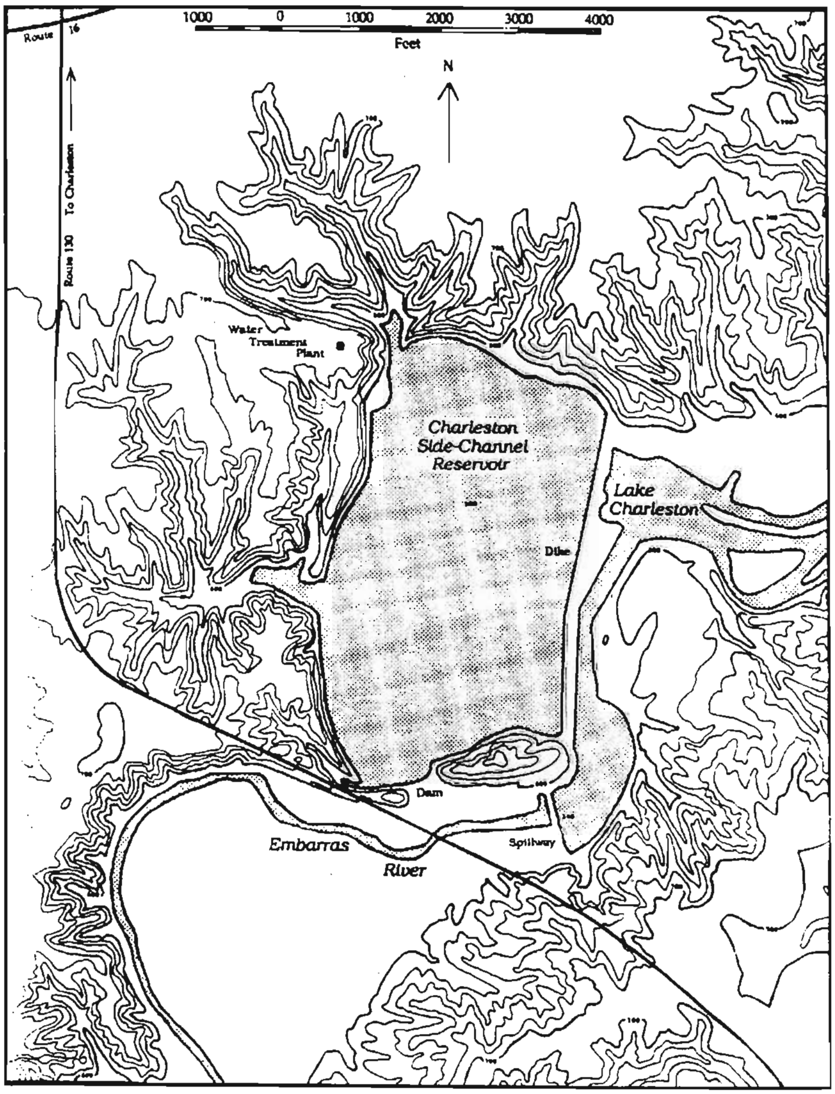
Charleston Side Channel Reservoir Restoration Plan

Clean Lake Program
Phase 1
Diagnostic/Feasibility Study



Steve Fritcher, EIU Cart Lab. 12/91

Charleston, Illinois Water Treatment Plant
520 Jackson Avenue • Charleston, Illinois 61920

Clean Lakes Program

Phase 1 Diagnostic/Feasibility Study

of the

Charleston Side-Channel Reservoir

Prepared by

City of Charleston

in cooperation with

Eastern Illinois University

Illinois Environmental Protection Agency

United States Environmental Protection Agency

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Table of Contents

List of Tables

List of Tables (cont.)

List of Figures

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Recent Baseline Limnological Data -	A. Alford
Reservoir Measurements -	V. Gutowski, A. Alford
Water Quality Characteristics -	A. Alford
Physical Characteristics -	A. Alford
Chemical Characteristics -	A. Alford
Biological Characteristics	
Algae -	Charles Pederson, Kaye Surratt, A. Alford
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Macrophytes -	John Ebinger
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Sediment Characteristics	
Hydrology and Sediment Load of Tributaries to the Reservoir	V. Gutowski
Shoreline Erosion -	V. Gutowski
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Chemical Content of Sediments -	A. Alford, Bonnie Allison, John Marquart
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Several groups of students assisted in numerous projects under the direction of Dr. Vincent Gutowski, Associate Professor in the Department of Geology/Geography at Eastern Illinois University. A bathymetric map of the reservoir was produced with the assistance of Mr. Mark Christ and Mr. Robert Young of the EIU Environmental Biology Program. Weirs were designed and constructed under the supervision of Mr. Richard Boyer with assistance by Mr. William Everly and Mr. Martin Zuber. Areas of shoreline erosion were mapped by Mr. William Everly and Mr. Stanley Spencer. Grain-size analysis of bottom sediments were done by Mr. Michael Dolan and Mr. Michael O'Keeffe. Measurements of tributary streamflow and sediment loads were done by Mr. Michael Dolan, Mr. Michael O'Keefe, Mr. Marty Zuber and Mr. Steve DiNaso. Cartographic assistance was supplied by Mr. Steve DiNaso and Mr. Steve Fritcher.

