upper Pond conditions, since additional data was not available. Outflow concentrations were assumed to be the same as lake site ROP-1.

Because reservoirs and lakes are often highly responsive to current and previous year weather and transport conditions (retention and storage history), it is often difficult to validate models such as BATHTUB. Therefore, BATHTUB was calibrated for variable weather conditions that bracket potential climatic situations. For Governor Bond Lake, chosen conditions included a dry year (1989), wet year (1993), and near normal year (1996). These specific years were chosen to represent variable climatic conditions due to precipitation amounts and availability of in-lake water quality monitoring data. 1999 was used for calibration and additional information, but was not chosen to represent the Normal year, even though annual precipitation was closer to normal in 1999 than 1996. The preceding year climate for 1999 was much wetter than preceding years for 1989, 1993, and 1996. This wetter history influences both transport and cycling processes, and therefore, 1999 is not as comparable to 1989 and 1993 as is 1996.

GWLF modeled output for each condition year was used for BATHTUB tributary concentrations and flows. First, coefficients for Upper Pond water quality models were calibrated to match in-lake concentrations. Next, residual mass balance differences for Total Phosphorous (TP) or Total Nitrogen (TN) in the downstream basins (Upper Lake Basin and Lower Lake Basin) were used to determine internal cycling load (modeled concentration less than measured) or storage/retention load (modeled concentration greater than measured).

Input Parameters

Global Parameters

The Diagnostic Feasibility Study for Governor Bond Lake (ZEIS, 2001) values for atmospheric nitrogen and phosphorous loads (497 $kg/km^2/yr$ and30.9 $kg/km^2/yr$, respectively) were used in BATHTUB models. One-half of total load was assumed to be in the dissolved fraction, which is consistent with default proportions in the BATHTUB model. Yearly evaporation (0.812 m/yr) and corresponding cv (0.031) was calculated from average monthly pan evaporation (Midwestern Regional Climate Center website). Generally, evaporation from a lake surface can be assumed to be 0.75 * pan evaporation.

Climate

Precipitation for each year was calculated from climate data (Midwestern Regional Climate Center, 1999). For 1989, 1993, and 1996, climate conditions (dry year, wet year, normal year) were preceded by a dry year (less than 0.95 m rainfall). Preceding year for 1999 (wet-normal rainfall), however, was a normal to wet year (greater than 1.0 m rainfall). BATHTUB modeled continuous conditions from 1987 through 1999 and consequently, includes antecedent conditions history in the analysis.

In-Lake Concentrations

STORET and 1999 Clean Lakes Program monitoring data was used to determine mean in-lake concentrations for both Upper and Lower Lake Basins and their coefficients of variation (cv). No data was available for the Upper Pond, therefore in-lake concentrations were assumed to be the same as the Upper Lake Basin. Two long term monitoring sites had associated data for the Lower Lake Basin and were averaged for an overall Lower Lake Basin value. Mixed layer depth, hypolimnetic oxygen demand (HOD), and metalimnion oxgen demand (MOD) were determined using the model PROFILE described at the end of this secction.

The following tables show input in-lake concentrations used for modeling Governor Bond Lake Upper Pond, Upper Lake Basin, and Lower Lake Basin, respectively.

Table C-17a: Upper Pond Characterisitcs In-Lake Concentrations (assumed same as Upper Lake Basin)

Site:	POND	Year:	1989
Area, km2			0.127
Mean Depth, m			1.27
Mixed Layer, m			0
Hypolimnetic Depth, m			0
Length, km			0.711

Parameter	Mean	cv
	ug/L	
TP	138	na
TN	1725	na
Chl-a	128.9	na
SD	0.3912	na
OrgN	1432	na
TP-OP	108.4	na
HOD	na	na
MOD	na	na

Site:	POND	Year:	1993
Area, km2			0.127
Mean Depth, m			1.27
Mixed Layer, m			0
Hypolimnetic Depth, m			0
Length, km			0.711

Parameter	Mean	cv
	ug/L	
TP	255.6	na
TN	1376	na
Chl-a	120.1	na
SD	0.4039	na
OrgN	1006	na
TP-OP	149	na
HOD	na	na
MOD	na	na

Site:	POND	Year:	1996
Area, km2			0.127
Mean Depth, m			1.27
Mixed Layer, m			0
Hypolimnetic Depth, m			0
Length, km			0.711

Parameter	Mean	cv
	ug/L	
TP	208.4	na
TN	1446	na
Chl-a	36.26	na
SD	0.4597	na
OrgN	1156	na
TP-OP	147.8	na
HOD	na	na
MOD	na	na

Site:	POND	Year:	1999
Area, km2			0.127
Mean Depth, m			1.27
Mixed Layer, m			0
Hypolimnetic Depth, m			0
Length, km			0.711

Parameter	Mean	cv
	ug/L	
TP	149.2	na
TN	730.7	na
Chl-a	90.18	na
SD	0.2426	na
OrgN	433.9	na
TP-OP	55.25	na
HOD	na	na
MOD	na	na

Table C-17b: Upper Lake Basin Characteristics and In-Lake Concentrations

Site:	UPPER BASIN	Year:	1989
Area, km2			1.867
Mean Depth, m			2.744
Mixed Layer, m			0.8
Hypolimnetic Depth, m			1.6
Length, km			2.42
Parameter	**Mean**	**cv**	
	ug/L		
TP	138	0.103	
TN	1725	0.112	
Chl-a	128.9	0.178	
SD	0.3912	0.062	
OrgN	1432	0.123	
TP-OP	108.4	0.013	
HOD	66.67	na	
MOD	36.63	na	

Site:	UPPER BASIN	Year:	1993
Area, km2			1.867
Mean Depth, m			2.744
Mixed Layer, m			0.4
Hypolimnetic Depth, m			1.5
Length, km			2.42
Parameter	**Mean**	**cv**	
	ug/L		
TP	255.6	0.168	
TN	1376	0.228	
Chl-a	120.1	0.229	
SD	0.4039	0.088	
OrgN	1006	0.215	
TP-OP	149	0.144	
HOD	123.4	na	
MOD	100.7	na	

Site:	UPPER BASIN	Year:	1996
Area, km2			1.867
Mean Depth, m			2.744
Mixed Layer, m			0.3
Hypolimnetic Depth, m			1.7
Length, km			2.42
Parameter	**Mean**	**cv**	
	ug/L		
TP	208.4	0.355	
TN	1446	0.267	
Chl-a	36.26	0.39	
SD	0.4597	0.125	
OrgN	1156	0.16	
TP-OP	147.8	0.303	
HOD	44	na	
MOD	15.78	na	

Site:	UPPER BASIN	Year:	1999
Area, km2			1.867
Mean Depth, m			2.744
Mixed Layer, m			1
Hypolimnetic Depth, m			1.6
Length, km			2.42
Parameter	**Mean**	**cv**	
	ug/L		
TP	149.2	0.145	
TN	730.7	0.094	
Chl-a	90.18	0.068	
SD	0.2426	0.125	
OrgN	433.9	0.14	
TP-OP	55.25	0.142	
HOD	148.6	na	
MOD	210.6	na	

Table C-17c: Lower Lake Basin Characteristics and In-Lake Concentrations

Site:	LOWER BASIN	Year:	1989
Area, km2			1.571
Mean Depth, m			6.098
Mixed Layer, m			3.45
Hypolimnetic Depth, m			5.35
Length, km			2.54
Parameter	**Mean**	**cv**	
	ug/L		
TP	120.7	0.102	
TN	1863	0.046	
Chl-a	105.4	0.11	
SD	0.3115	0.227	
OrgN	1524	0.047	
TP-OP	91.53	0.056	
HOD	39.52	na	
MOD	101.1	na	

Site:	LOWER BASIN	Year:	1993
Area, km2			1.571
Mean Depth, m			6.098
Mixed Layer, m			1.3
Hypolimnetic Depth, m			2.8
Length, km			2.54
Parameter	**Mean**	**cv**	
	ug/L		
TP	102.3	0.075	
TN	1195	0.127	
Chl-a	68.58	0.138	
SD	0.3522	0.231	
OrgN	839.3	0.1	
TP-OP	73.73	0.062	
HOD	117.5	na	
MOD	77.04	na	

Site:	LOWER BASIN	Year:	1996
Area, km2			1.571
Mean Depth, m			6.098
Mixed Layer, m			1.45
Hypolimnetic Depth, m			2.8
Length, km			2.54
Parameter	**Mean**	**cv**	
	ug/L		
TP	115.5	0.238	
TN	1248	0.129	
Chl-a	19.7	172	
SD	0.425	172	
OrgN	787.3	0.273	
TP-OP	77.73	0.04	
HOD	107.1	0.176	
MOD	56.06	na	

Site:	LOWER BASIN	Year:	1999
Area, km2			1.571
Mean Depth, m			6.098
Mixed Layer, m			2.58
Hypolimnetic Depth, m			3.55
Length, km			2.54
Parameter	**Mean**	**cv**	
	ug/L		
TP	84.2	0.288	
TN	828.5	0.142	
Chl-a	78.03	0.078	
SD	0.3025	0.118	
OrgN	383.2	0.104	
TP-OP	28.8	0.131	
HOD	215.8	na	
MOD	218.3	na	

Tributary Concentrations

Tributary concentrations and flow data were derived from GWLF model output. Directly contributing watersheds were also modeled as tributaries for ease in manipulation. Following submodel calibration, for BMPs assessment, concentrations were reduced until BATHTUB predicted in-lake concentrations complied with target water quality guidelines. The following table lists initial input values for all tributaries for each year modeled.

Table C-18. BATHTUB Initial Tributary Inputs From GWLF Models

Site/ Year	Dissolved Nitrogen	Total Nitrogen	Dissolved Phosphorous	Total Phosphorous	Streamflow
	mg/L				Hm3
ROP02: Unnamed Tributary					
1989	2.737	3.315	0.336	0.393	1.80
1993	2.683	3.139	0.341	0.387	2.82
1996	2.637	3.264	0.346	0.409	2.20
1999	2.921	3.356	0.313	0.357	2.42
ROP03: Dry Branch					
1989	1.631	2.653	0.110	0.225	7.11
1993	1.351	1.960	0.126	0.194	14.83
1996	1.128	1.768	0.137	0.209	15.02
1999	0.847	1.332	0.151	0.206	15.24
ROP04: Kingsbury Branch					
1989	6.268	13.371	0.636	1.062	4.93
1993	5.307	9.707	0.570	0.834	9.86
1996	4.486	9.272	0.515	0.802	9.70
1999	3.446	7.154	0.444	0.667	9.57
ROP05: Lower Kingsbury Branch					
1989	1.602	2.861	0.631	1.077	2.48
1993	1.362	2.185	0.544	0.837	5.00
1996	1.158	1.911	0.470	0.734	4.97
1999	0.905	1.634	0.379	0.640	4.92
Unmonitored Tributary					
1989	0.968	1.271	0.385	0.399	1.50
1993	0.834	1.024	0.340	0.349	3.11
1996	0.700	0.879	0.293	0.301	3.19
1999	0.521	0.671	0.231	0.238	3.26
Pond: Upper Pond					
1989	1.286	3.198	0.402	0.605	1.17
1993	1.055	2.156	0.358	0.475	2.51
1996	0.870	2.009	0.323	0.444	2.60
1999	0.660	1.504	0.284	0.374	2.68
Upper: Upper Lake Basin					
1989	1.547	2.892	0.399	0.546	1.07
1993	1.042	1.790	0.326	0.408	2.38
1996	0.897	1.646	0.302	0.384	2.53
1999	0.731	1.281	0.277	0.338	2.66
Lower: Lower Lake Basin					
1989	2.001	4.857	0.434	0.728	0.61
1993	1.162	2.701	0.327	0.484	1.41
1996	1.030	2.534	0.308	0.464	1.53
1999	0.864	1.954	0.284	0.396	1.63

Internal Submodel Selection

The most complete water quality data set existed for 1999, including GWLF output calibrated to measured concentrations. Therefore, 1999 data was used to determine suitable internal models and processes for the Governor Bond Lake system. 1999 conditions also reflect load and response during consistently wet climate patterns.

Internal Cycling

In all cases, Upper Pond values were assumed to be the same as Upper Lake Basin concentrations. Model coefficients were locally calibrated for the Upper Pond, and then residual TP or TN was used to account for internal cycling, if necessary. Predicted in-lake TP less than measured TP reflects potential internal cycling effects. After addition of internal cycling component, all local internal submodel coefficients were calibrated to reflect each situation (dry year, normal year, or wet year). Calibrated models can then be used to assess load reduction impacts on in-lake water quality (e.g., Chlorophyll-a, Total Phosphorous - TP, Trophic State Index -TSI) parameters.

Retention

The Upper Pond likely acts as a sediment and nutrient trap for water entering from Kingsbury Branches and direct contributions. Assuming an 80 percent trapping efficiency for sediment (NURP pond standards), sediment transport from the Upper Pond to the Upper Lake Basin can be assumed from GWLF in-stream sediment loads. Differences between tributary and upstream NVSS loads were used to determine trapping efficiency, sedimentation, and load reductions necessary to reach target NVSS values.

Model Application

Models were adjusted to determine load reductions necessary to meet target water quality conditions, based on Illinois EPA guidelines for Governor Bond Lake causes contributing to impairment as listed in the 2000 Illinois Water Quality Report. Target water quality values were chosen to reflect the range of conditions considered acceptable for various designated uses. Compliance with the below target water quality values will result in assessment as non-impaired for all currently impaired designated uses:

- Trophic State Index (TSI) of < 55
- Non-Volatile Suspended Solids (NVSS) ranging from < 7
- Secchi Depth > 0.6096 m
- Total Phosphorous < 0.050 mg/L
- Chlorophyll-a < 0.020 mg/L

The following table lists some Water Quality Report 2000 Guidelines. Fecal coliforms and macrophyte coverage are also considered potential causes contributing to impairment; however they were not measured or assessed and are therefore not included in this table.

Table C-19. Water Quality Parameter Guidelines for Meeting Designated Uses

Designated Use	Water Quality Guidelines		
Swimming	**TSI**	**Secchi Depth (m)**	
Full Support	< 55> 0.6096		
Partial Impairment	< 75< 0.6096		
Recreation	**TSI**	**NVSS (mg/L)**	
Full Support	< 60	< 3	
Full Support	< 55	< 7	
Aquatic Life	**TSI**	**NVSS (mg/L)**	
Full Support	< 85		
Full Support	< 90	< 20	
Additional Applicable Guidelines	**TP (mg/L)**	**Siltation (% Orig. Vol.)**	**Chlorophyll-a (µg/L)**
Full Support	< 0.050	< 0.25	< 20
Partial Impaired	< 0.140	< 0.75	< 92
	NVSS (mg/L)		
Full Support	< 12		

Input values for calibrated BATHTUB models for each year condition (dry, wet, normal, wet-normal) were adjusted to determine what load reductions and corresponding nutrient concentrations are necessary to achieve in-lake water quality target goals listed above.

Non-Volatile Suspended Solids (NVSS) and Siltation

Non-volatile suspended solids (NVSS) and siltation are considered causes contributing to recreation and overall use impairment. GWLF modeled tributary sediment concentrations were used to determine sediment loads and flow weighted concentrations for the Upper Pond, Upper Lake Basin, and the Lower

Lake Basin. GWLF concentrations were compared with measured in-lake concentrations to determine retention factors (proportion of sediment that settles out) and total load retained in each portion of the lake. For the Upper Pond area, no in-lake data was available, consequently a well designed NURP (National Urban Runoff Program) Pond retention factor of 80 percent removal rate was assumed. The following table summarizes GWLF modeled sediment transport to Governor Bond Lake and the individual basins. From this data, load reductions to meet target goals can be determined.

Table C-20. GWLF Modeled Sediment Transport for the Governor Bond Lake Watershed

Climate Condition	Direct Inflow	Direct Inflow + Upstream	Sediment Flow-Weighted Concentration	NVSS In-Lake Concentration	Proportion of Sediment Retained	Runoff Load In	Shoreline and Gulley Erosion ****	Load Retained	Volume of Load	As-Built Vol. Loss ***
	Hm3	*Hm3*	*mg/L*	*mg/L*		*Mg*		*Mg*	*Acre-ft*	*%*
Upper Pond *										
1989	8.6	8.6	1.184	**0.948**	**0.8**	10159		8127	4.5	
1993	17.4	17.4	0.725	**0.580**	**0.8**	12586		10069	5.5	
1996	17.3	17.3	0.780	**0.624**	**0.8**	13478		10782	5.9	
1999	17.2	17.2	0.600	**0.480**	**0.8**	10298		8238	4.5	
Upper Lake Basin **										
1989	10.0	18.6	1.079	**0.043**	**0.96**	20023		19222	10.6	
1993	20.0	37.4	0.663	**0.027**	**0.96**	24805		23813	13.1	
1996	19.8	37.0	0.717	**0.029**	**0.96**	26562		25500	14.1	
1999	20.3	37.5	0.541	0.022	0.96	20297		19473	10.7	
Lower Lake Basin										
1989	16.3	26.3	0.082	0.017	0.79	2147		1700	0.9	
1993	33.6	53.6	0.050	0.016	0.68	2659		1801	1.0	
1996	33.8	53.6	0.053	0.026	0.51	2847		1454	0.8	
1999	34.0	54.4	0.040	0.016	0.60	2176		1306	0.7	
Wet	17.7	26.3	0.923	0.030	0.87	22170	28300	44107	24.3	**0.246**
Dry	36.3	53.6	0.560	0.021	0.82	27464	28300	45459	25.1	**0.253**
Normal	36.3	53.6	0.600	0.027	0.73	29409	28300	42123	23.2	**0.235**
Wet-Normal	37.2	54.4	0.452	0.019	0.78	22473	28300	39372	21.7	**0.219**

* Upper Pond sediment retention assumed to be 80%
** Upper Lake Basin assumed retnetion of all years if the same as 1999 due to lack of previous year measured data
***As-Built Volume = 9,900 Acre-ft
****From Zahniser Institute of Environmetal Studies 2001 Clean Lakes Program Report = estimate

Gully and Streambank Erosion

Measured in-stream NVSS can be assumed to represent sediment transported to tributaries that will eventually reach the lake. However, NVSS does not account for bedload transport and sediment that is deposited within tributary systems. NVSS is therefore likely to under-represent actual sediment transport. Because predicted (modeled) sediment concentrations are consistently higher than measured NVSS concentrations, contributions due to streambank or gully erosion cannot be accounted for. A previous report by the Bond County Soil and Water Conservation District (2000) estimated that these sediment sources could add another 14 percent sheet and rill erosion rates with a sediment delivery ratio of 0.40 (proportion of eroded sediment reaching the lake). Total gully and streambank erosion would increase lake siltation rates by 0.13 percent original volume loss per year.