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Numerous other people contributed to the study. These include: Mr. Donald Dufford, Mr. Robert Kirschner, Mr. Keith Alexander, Mr. Michael Lupke, Mr. Timothy O'Neill, Ms. Pamela LeVine, Mr. Van Bowersox, and Dr. Ted Peck.

PART 1

DIAGNOSTIC STUDY

OF THE

CHARLESTON SIDE-CHANNEL RESERVOIR

COLES COUNTY, ILLINOIS

Section (a) (1) Lake Identification and Location

The Charleston Side-Channel Reservoir is a water supply and recreational reservoir in Coles County, Illinois, two miles south of the city of Charleston. The Side-Channel Reservoir is the sole sources of water for the City's potable water supply. The City and its water bodies are located in east-central Illinois (Figure 1). The City is proud to be the home of Illinois Governor Jim Edgar.

In 1895 an eight foot high channel dam was constructed in the Embarras River to create the City's first water supply reservoir (Figure 2,B). This supply became inadequate in the 1930's, and alternate sources were sought. The completion of the Riverview Dam in 1947 gave the City, Lake Charleston, a lake with a 744 million gallon storage capacity (Figure 2,C). In 1953, 1960, and 1974 the Illinois State Water Survey (ISWS) published reports on the sedimentation problems in Lake Charleston.

To master the sedimentation problem, a side-channel reservoir was constructed (1979 to 1982) at Lake Charleston. A channel cut through a peninsula redirected the normal flow of water. A dike built beside the channel isolated most of the lake from the direct effect of the Embarras River. Water pumped from the east side of the dike into the isolated portion, or side-channel reservoir, raised the water level eight feet above the original lake level. Pumping to fill the reservoir was completed in January of 1982. This created a reservoir with a 1,199 million gallon capacity (Figure 2,D).

In the years since the completion of the reservoir, the names of the resulting bodies of water have created some confusion. Different reports and maps use different names for these waters. For this report, the large body of water to the west of the side-channel dike will be called the Charleston Side-Channel Reservoir (CSCR). The body of water on the east side of the side-channel dike from the Riverview Dam-spillway to the Illinois route 16 bridge will be called Lake Charleston (LC). The name of the river above and below Lake Charleston is the Embarras River (ER). The ER is a tributary of the Wabash River (Table 1).

The origin of the ER is located on the southern edge of the University of Illinois (UI) campus in Urbana, Illinois. The ER flows south to its first impoundment, the Riverview Dam at LC. The LC has an 811 square mile (519,040 acres) watershed. Water can be selectively pumped from LC into the CSCR. The two main criteria for pumping are 1) a turbidity of less than 40 NTU and 2) no noticeable algae bloom in LC water. The watershed of the CSCR is only 1,133 acres of which 328 acres are made up of water. The hydraulic budget of the CSCR consists of over 50% input from pumping and greater than 40% from direct precipitation.

In the mid 1980's the City of Charleston (City) began receiving complaints regarding the declining fishery and increased fish kills within its reservoir as well as numerous complaints of foul tastes and odors in its potable water supply. Hoping to eliminate these problems, the City of Charleston initiated a Federal Clean Lakes Program Phase I diagnostic-feasibility study of the CSCR. The United States Environmental Protection Agency (USEPA) funded 50 percent of the study under the provisions of Section 314 of the Federal Clean Water Act, and the City provided the remaining 50 percent. Grant administration and program management was conducted by the Illinois Environmental Protection Agency (IEPA). The diagnostic study was conducted by the City with considerable assistance from the Environmental Biology Program and Geology/Geography Department of Eastern Illinois University (EIU). Additional assistance was provided by IEPA, Illinois Department of Conservation (IDOC), United States Department of Agriculture (USDA) Soil Conservation Service (SCS) and the Chemistry Department of EIU.