Table C-21. Modeled Current Conditions Target Water Quality Parameters

Year/ Parameter	Current Value	Year/ Parameter	Current Value	Units
1989: Dry Year		**1996: Normal Year**		
TP Load: 13,400 kg/yr		**TP Load: 33,970 kg/yr**		
TN Load: 92,350 kg/yr		**TN Load: 124,430 kg/yr**		
TSI	75.9	TSI	70.8	
SD	0.36	SD	0.44	*m*
TP	130	TP	166	*ug/L*
TN	1757	TN	1340	*ug/L*
TN/TP	13.5	TN/TP	8.1	
Chla	117.9	Chla	29	*ug/L*
1993: Wet Year		**1999: Wet- NormalYear**		
TP Load: 50,270 kg/yr		**TP Load: 18,910 kg/yr**		
TN Load: 133,800 kg/yr		**TN Load: 99,140 kg/yr**		
TSI	77.6	TSI	73.7	
SD	0.38	SD	0.27	*m*
TP	188	TP	120	*ug/L*
TN	1236	TN	760	*ug/L*
TN/TP	6.6	TN/TP	6.3	
Chla	97.2	Chla	84.5	*ug/L*

TSI = mean of Chlorophyll-a and TP Trophic State Indexes
SD = Secchi Depth
TP = Total Phosphorous
TN = Total Nitrogen
Chla = Chlorophyll-a
TN/TP = TN to TP ratio; a measure of limiting nutrient
ug/L = part per billion, or micrograms per liter

Trophic State Index (TSI), Total Phosphorous (TP), Total Nitrogen (TN), Secchi Depth (SD), and Chlorophyll-a (Chla)

Total Phosphorous was the limiting nutrient for eutrophication (nutrient enrichment) processes. Chlorophyll-a concentrations, using BATHTUB, were best explained by a submodel using only TP, light, and flushing rate. Submodels based on using TN in combination with other parameters did not predict chlorophyll-a concentrations very well. Consequently, reductions in TP will have the greatest effect on reducing lake TSI and Chla, and in increasing SD.

Nutrient load reductions result in reduced TSI, increased SD, and lower Chla concentrations; the exact effect depends upon the type of weather condition (dry, wet, normal, or wet-normal years) and resulting internal submodel coefficients. The following table allocates current pollutant loads within the watershed.

Table C-22 Governor Bond Lake Load Allocations For Various Climate Conditions

Contributor	Nonpoint Source Load			Contributor	Nonpoint Source Load		
	TP	TN	Sediment		TP	TN	Sediment
	kg/yr	kg/yr	Mg/yr		kg/yr	kg/yr	Mg/yr
1989: Dry Year				**1996: Normal Year**			
Dry Br.	1,600	18,868	8,867	Dry Br.	3,139	26,552	11,762
Kingsbury Br.s	7,905	72,987	7,366	Kingsbury Br.s	11,429	99,455	9,771
Direct Watersheds	1,734	9,789	3,816	Direct Watersheds	2,840	13,283	8,617
Other	1,307	7,873	3,444	Other	1,860	9,989	4,565
Atmospheric	106	1,705	-	Atmospheric	106	1,705	-
Internal	2,353	-	-	Internal	17,730	-	-
Total	13,405	92,354	23,493	Total	33,965	124,432	34,715
1993: Wet Year				**1999: Wet-Normal Year**			
Dry Br.	2,876	29,061	10,984	Dry Br.	3,139	20,300	8,988
Kingsbury Br.s	12,405	106,597	9,125	Kingsbury Br.s	9,530	76,481	7,466
Direct Watersheds	2,848	13,491	10,065	Direct Watersheds	2,522	10,633	6,700
Other	2,177	12,036	4,263	Other	1,641	10,324	3,489
Atmospheric	106	1,705	-	Atmospheric	106	1,705	-
Internal	32,732	-	-	Internal	5,114	-	-
Total	50,268	133,829	34,437	Total	18,913	99,143	26,643

Internal cycling is calculated as the residual (difference) between predicted (modeled) in-lake concentration and measured concentration. No nitrogen internal cycling was noted (i.e., predicted concentrations were not less than measured concentration indicating an internal source of nitrogen necessary to make up the difference). Internal cycling of phosphorous occurred mostly in the Upper Lake Basin and ranged from 27 to 65 percent. Due to the shallow nature of this basin, it is likely that internal cycling was more a result of re-suspension of settled and redissolved TP. Re-suspension, as opposed to lake turnover processes (convection), is more likely to occur in shallower lakes and under higher flow conditions (wet and normal years). In 1999, wet conditions during the previous year may have partially flushed some previously deposited TP resulting in less TP available for re-suspension during 1999.

Best Management Practices (BMPs)

Best Management Practices to reduce pollutant loads were assessed by either modeling effects on watershed characteristics, or by applying known pollutant reduction rates to modeled watershed loads.

Effects of the following scenarios were evaluated by adjusting GWLF model input parameters to determine effects on load reduction (reduced pollutant concentrations). In addition to evaluating the effect of various agricultural BMPs, the effect of full build-out for developments surrounding the lake was assessed for septic system contributions.

Table C-23. Modeled Cultural Agricultural BMPs

BMP	Assumptions	Model Process
Double CRP Acreage (2xCRP)	Assume 31.4% of cropland in grass/pasture (original CRP 15.7% of cropland)	Move 15.7% of original cropland to grass/pasture landuse for each subwatershed
Double Conservation Tillage Acreage (60% CT)	Assume 60% No-till (2000 Illinois Soil Conservation Transect Survey Summary, currently 29% CT, most in No-till)	Adjust KLSCP factor in each subwatershed by proportional reduction in C factor
Double Conservation Tillage and CRP Acreage (2xCRP + 60% CT)	Combination of above	Combination of above
100% Conservation Tillage (100% CT)	Assume 100% No-till	Adjust KLSCP factor in each subwatershed by proportional reduction in C factor
Full Development (FD)	Assume all lots developed and on septic systems	Add additional septic units to Lower and Upper Lake Basin subwatersheds

Construction of less than 12 houses per year (last 10 years trend; city of Greenville, 1999) around Governor Bond Lake implies that only approximately one acre will remain bare soil for an entire year. This is equivalent to 0.1 percent of the subwatershed area directly surrounding the lake. Contributions from this source are negligible (< 0.15 percent) in comparison to other sources, however, due proximity to the lake, construction BMPs should not be neglected if large load reductions are necessary.

Other BMPs considered for application to modeled loads include:

- Extended detention wet ponds
- Constructed wetlands
- Filter/buffer strips
- Reduced inputs
- Feedlot runoff wetlands
- Stream fencing
- Lakeshore aquascaping
- Lake bank stabilization

C.4 PROFILE

Profile is a model that calculates oxygen depletion rates based on dissolved oxygen and/or temperature profiles in a lake. Mixed layer depth (top of the metalimneon) and bottom layer depth (top of the hypolimneon) are read from PROFILE graphical displays. These rates and values can be used in BATHTUB to describe in-lake conditions for comparison with modeled data.

At least two profiles must be chosen to analyze depletion rates which must not include limiting oxygen conditions (anoxic; without oxygen) or turnover situations (complete mixing), but must show evidence of stratification (changing temperature/concentration as a function of depth). Consequently, in most cases only two profiles in early spring satisfied these criteria.

In addition to concentrations and/or temperature as a function of date and depth, lake basin physical characteristics are required. The following table lists the basin characteristics used for PROFILE. Values were calculated from digitized 1995 NRCS Bathymetry maps.

Table C-24. Depth - Area Relationships for Hypsographic Curves

Site and Depth	Length	Area	ElevationZ
	(m)	(Ha)	(m)
Upper Basin	3616.7		
0 m		186.7	925
3 m		161.7	922
5 m		126.6	920
10 m		45.5	915
Lower Basin	2419.2		
0 m		157.1	925
3 m		147.2	922
5 m		136.7	920
10 m		125.8	915
15 m		97.4	910
20 m		42.3	905
25 m		1.5	900
Pond	711.4	12.67	925

D. INPUT AND OUTPUT FILES FOR MODELS

D.1 MEASURED STAGE-DISCHARGE RELATIONSHIP DATA

ROP02: Unnamed Tributary

Gaged Stage	Corrected Stage	Measured Velocity	Area	Discharge
ft	ft	ft/s	ft2	cfs
1.98	2.39	0.1	15.25	1.52
2.10	2.51	0.11	16.42	1.81
2.18	2.59	0.1	17.23	1.72
2.28	2.69	0.08	18.25	1.46
2.70	3.11	0.45	22.87	10.29
2.92	3.33	0.49	25.49	12.49
2.94	3.35	0.55	25.73	14.15
3.10	3.51	0.35	27.72	9.70
3.38	3.79	0.47	31.37	14.74
3.72	4.13	0.55	36.08	19.84

ROP05: Lower Kingsbury Branch

Gaged Stage	Corrected Stage	Measured Velocity	Area	Discharge
ft	ft	ft/s	ft2	cfs
1.82	1.88	0.12	14.16	1.70
1.92	1.98	0.15	15.02	2.25
2.58	2.64	0.25	20.90	5.22
3.18	3.24	0.46	26.61	12.24
3.38	3.44	0.47	28.60	13.44
3.48	3.54	0.49	29.61	14.51
3.60	3.66	0.54	30.83	16.65
3.86	3.92	0.6	33.53	20.12
3.96	4.02	0.61	34.58	21.10
6.60	6.66	1.63	66.04	107.64

ROP04: Upper Kingsbury Branch

Gaged Stage	Corrected Stage	Measured Velocity	Area	Discharge
ft	ft	ft/s	ft2	cfs
2.24	2.69	0.11	53.18	5.85
2.30	2.75	0.05	54.94	2.80
2.40	2.85	0.03	57.93	1.97
2.66	3.11	0.13	66.02	8.58
3.54	3.99	0.63	96.91	61.05
3.80	4.25	0.56	107.06	59.95
3.90	4.35	0.64	111.09	71.10
4.46	4.91	0.85	134.95	114.71
4.50	4.95	0.89	136.74	121.70

ROP06: Dry Branch Above Site ROP03

Gaged Stage	Corrected Stage	Measured Velocity	Area	Discharge
ft	ft	ft/s	ft2	cfs
0.86	2.02	0.1	30.47	3.05
0.94	2.10	0.29	32.53	9.43
1.10	2.26	0.33	36.81	12.15
1.10	2.26	0.65	36.81	23.93
1.22	2.38	0.73	40.15	29.31
1.30	2.46	0.71	42.44	30.13
2.60	3.76	1.67	84.86	141.71
3.38	4.54	1.6	113.41	181.45
3.40	4.56	1.78	114.15	203.19
3.56	4.72	2.24	120.14	269.11

Corrected Stage adjusts for datum

Section D.2 FLEX Output

Pages 37-56 contain the computer runs for the FLEX mathematical model and are not included in this reproduction of the appendix.

D.3 WATER QUALITY STATISTICAL ANALYSIS

Statistical analysis of STORET and Clean Lakes Program in-lake water quality measurements for each year was performed using JMP 3.2.1 statistical software (SAS Institute, Inc). Both Lower Lake Basin sites (ROP-1 and ROP-2) were combined for a total Lower Lake Basin value. Coefficient of variation (cv) was determined by:

cv = Std Err Mean/Mean.

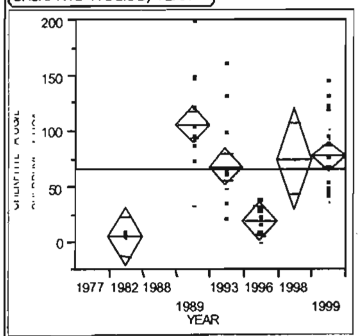
Results were used in BATHTUB models for calibration and comparison of predicted versus actual concentrations

Where:

CHLRPHYL A	= Chlorophyll-a Concentration, ug/L
PHOS-TOT	= Total Phosphorous, mg/L
TOT KJEL N	= Total Kjeldahl Nitrogen, mg/L
DISP	= Dissolved Phosphorous, mg/L
NO2&NO3 N-TOTAL	= Total Nitrate + Nitrite Nitrogen, mg/L
COD-LL	= Chemical Oxygen Demand, mg/L
TP-OP	= Total Phosphorous - Ortho(dissolved) Phosphorous or Particulate Phosphorous, mg/L
TN	= Total Nitrogen, mg/L
OrgN	= Organic N, mg/L = TOT KJEL N + NO2&NO3 N-TOTAL
NVSS	= Non-Volatile Suspended Solids
?	= No data
Std Err Mean	= Standard Area of Mean

LOWER LAKE BASIN: ROP-1 + ROP-2

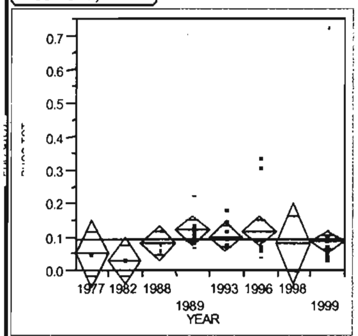
CHLRPHYL A UG/L By YEAR



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	0	?	?	?
1982	6	5.482	1.6682	0.681
1988	0	?	?	?
1989	15	105.394	45.0115	11.622
1993	15	68.580	36.8087	9.504
1996	12	19.703	11.7133	3.381
1998	2	75.430	0.0000	0.000
1999	22	78.030	32.3636	6.900

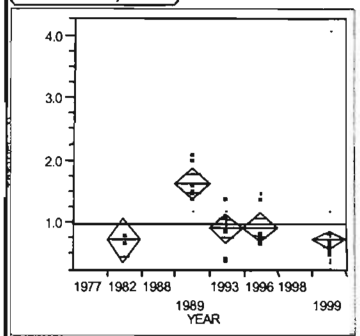
PHOS-TOT By YEAR



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	3	0.050000	0.000000	0.00000
1982	6	0.029833	0.000753	0.00031
1988	10	0.082600	0.025136	0.00795
1989	15	0.120667	0.047500	0.01226
1993	15	0.102333	0.029717	0.00767
1996	15	0.115533	0.106454	0.02749
1998	2	0.080000	0.000000	0.00000
1999	28	0.084214	0.128140	0.02422

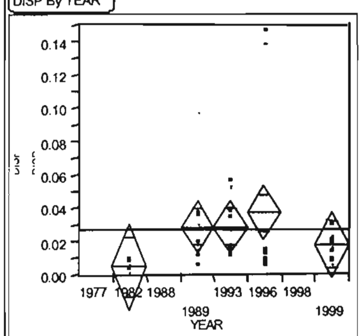
TOT KJEL N By YEAR



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	0	?	?	?
1982	6	0.73333	0.051640	0.02108
1988	0	?	?	?
1989	15	1.62667	0.281493	0.07268
1993	15	0.92067	0.295719	0.07635
1996	15	0.92467	0.287672	0.07428
1998	0	?	?	?
1999	31	0.73355	0.647871	0.11636

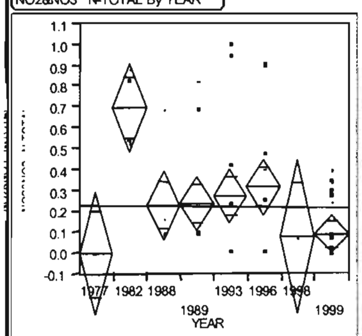
DISP By YEAR



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	0	?	?	?
1982	6	0.005500	0.003146	0.00128
1988	0	?	?	?
1989	15	0.029133	0.030016	0.00775
1993	15	0.028600	0.015620	0.00403
1996	15	0.037800	0.054061	0.01396
1998	0	?	?	?
1999	10	0.018700	0.006929	0.00219

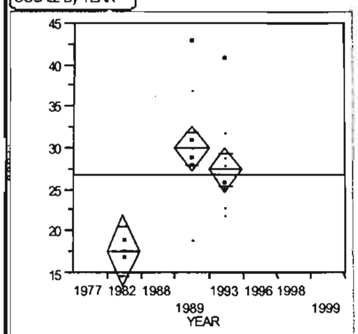
NO2&NO3 N-TOTAL By YEAR



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	3	0.000000	0.000000	0.00000
1982	6	0.698333	0.181705	0.07418
1988	10	0.232000	0.243073	0.07687
1989	15	0.236667	0.284572	0.07348
1993	15	0.274000	0.388013	0.10018
1996	15	0.323333	0.347844	0.08981
1998	2	0.080000	0.000000	0.00000
1999	31	0.094968	0.133724	0.02402

COD-LL By YEAR

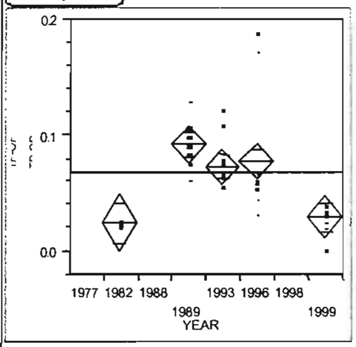


Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	0	?	?	?
1982	6	17.6667	0.81650	0.3333
1988	0	?	?	?
1989	15	29.8667	6.12800	1.5822
1993	15	27.4667	4.94060	1.2757
1996	0	?	?	?
1998	0	?	?	?
1999	0	?	?	?