Table 1. General Information Pertaining to the Charleston Side-Channel Reservoir

Lake name:	Charleston Side-Channel Reservoir
State:	Illinois
County:	Coles; T12N., R9E., Section 24, 25
Nearest municipality:	Charleston, Illinois
Latitude:	39°-28'-01"
Longitude:	88°-08'-35"
EPA region:	V
EPA major basin name and code:	Ohio, 05
EPA minor basin name and code:	Wabash, 17
Major tributary:	Embarras
Receiving water body:	Embarras
Water quality standards:	State of Illinois Rules and Regulations Title 35: Subtitle C: Chapter 1

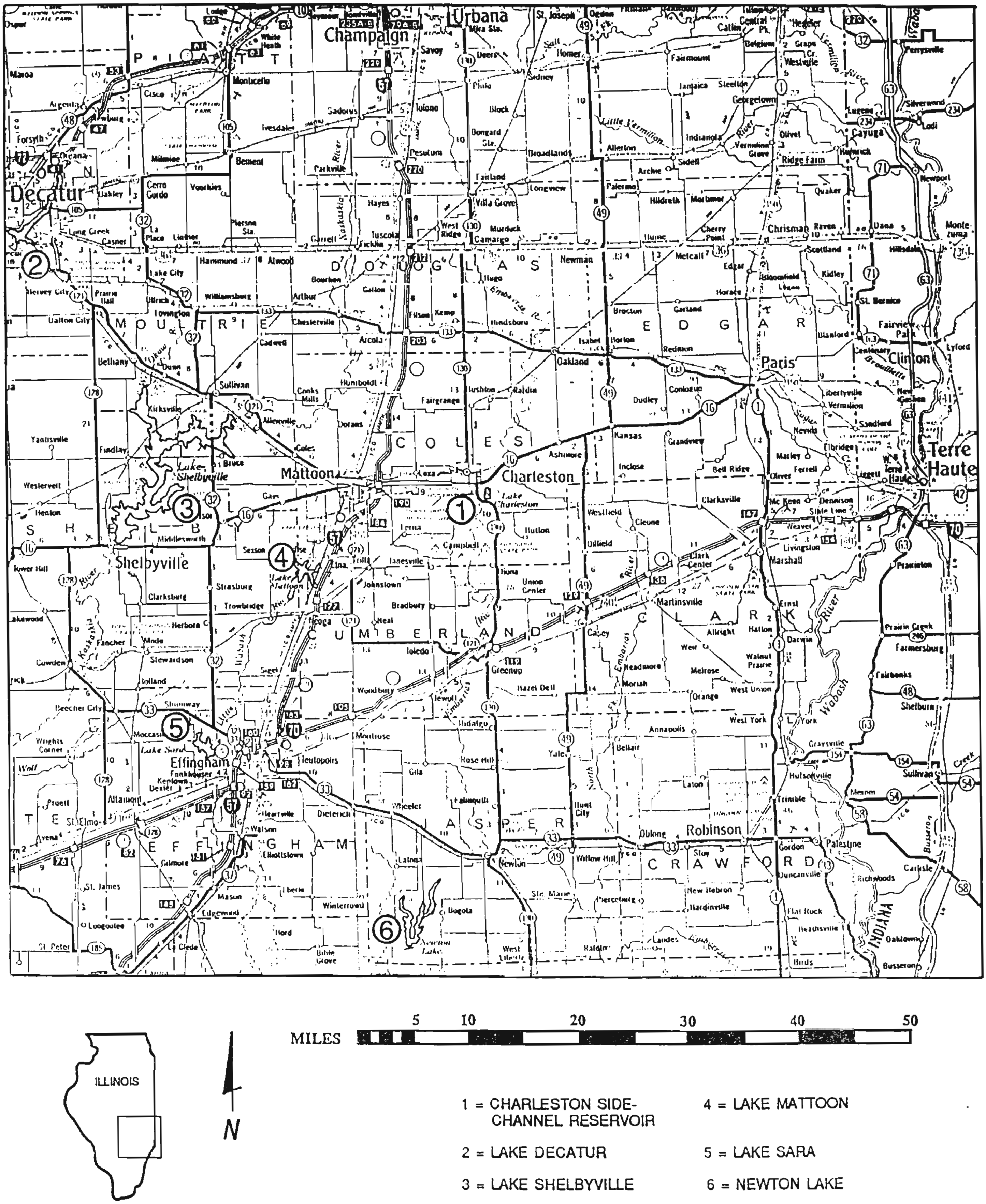

Figure 1. Area Map

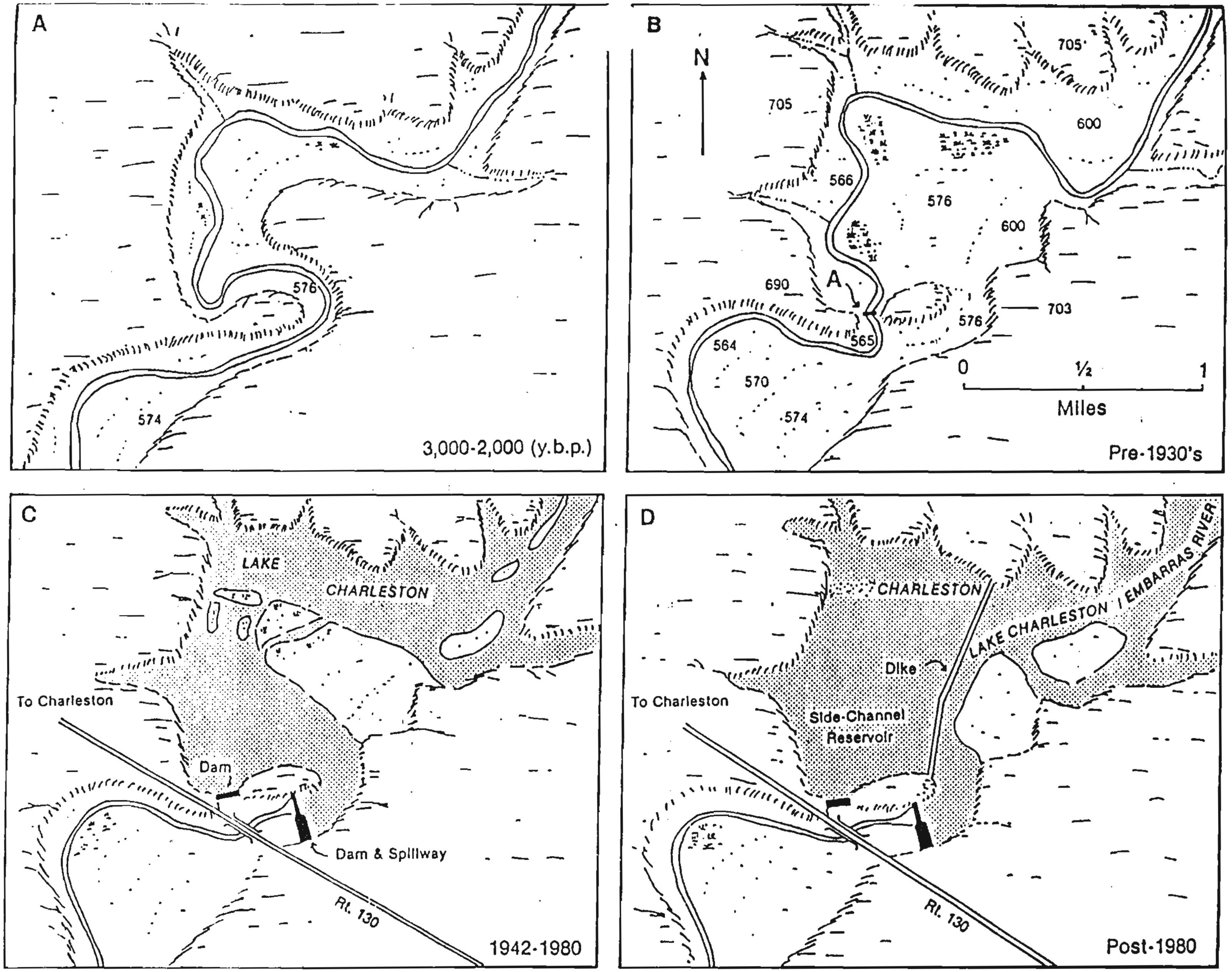

Figure 2. (A) The route of the Embarras River prior to the meander cutoff, (B) the valley of the Embarras River after the meander cutoff, (C) the original Lake Charleston, 1942 to 1980, and (D) Lake Charleston after completion of the side-channel reservoir (Gutowski, 1986).

Section (a) (2) Geological and Soil Description of the Drainage Basin

Geological Description

Bedrock Geology - The watershed of the CSCR is located in an area underlain by Pennsylvanian Age rocks of the McLeansboro Group. Outcrops of sandstones, shale and limestones of the Mattoon Formation are located along 800 feet of the northwest shore of the CSCR. A submerged peninsula in the central portion of the CSCR contains a bedrock core draped with alluvial deposits. Tributaries entering the northwest corner of the CSCR have few areas where the streams flow over bedrock.

Glacial Deposits - The watershed area is underlain by Wisconsinan Age glacial deposits. There is a possibility that Illinoisan Age deposits underlie the Wisconsinan deposits in some portions of the area. The glacial materials are end moraine deposits of the Wisconsinan Shelbyville Moraine which locally is 80 to 90 feet thick. The CSCR maybe hydraulically connected to a surficial aquifer in the Henry Formation (Kempton etal 1982).

Groundwater Hydrology

Although the groundwater hydrology of the CSCR has not been investigated to any great extent, some qualitative observations should be mentioned. During the winter and early summer, tributaries directly entering the CSCR have some surface flow. During the dry late summer, fall and early winter periods, none of the tributaries have any sustained surface flow. This may indicate that the CSCR receives surface and groundwater input during the wet portion of the year and groundwater may serve as a recharge agent during the dry season. It should be recognized that the surface of the CSCR is presently 20 feet higher than the pre-lake surface of the ER which occupied the valley and 7 feet higher than the present spillway cap. The CSCR and LC are under-laid by a sand and gravel aquifer that is normally 10 to 20 feet thick. Water seeps through the dike from the CSCR to the LC.

Topography

The topographic setting of the CSCR is a meander bend in the half-mile wide Embarras River Valley. The valley cuts through glacial till and in some areas bedrock. The watershed for the CSCR is predominantly ridge and ravine topography with steep slopes and short length, high gradient tributaries (Figure 3). The maximum depth of the ravines is 90 feet, and the slopes have a characteristic angle of approximately 27 degrees. Land use on these slopes is predominantly forest but the encroachment of residential developments is an increasing problem. A portion of the watershed is flat uplands not yet dissected by the ravine network. The uplands have little gradient, and land use is either agriculture or low to medium density residential.

Soils

The CSCR watershed contains eight soil types with varying slopes and drainage conditions (Figure 4 and Table 2). A review of the CSCR topography will provide insight into why some of the soil types have been labeled eroded (Figure 3, 4 and Table 2). Estimates of soil loss to watercourses are described in Section (a) (9).

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Table 2. Soils of the Drainage Basin

CODE	NAME	SLOPE	EROSION	DRAINAGE (drained)
27c2	Miami loam	5 - 10%	Eroded	well
27d2	Miami loam	10 - 15%	Eroded	well
27g	Miami loam	30 - 60%		well
152	Drummer silty clay loam	>1%		poorly
284	Tice silty clay loam	>1%		somewhat poorly
291b	Xenia silt loam	1 - 5%		moderately well
322b	Russell silt loam	1 - 5%		well
322c2	Russell silt loam	5 - 10%	Eroded	well
481	Ruab silt loam	>1%		somewhat poorly
496	Fincastle silt loam	>1%		somewhat poorly
871	Lenzburg gravely loam	1 - 5%		well
871d	Lenzburg gravely loam	7 - 20%		well
2152	Drummer-Urban land complex	>1%		poorly
2496	Fincastle-Urban land complex	>1%		somewhat poorly

Source: Mr. Andrew B. Cerven, District Conservationist, USDA Soil Conservation Service