LOWER BASIN CONTINUED: ROP-1 + ROP-2

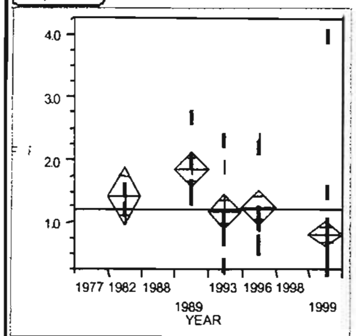
TP-OP By YEAR



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	0	?	?	?
1982	6	0.024333	0.002422	0.00099
1988	0	?	?	?
1989	15	0.091533	0.020042	0.00517
1993	15	0.073733	0.018305	0.00473
1996	15	0.077733	0.053019	0.01369
1998	0	?	?	?
1999	10	0.028800	0.011942	0.00378

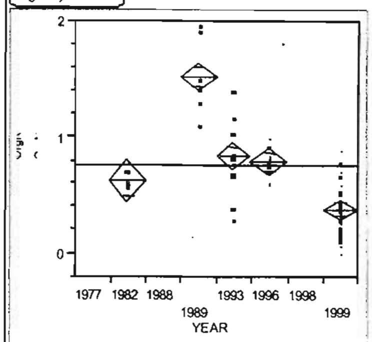
TN By YEAR



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	0	?	?	?
1982	6	1.43167	0.186056	0.07596
1988	0	?	?	?
1989	15	1.86333	0.333352	0.08607
1993	15	1.19467	0.588762	0.15202
1996	15	1.24800	0.624376	0.16121
1998	0	?	?	?
1999	31	0.82852	0.655220	0.11768

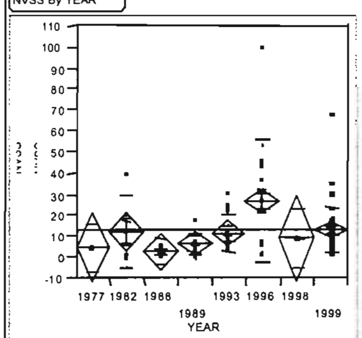
OrgN By YEAR



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	0	?	?	?
1982	6	0.62333	0.060882	0.02486
1988	0	?	?	?
1989	15	1.52400	0.276839	0.07148
1993	15	0.83933	0.325235	0.08398
1996	15	0.78733	0.122560	0.03164
1998	0	?	?	?
1999	31	0.38316	0.221362	0.03976

NVSS By YEAR



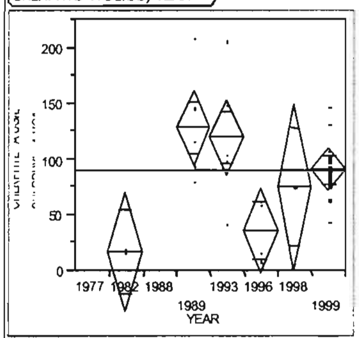
Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	3	5.0000	0.0000	0.0000
1982	10	12.2000	17.0542	5.3930
1988	10	3.0000	1.8856	0.5963
1989	25	6.9200	5.1228	1.0246
1993	25	11.9600	8.9976	1.7995
1996	23	27.1304	29.2346	6.0958
1998	2	9.0000	0.0000	0.0000
1999	47	12.9574	10.9206	1.5929

Means Comparisons

UPPER LAKE BASIN: ROP-3

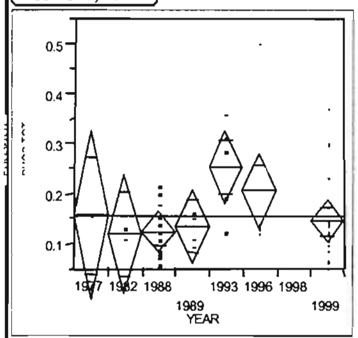
CHLRPHYL A UG/L By YEAR



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	0	?	?	?
1982	2	17.425	2.5385	1.795
1988	0	?	?	?
1989	5	128.900	51.2578	22.923
1993	5	120.108	61.5738	27.537
1996	4	36.257	28.2915	14.146
1998	1	75.430	?	?
1999	16	90.178	24.4859	6.121

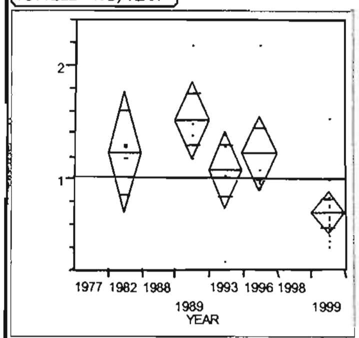
PHOS-TOT By YEAR



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	1	0.160000	?	?
1982	2	0.122000	0.014142	0.01000
1988	15	0.127867	0.049756	0.01285
1989	5	0.138000	0.031757	0.01420
1993	5	0.255600	0.095960	0.04291
1996	5	0.208400	0.165449	0.07399
1998	0	?	?	?
1999	16	0.149188	0.086746	0.02169

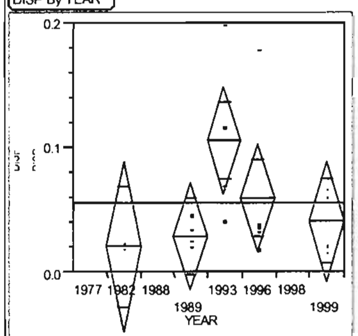
TOT KJEL N By YEAR



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	0	?	?	?
1982	2	1.25000	0.070711	0.05000
1988	0	?	?	?
1989	5	1.54000	0.384708	0.17205
1993	5	1.08600	0.469287	0.20987
1996	5	1.24200	0.539092	0.24109
1998	0	?	?	?
1999	15	0.71000	0.275474	0.07113

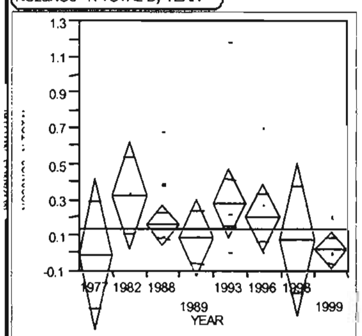
DISP By YEAR



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	0	?	?	?
1982	2	0.022000	0.002828	0.00200
1988	0	?	?	?
1989	5	0.029600	0.010597	0.00474
1993	5	0.106600	0.059066	0.02642
1996	5	0.060600	0.066097	0.02956
1998	0	?	?	?
1999	4	0.041500	0.026211	0.01311

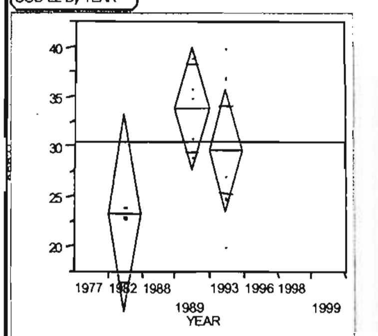
NO2&NO3 N-TOTAL By YEAR



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	1	0.000000	?	?
1982	2	0.335000	0.007071	0.00500
1988	15	0.163333	0.164085	0.04237
1989	4	0.100000	0.000000	0.00000
1993	5	0.290000	0.516769	0.23111
1996	5	0.204000	0.306072	0.13688
1998	1	0.080000	?	?
1999	16	0.019500	0.051678	0.01292

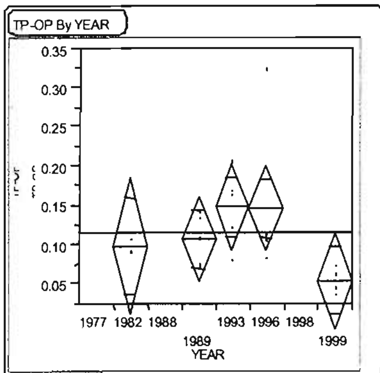
COD-LL By YEAR



Means and Std Deviations

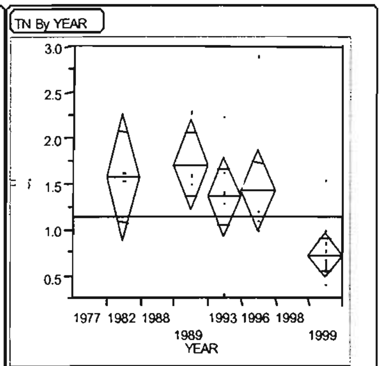
Level	Number	Mean	Std Dev	Std Err Mean
1977	0	?	?	?
1982	2	23.5000	0.70711	0.5000
1988	0	?	?	?
1989	5	34.0000	4.00000	1.7889
1993	5	29.8000	8.40833	3.7603
1996	0	?	?	?
1998	0	?	?	?
1999	0	?	?	?

UPPER LAKE BASIN CONTINUED: ROP-3



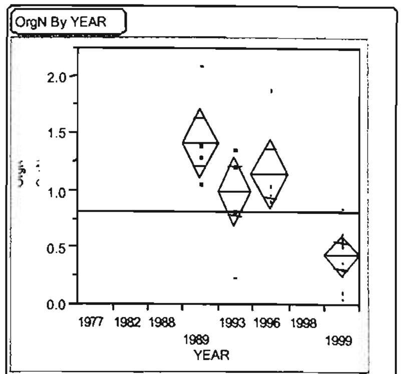
Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	0	?	?	?
1982	2	0.100000	0.011314	0.00800
1988	0	?	?	?
1989	5	0.108400	0.031895	0.01426
1993	5	0.149000	0.047838	0.02139
1996	5	0.147800	0.100291	0.04485
1998	0	?	?	?
1999	4	0.055250	0.015714	0.00786



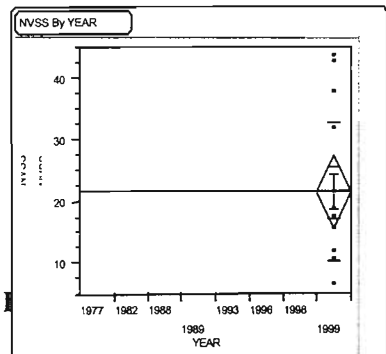
Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	0	?	?	?
1982	2	1.58500	0.063640	0.04500
1988	0	?	?	?
1989	4	1.72500	0.386221	0.19311
1993	5	1.37600	0.702802	0.31430
1996	5	1.44600	0.823092	0.36810
1998	0	?	?	?
1999	15	0.73067	0.266058	0.06870



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	0	?	?	?
1982	0	?	?	?
1988	0	?	?	?
1989	5	1.43200	0.393853	0.17614
1993	5	1.00600	0.484644	0.21674
1996	5	1.15600	0.413376	0.18487
1998	0	?	?	?
1999	15	0.43387	0.234640	0.06058



Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean
1977	0	?	?	?
1982	0	?	?	?
1988	0	?	?	?
1989	0	?	?	?
1993	0	?	?	?
1996	0	?	?	?
1998	0	?	?	?
1999	16	21.7500	11.2931	2.8233

D.4 PROFILE MODEL Input

Pages 63-104 contain the computer model runs for this mathematical model and are not included in this reproduction of the appendix.

APPENDIX B

FEDERAL FUNDING SOURCES

A variety of funding sources are available to support implementation of the Best Management Practices and other management measures addressed in the TMDL document. The following table provides a brief overview of several of these sources available at the Federal level. Additional information on these sources is available from the U.S. Environmental Protection Agency publication, *Catalog of Federal Funding Sources for Watershed Protection,* EPA 841-B-99-003. The publication presents information on 69 federal funding sources (grants and loans) that may be used to fund a variety of watershed protection projects. The information on funding sources is organized into categories including coastal waters, conservation, economic development, education, environmental justice, fisheries, forestry, Indian tribes, mining, pollution prevention and wetlands. More information is also available at http://www.epa.gov/owow/watershed/funding.html/.

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
U.S. ENVIRONMENTAL PROTECTION AGENCY (EPA) - PROGRAM GRANTS TO STATES Watersheds and Nonpoint Source Programs Branch, U.S. EPA Region 5			
Nonpoint Source Implementation Grants (319)	The 319 program provides formula grants to the States to implement nonpoint source projects and programs in accordance with Section 319 of the Clean Water Act.	States and Indian Tribes	Grants are awarded to a lead state agency. States and local organizations receiving 319 grants are required to provide 40 percent of program cost.
Water Quality Cooperative Agreements (104 (b)(3))	Grants are provided to support new approaches to meeting storm water, combined sewer outflows, sludge, and pretreatment requirements as well as enhancing State capabilities. Eligible projects usually include research, investigations, experiments, training, environmental technology demonstrations, surveys, and studies related to the causes, effects, extent, and prevention of pollution.	State water pollution control agencies, interstate agencies, local public agencies, Indian Tribes, nonprofit institutions, organizations, and individuals	Grants are awarded; matching is encouraged .
Water Quality Management Planning (205 (J))	Formula grants are awarded to State water quality management agencies to carry out water quality planning. States are required to allocate at least 40 percent of funds to eligible Regional Public Comprehensive Planning Agencies (RPCPO) and Interstate Organizations (IO).	States	States are required to allocate at least 40 percent of funds to eligible RPCPOs and IOs.

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
State Revolving Funds (SRF)	EPA awards grant money to States to establish SRFs. Under the SRF program, Illinois has created revolving loan funds to provide independent and permanent sources of low-cost financing for a range of water quality infrastructure projects. States set loan terms, repayment periods, and other loan features. SRFs are available to fund a wide variety of water quality projects including all types of nonpoint source and estuary management projects, as well as more traditional wastewater treatment projects.	States	Grants are awarded to a lead agency. Loans are provided to eligible participants.
Capitalization Grants for State Revolving Funds	EPA awards grants to States to capitalize their Clean Water State Resolving Funds (SRF). The States, through the SRF, make loans for high priority water quality activities. Loans are used for water quality management activities.	States, Tribes, Puerto Rico, Territories, and DC	Grants are awarded to a lead agency. Loans are provided by the state to eligible participants. States are required to provide a 20 percent match
Capitalization Grants for Drinking Water State Revolving Funds	EPA awards grant money to Illinois for Drinking Water State Revolving Funds (DWSRF) creation. Illinois, through its DWSRF, provides loans for drinking water supply-related projects. Although the majority of loan money is intended for upgrades of infrastructure (public or private drinking water supplies), Illinois also has the option to use some of the DWSRF funds for source water protection, capacity development, drinking water programs, and operator certification programs. DWSRF emphasizes preventing contamination and enhancing water systems management.	States, Territories, U.S. possessions, and Indian Tribes.	Grants and loans are awarded to drinking water suppliers. A 20 percent match from the State is required.
Water Pollution Control Program Grants (Section 106)	This program authorizes EPA to provide assistance to States and interstate agencies to establish and implement ongoing water pollution control programs. Prevention and control measures supported include permitting, pollution control activities, surveillance, monitoring, and enforcement; advice and assistance to local agencies; and the provision of training and public information. The Section 106 programs help foster a watershed approach at the State level by looking at water quality problems holistically.	States, interstate agencies, and Indian Tribes	Funds are allotted among the State and Interstate Water Pollution Control agencies on the basis of the extent of water pollution problems in the respective States.

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
EPA - PROJECT GRANTS Watersheds and Nonpoint Source Programs Branch, U.S. EPA Region 5			
Great Lakes Program	EPA's Great Lakes Program issues awards assistance to projects affecting the Great Lakes Basin or in support of the U.S.-Canada Great Lakes Water Quality Agreement. Such activities include surveillance and monitoring of Great Lakes water quality and land use activities.	State water pollution control agencies, interstate agencies, other public or nonprofit agencies, institutions, organizations, and individuals	Project grants, use of property and equipment, provision of specialized services, and dissemination of technical information are the forms of assistance provided.
Pollution Prevention Grants Program	This program provides project grants to States to implement pollution prevention projects. The grant program is focused on institutionalizing multimedia pollution prevention (air, water, land).	States and Indian Tribes	Individual grants are awarded based on requests. States are required to provide at least 50 percent of total project costs
Wetlands Protection Development Grants Program	This program provides financial assistance to States, Indian Tribes, and local governments to support wetlands development or augmentation and enhancement of existing programs. Projects must clearly demonstrate a direct link to an increase in the group's ability to protect its wetland resources.	States, Indian Tribes, Interstate/Intertribal agencies, local governments	Project grants are used to fund individual projects. States or Tribes must provide a 25 percent match of the total project cost
NATURAL RESOURCES CONSERVATION SERVICE (NRCS)			
Environmental Quality Incentives Program (EQIP)	EQIP provides technical, financial, and educational assistance, half of it targeted to livestock-related natural resource concerns and the other half to more general conservation priorities. EQIP is available primarily in priority areas where there are significant natural resource concerns and objectives.	Non-federal landowners engaged in livestock operations or agricultural productions. Eligible land includes cropland, rangeland, pasture, forest land, and other farm and ranch lands	EQIP can provide up to 75 percent of costs of certain conservation practices. Incentive payments can be up to 100 percent for 3 years, paid at a flat rate. The maximum is $10,000 per person per year and $50,000 over the length of the contract.

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Forestry Incentives Program (FIP)	FIP supports good forest management practices on privately owned, nonindustrial forest lands nationwide. FIP is designed to benefit the environment while meeting future demands for wood products. Eligible practices are tree planting, timber stand improvement, site preparation for natural regeneration, and other related activities. FIP's forest maintenance and reforestation provides numerous natural resource benefits, including reduced soil erosion and enhanced water quality and wildlife habitat. Land must be suitable for conversion from nonforest to forest land, for reforestation, or for improved forest management and be capable of producing marketable timber crops.	Private landowner of at least 10 acres and no more than 1,000 acres of nonindustrial forest or other suitable land. Individuals, groups, Indian Tribes, and corporations whose stocks are not publicly traded might be eligible provided they are not primarily manufacturing forest products or providing public utility services.	FIP provides no more than 65 percent of the total costs, with a maximum of $10,000 per person per year.
Small Watershed Program	This program works through local government sponsors and helps participants solve natural resource and related economic problems on a watershed basis. Projects include watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in watersheds of 250,000 or fewer acres. Technical and financial assistance is available for installation of works of improvement to protect, develop, and utilize the land and water resources in small watersheds.	Local or State agency, county, municipality, town or township, soil and water conservation district, flood prevention or flood control district, Indian Tribe or Tribal organization, or nonprofit agency with authority to carry out, maintain, and operate watershed improvement works	Assistance can cover 100 percent of flood prevention construction costs; 50 percent of construction costs related to agricultural water management, recreation and fish and wildlife; and none of the costs for other municipal and industrial water management. Technical assistance and counseling may also be provided.
Wetlands Reserve Program (WRP)	The Wetlands Reserve Program (WRP) is a voluntary program to restore and protect wetlands on private property. WRP provides landowners with financial incentives to enhance wetlands in exchange for retiring marginal agricultural land. Landowners may sell a conservation easement or enter into a cost-share restoration agreement. Landowners voluntarily limit future use of the land, yet retain private ownership. Landowners and the NRCS develop a plan for the restoration and maintenance of the wetland.	The easement participant must have owned the land for at least 1 year. An owner can be an individual, partnership, association, corporation, estate, trust, business or other legal entities, a State (when applicable), political subdivision of a State, or any agency thereof owning private land. Land must be restorable and suitable for wildlife benefits.	WRP provides three options to the landowner: *Permanent Easement*: USDA purchases easement (price is lesser of land value or payment cap.) USDA pays 100 percent of restoration costs. *30-year Easement*: Payment will be 75 percent of what would be paid for a permanent easement. USDA pays 75 percent of restoration costs. *Restoration Cost Share Agreement*: Agreement (min. 10 yr.) to restore degraded wetland habitat. USDA pays 75 percent of restoration costs.