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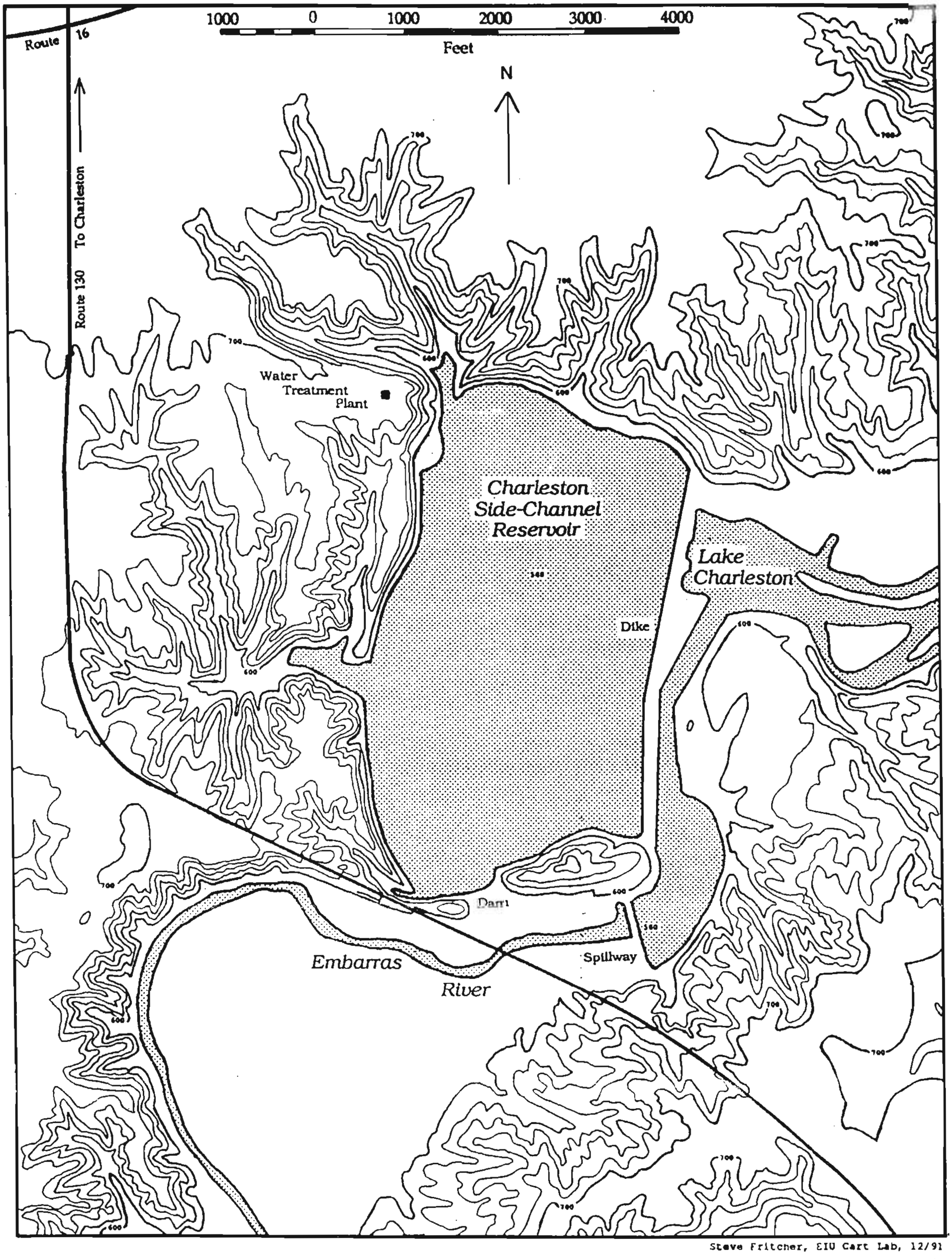


Figure 3. Topography of the Watershed for the Charleston Side-Channel Reservoir (contour interval 20 feet)