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Wildlife Habitat Incentives Program (WHIP)	WHIP is a voluntary program for people who want to develop and improve wildlife habitat on private land. It provides both technical assistance and cost sharing to help establish and improve fish and wildlife habitat. A wildlife habitat plan is developed that describes the landowner's goals for improving wildlife habitat, includes a list of practices and schedule for installing them, and details the steps necessary for maintenance.	Individuals must own or have control of the land under consideration, and cannot have the land already enrolled in programs that have a wildlife focus, such as the WRP, or use the land for mitigation.	USDA will pay up to 75 percent of installation costs and will provide technical assistance for successfully establishing habitat development projects.
Resource Conservation and Development Program (RC&D)	RC & D provides a way for local residents to work together and plan how they can actively solve environmental, economic, and social problems facing their communities. Assistance is available for planning and installation of approved projects specified in RC&D area plans, for land conservation, water management, community development, and environmental enhancement.	Must be an RC&D area authorized by the Secretary of Agriculture for assistance	Technical assistance Grants (as funding allows) up to 25 percent of total cost not to exceed $50,000. Financial assistance has not been available in recent years due to budget constraints. Local or State government must provide 10 percent of total cost and are also responsible for operation and maintenance.
Watershed Surveys and Planning	This program provides planning assistance to Federal, State and local agencies for the development of coordinated water and related land resources programs in watershed and river basins. Special priority is given to projects helping to solve problems of upstream rural community flooding, water quality improvement coming from agricultural nonpoint sources, wetland preservation, and drought management for agricultural and rural communities.	State, Federal, Indian tribes, or local agencies	Technical assistance is provided. Each cooperating agency is expected to fund its own participation.
Emergency Watershed Protection (EWP) Program	The EWP Program was set up to respond to emergencies created by natural disasters. All EWP work must reduce threats to life and property. It must be economically and environmentally defensible. EWP work can include a wide variety of measures ranging from reshaping and protecting eroded banks to reseeding damaged areas.	Public and private landowners are eligible for assistance but must be represented by a project sponsor who must be a public agency.	NRCS can fund up to 75 percent of total cost.

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
U.S. FOREST SERVICE			
Cooperative Forestry Assistance	Cooperative Forestry Assistance helps State Foresters or equivalent agencies with forest stewardship programs on private, State, local, and other non-Federal forest and rural lands, plus rural communities and urban areas. This assistance is provided through the following programs: Forest Stewardship Program, Stewardship Incentive Program, Economic Action Programs, Urban and Community Forestry Program, Cooperative Lands Forest Health Protection Program, and Cooperative Lands Fire Protection Program. These programs help to achieve ecosystem health and sustainability by improving wildlife habitat, conserving forest land, reforestation, improving soil and water quality, preventing and suppressing damaging insects and diseases, wildfire protection, expanding economies of rural communities, and improving urban environments.	State Forester or equivalent State agency can receive moneys. State agencies can provide these moneys to owners of non-Federal lands, rural communities, urban/municipal governments, nonprofit organizations, and State, local, and private agencies acting through State Foresters or equivalent.	Formula grants, project grants, and cost share programs are available as well as use of property and facilities.
Stewardship Incentive Program	The Stewardship Incentive Program provides technical and financial assistance to encourage nonindustrial private forest landowners to keep their lands and natural resources productive and healthy. Qualifying land includes rural lands with existing tree cover or land suitable for growing trees and which is owned by a private individual, group, association, corporation, Indian tribe, or other legal private entity.	Eligible landowners must have an approved Forest Stewardship Plan and own 1,000 or fewer acres of qualifying land. Authorizations may be obtained for exceptions of up to 5,000 acres.	Technical or financial assistance can be provided.
U.S. FISH AND WILDLIFE SERVICE			
Coastal Wetlands Planning, Protection, and Restoration Act	This program provides funds to assist States in pursuing coastal wetland conservation projects. Funds can be used for acquisition of interests in coastal lands or waters, and for restoration, enhancement, or management of coastal wetland ecosystems on a competitive basis with all coastal states.	All States bordering the Atlantic, Gulf and Pacific coasts, Great Lakes and other U.S. coastal territories	Project grants. Federal share of costs not to exceed 50 percent; Federal share may be increased to 75 percent if a coastal State has established a fund (1) for the acquisition of coastal wetlands, other natural areas, or open spaces, or (2) derived from a dedicated recurring source of moneys.

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
Partners for Wildlife Habitat Restoration Program	The Partners for Wildlife Program provides technical and financial assistance to private landowners through voluntary cooperative agreements in order to restore formerly degraded wetlands, native grasslands, riparian areas, and other habitats to conditions as natural as feasible. Under cooperative agreements, private landowners agree to maintain restoration projects as specified in the agreement but otherwise retain full control of the land. To date, the Partners for Wildlife Program has restored over 360,000 acres of wetlands, 128,000 acres of prairie grassland, 930 miles of riparian habitat, and 90 miles of in-stream aquatic habitat.	Private landowners (must enter into a cooperative agreement for a fixed term of at least 10 years)	Project grants (cooperative agreements) are provided. Program's goal is that no more than 60 percent of project cost is paid by Federal moneys (the program seeks remainder of cost share from landowners and nationally-based and local entities).
Wildlife Conservation and Appreciation Program	The Wildlife Conservation and Appreciation Program provides grants to fund projects that bring together USFWS, State agencies, and private organizations and individuals. Projects include identification of significant problems that can adversely affect fish and wildlife and their habitats; actions to conserve species and their habitats; actions that will provide opportunities for the public to use and enjoy fish and wildlife through nonconsumptive activities; monitoring of species; and identification of significant habitats.	State fish and wildlife agencies	Project grants are provided.
North American Wetlands Conservation Act (NAWCA) Grant Program	The NAWCA grant program promotes long-term conservation of North American wetland ecosystems. Principal conservation actions supported by NAWCA are acquisition, enhancement and restoration of wetlands and wetlands-associated habitat.	Public or private, profit or nonprofit entities or individuals establishing public-private sector partnerships	Project grants (cooperative agreements and contracts) are provided. Cost-share partners must at least match grant funds 1:1 with U.S. non-federal dollars.

PROGRAM	OVERVIEW	ELIGIBILITY	ASSISTANCE PROVIDED
U.S. ARMY CORPS OF ENGINEERS			
Planning Assistance to States Program	The USACE to assist States, Indian Tribes local governments, and other non-Federal entities in the preparation of comprehensive plans for the development, utilization, and conservation of water and related land resources under this program. The program can encompass many types of studies dealing with water resources issues. Typical studies are only planning level of detail. Types of studies conducted in recent years include water quality studies, flood plain management, environmental conservation, and many others.	States, Indian Tribes local governments, and other non-Federal entities	Federal allotments for each State or Tribe from the nation-wide appropriation are limited to $500,000 annually.

PHASE 1 DIAGNOSTIC FEASIBILITY STUDY OF GOVERNOR BOND LAKE

APPENDIX 3

CITY ORDINANCES

ZONE A. Comprises all that portion of the reservoir lying 150 feet from the water intake.

ZONE B. Comprises that portion of the reservoir lying within 150 feet of the shoreline, regardless of the high water line or the normal pool of such reservoir.

ZONE C. Comprises that portion of the reservoir which lies more than 150 feet from the shoreline of the reservoir and exclusive of the area designated for Zone D.

ZONE D. Comprises that portion of the reservoir especially designated by the city as boat harbors, boat mooring areas, boat launching areas or other particularly designated areas operated by the city either directly or indirectly.

ZONE E. Comprises all land in the drainage area which is or may be owned or controlled by the city, and is not flooded by the water of the reservoir. ***ZONE E*** also includes public highways and railroad rights of way where the same pass through or over land owned by the city.

ZONE F. Comprises all land located within nine miles of the limits of the city owned land and within the drainage area and includes all of Zones A, B, C, D and E, except that part of Zone E which is outside the drainage area.
('74 Code, Ch. 12, Art. 4, § 1) (Ord. 2054, passed 6-11-85)

throw, discharge, or cause to be discharged any sewage, garbage, decayed or fermented fruit or vegetables, offal, dead body, manure, polluted, filthy, decaying, fermenting, putrescible or oily matter or liquid, or industrial waste into or so as to reach any natural or artificial watercourse or open or covered sewer, ditch, tile, or drain flowing directly or indirectly, continuously or intermittently, into and so as to pollute or tend to pollute the reservoir or other waters from which the city obtains a water supply. No person shall construct in Zone F or in any part of the drainage area any open or covered sewer, ditch, tile, or drain or make any change therein or connection therewith so as to cause any pollution or polluted or oily water to flow into or reach more quickly, such reservoir or water supply of the city. No person shall within Zone F or in any part of the drainage area construct or cause to be constructed, or use any toilet, water closet, urinal, sink, cesspool, privy, garage, slaughterhouse, or other structure, establishment, or place which is so situated that polluted or oily liquid therefrom may continuously or intermittently so flow as to ultimately reach and pollute or tend to pollute the waters of such reservoir or other waters from which the city obtains or may obtain a water supply unless there is constructed, maintained, and operated such sewage treatment and disposal units and facilities for the treatment of disposal thereof, approved by the city, whereby such polluted or oily liquid is treated, or caused to be treated, so as not to pollute or tend to pollute or threaten pollution of the waters of such reservoir or water supply of the city. No connection for water service shall be installed or water service furnished by the city at any place in the drainage area (being that entire area of land which drains into the artificial water supply to the city known as Governor Bond Lake or into the Kingsbury Branch or any tributary or other stream above the impounding dam of such public water supply reservoir), unless there are constructed and satisfactorily maintained and operated such approved sewage treatment and disposal units and facilities for the treatment or disposal of the sewage from such premises.

(C) No house slop, sink waste, garbage, decayed or fermented fruit or vegetables or other fruit or vegetable refuse, offal, swill, carcass, filthy, decaying, fermenting or putrescible matter of any kind, or unsanitary waste product or polluted or oily liquid or solid shall be thrown into the reservoir or placed, piled, or discharged in any manner in Zones A, B, C, D or E but shall be kept in watertight closed containers, approved by the city, and at regular intervals be buried under the ground and completely covered in level noneroding soil at least 150 feet from the reservoir or be destroyed by fire or removed from Zone E in time or manner as required by the city; provided, however, that manure and commercial fertilizer may be used for horticultural purposes in Zone E, but no manure or commercial fertilizer shall be placed, spread or used on or in the grounds within Zone E, in such quantities or in such a manner as to cause to threaten any pollution of the reservoir or bring about any public or private nuisances whatsoever.

('74 Code, Ch. 12, Art. 4, §§ 4-6) (Ord. 2054, passed 6-11-85) Penalty, see § 95.99

TITLE IX: GENERAL REGULATIONS / CHAPTER 95: LAKES AND RESERVOIRS / RESERVOIR MANAGEMENT / § 95.20 INTERMENTS PROHIBITED.

§ 95.20 INTERMENTS PROHIBITED.

No interment of a human body shall be made within Zones A, B, C, D or E.

('74 Code, Ch. 12, Art. 4, § 7) Penalty, see § 95.99

TITLE IX: GENERAL REGULATIONS / CHAPTER 95: LAKES AND RESERVOIRS / RESERVOIR MANAGEMENT / § 95.21 REGULATION OF LIVESTOCK AND POULTRY.

§ 95.21 REGULATION OF LIVESTOCK AND POULTRY.

No person shall cause to permit any domestic livestock or poultry to run at large in Zone E. Any such livestock or poultry found at large in Zones A, B, C, D or E may be taken up by the city and sold to pay the expense of taking, keeping, advertising and selling such livestock or poultry, and all damages caused to the city or its property by such livestock or poultry. No livestock or poultry shall be kept in Zone E except in such places and to such limited extent as may be expressly authorized by the city by lease and in a manner not tending to pollute any part of the reservoir or tending to be offensive or annoying to any custodian of any marginal land in such zone. No animal or poultry shall be allowed to stand, wallow, wade or swim or be washed or watered in the reservoir. No person shall bring, drive or lead any domestic livestock in Zone E except in lawful use of the public highway and except horses and draft animals while engaged in work or ridden on such portions of Zone E as may be designated for riding or driving. No person shall cause or permit any horse or other animal to stand in any street, road or parkway unless securely hitched or in charge of some competent person.
('74 Code, Ch. 12, Art. 4, § 8) Penalty, see § 95.99

TITLE IX: GENERAL REGULATIONS / CHAPTER 95: LAKES AND RESERVOIRS / RESERVOIR MANAGEMENT / § 95.22 WASHING CLOTHES, AND THE LIKE.

§ 95.22 WASHING CLOTHES, AND THE LIKE.

No clothing, bedding, carpet, vehicle, receptacle, utensil or article that tends to pollute water shall be washed in the reservoir.
('74 Code, Ch. 12, Art. 4, § 9) Penalty, see § 95.99

TITLE IX: GENERAL REGULATIONS / CHAPTER 95: LAKES AND RESERVOIRS / RESERVOIR MANAGEMENT / § 95.17 BUILDINGS AND STRUCTURES.

§ 95.17 BUILDINGS AND STRUCTURES.

(A) No building or other structure, whether for habitation or otherwise, including any dock, wharf, boathouse or anchored or stationary raft shall be constructed, altered or maintained within the limits of Zones A, B, C, D or E unless a permit in writing, based upon a written application setting forth the location, plans, specifications and intended use thereof is granted by the city.

(B) The plans, specifications and construction shall be in compliance with the current Basic Building Code as found in the Model Building Regulations published by Building Officials and Code Administrators International, Inc., which is adopted herein by reference. In addition, applicants shall comply with the following requirements:

(1) All docks must be bolted together with bolts not subject to rust.

(2) All docks are required to be connected to the shoreline, at no less than two points, and that points of connection be by steel cable or chain.

(3) All electrical conductors be enclosed in grounded material beyond the shoreline.

(4) There will be no fuel stored on the dock, or any fuel connection be permitted between the dock and the shoreline.

(5) No metal drums may be used as buoyancy devices. Styrofoam may be used for floating docks.

(6) No dock may project more than 25 feet beyond the shoreline.

(7) No nails can be used for construction except ringshank.

(8) All stationary docks must have ample piling support to support dock.

(9) Pressure treated lumber, such as redwood, cypress, or any material which has been given the building inspector's written approval for use should be used for all construction.

(C) The owner of each such structure shall pay a fee of $2 per year or $6 for three years for the issuance of said permit. This fee is payable at the time of renewing the above mentioned application.

(D) An inspection of said structures shall be made each year by the city. If a structure fails to be found in compliance with any of the rules and regulations above stated, an owner may:

(1) ˙Have the permit for such structure suspended for a determinate or indeterminate length of time.

(2) Pay a fine of not less than $50 nor more than $500.

(3) Forfeit the right to use, possess or maintain the structure and the city may take exclusive possession of the structure and remove it from the reservoir and dispose of it as the city shall see fit. The owner, by applying for said permit, does hereby grant to the city the right and privilege of going onto, over and across land owned by the owner in order to take possession of the structure and remove the same.
('74 Code, Ch. 12, Art. 4, § 3) (Ord. 2054, passed 6-11-85)

TITLE IX: GENERAL REGULATIONS / CHAPTER 95: LAKES AND RESERVOIRS / RESERVOIR MANAGEMENT / § 95.18 ALTERATION OF SHORELINE.

§ 95.18 ALTERATION OF SHORELINE.

No alteration of the shoreline or land owned or controlled by the city shall be permitted without a written permit granted by the city. Alterations are hereby defined as the cutting of trees, removal or addition of earth or rip-rap, change in the topography or elevation or installation of any permanent object. Application for said permit shall be accompanied by complete plans and specifications. There shall be a $5 fee for said permits. The City Manager may deny the granting of any application for shoreline alteration where such alteration will cause harm to the environment, pollution of the lake or interfere with the public or private use of the lake or its shoreline.
('74 Code, Ch. 12, Art. 4, § 3A) (Ord. 2123, passed 2-9-88) Penalty, see § 95.99

TITLE IX: GENERAL REGULATIONS / CHAPTER 95: LAKES AND RESERVOIRS / RESERVOIR MANAGEMENT / § 95.19 SEWAGE DISPOSAL; POLLUTION; DISPOSAL OF WASTE.

§ 95.19 SEWAGE DISPOSAL; POLLUTION; DISPOSAL OF WASTE.

(A) No toilet, water closet, urinal, privy, cesspool, septic tank, sewer, or other means for the depositing, storing, retaining or disposing of sewage or sink or bathroom wastes shall be built or maintained within Zones A, B, C, or D, and only in Zone E after a written permit has been granted by the city based upon a written application disclosing the location and specifications therefor and means for the treatment or disposal of such sewage or sink or bathroom wastes in such manner as may be approved by the appropriate body so as not to pollute or threaten pollution of the reservoir or tend to create a nuisance, and the construction and maintenance thereof shall be subject to supervision by the city.

(B) No person shall, within Zone F or in any other part of the drainage area, place,