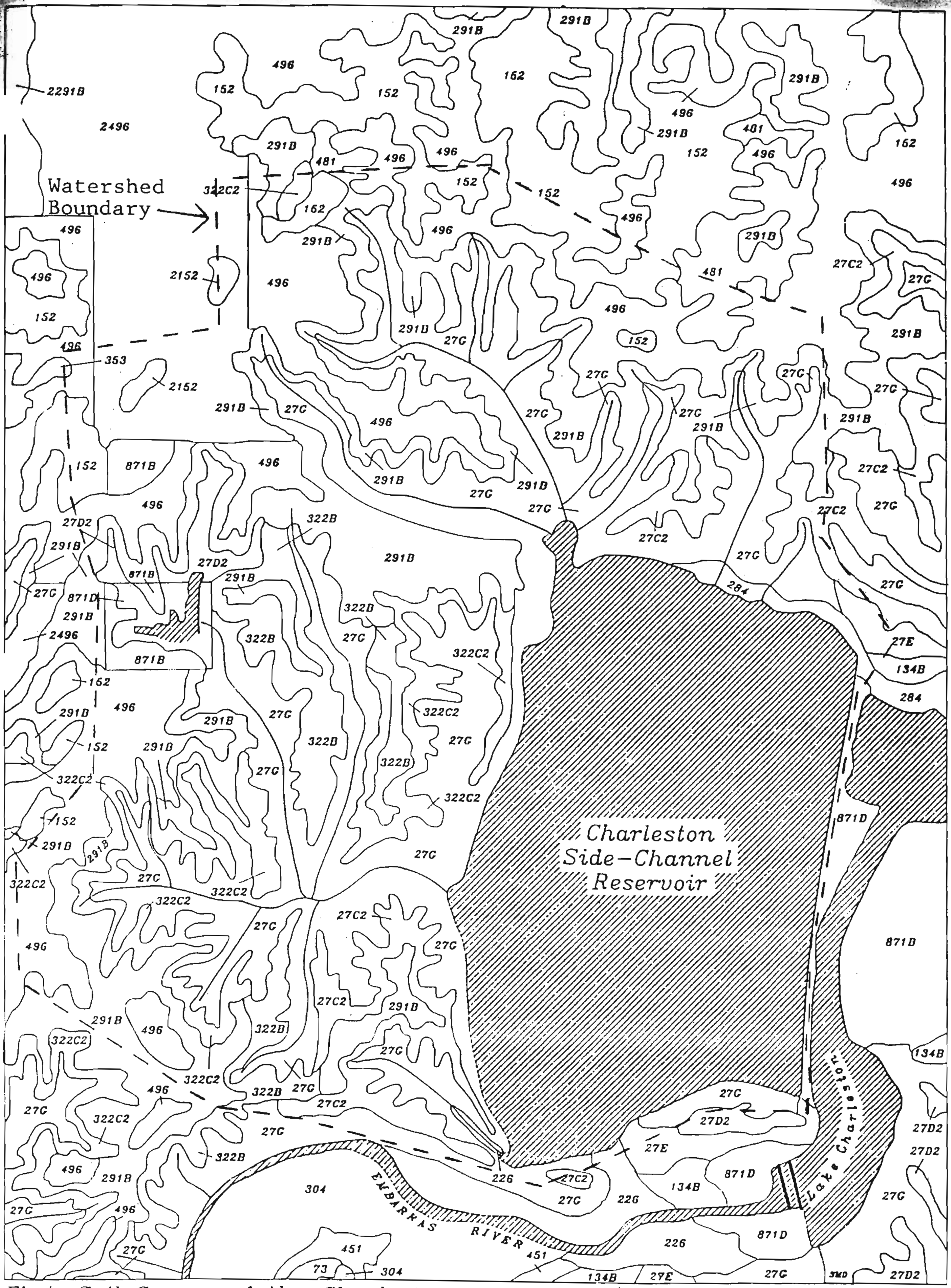


Fig.4 Soil Survey of the Charleston Side Channel Watershed. Source, Soil Conservation Service, an agency of the Department of Agriculture.

Section (a) (3) Public Access to the Charleston Side-Channel Reservoir

The cities of Charleston and Mattoon are the two major population centers close to the CSCR. There is no public transportation system in this area that provides service to and from the CSCR.

The CSCR is just east of Illinois Highway 130, a north-south highway. Two miles north of the CSCR, Illinois 130 intersects with Illinois highway 16, an east-west highway. This intersection is in the Charleston City limits. Highway 16 continues west from the intersection for 10 miles where, at the edge of the Mattoon City limit, it intersects with Interstate 57. South of the CSCR about 16 miles, Illinois 130 intersects with Interstate 70 (See map in Figure 1).

The concrete apron located in the northwest corner of the CSCR is about all that remains of one of Charleston's former water treatment facilities. Erosion of soil from behind the apron has caused some damage to this structure. On the south shore the boat docks and ramps were put in shortly after the creation of the CSCR and are in good shape. The facilities at Lakeview and Riverview Parks are old and in need of repair. Riverview Park is the only area around the CSCR that has working restrooms.

The City of Charleston is responsible for all of the facilities around the CSCR. The City charges no fees for the use of any of these facilities. In general there are five access areas surrounding the CSCR (Figure 5). These five areas contain several types of recreational opportunities (Table 3).

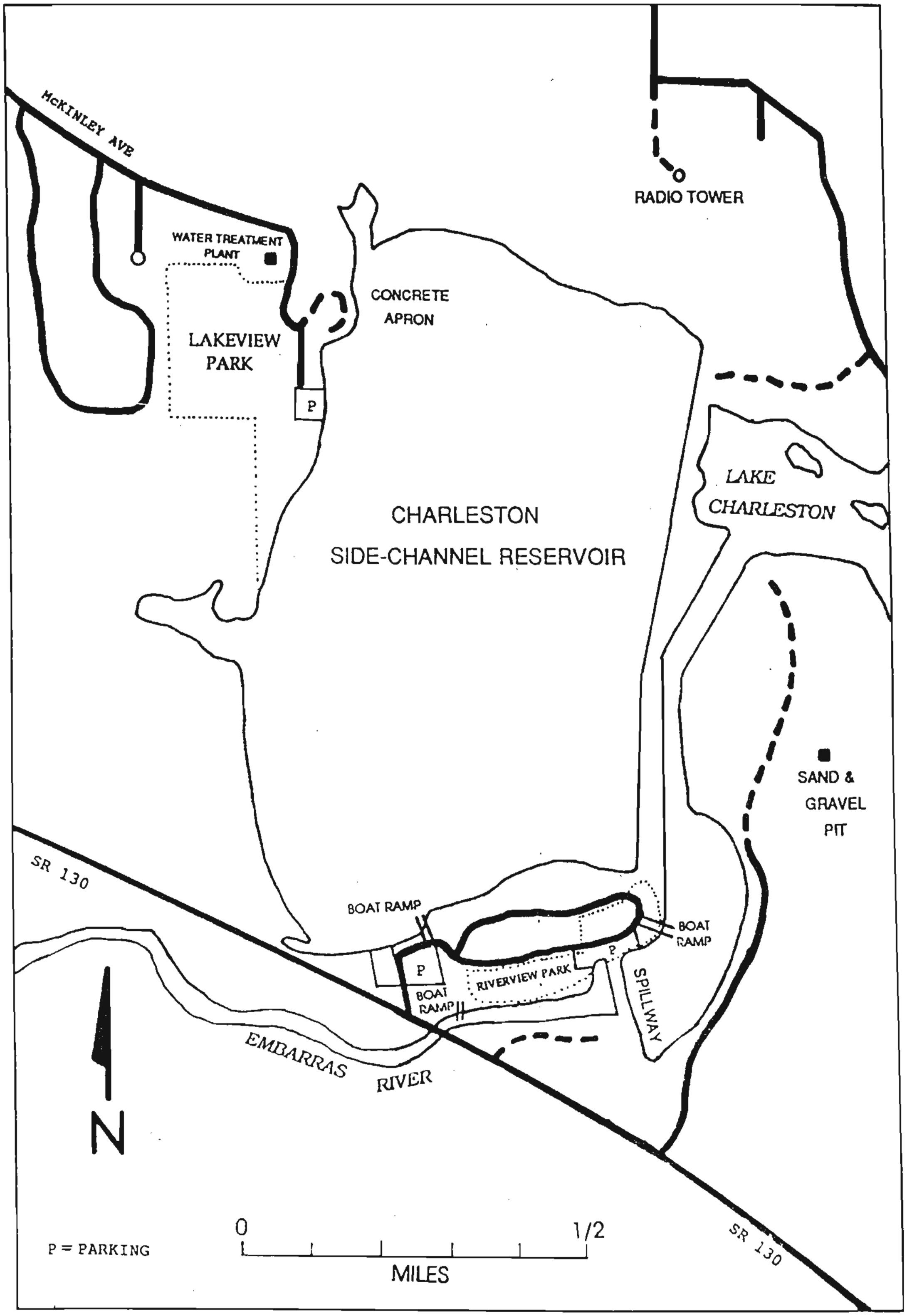


Figure 5. Public Access to the CSCR and Surrounding Areas

Table 3. Access Points to the Charleston Side-Channel Reservoir.

NAME	TYPE	AREA (acres)	FRONTAGE (feet)	FACILITIES
1. Old Water Plant	fishing	2.3	500	500 foot concert apron, closed to vehicle traffic
2. Lakeview Park	park	50.0	2300	Hiking trails (3), Picnic tables (6), Grills (2), Parking for 8 Vehicles The park is closed to vehicle traffic from December 1st to April 1st
3. Boat Ramp	dock & ramp	0.4	450	1 Boat ramp sufficient for inland fishing, docks 24 feet (2), boat-vehicle parking (17)
4. Dike	walking path bank fishing	17.1	4100	The maintenance road for the dike is used for a walking path and access to bank fishing
5. Riverview Park	park	33.6	0	Pavilion (1), tables (5), grills (3), swing set (1), boat ramp (2) and boat dock (1) restroom (2)

Section (a) (4) Potential User Population

The resident population adjacent to the CSCR is made up of less then ten homes. All but one of these are located on the south shore of the CSCR. Most of the visitors to the CSCR come from the Charleston and Mattoon area, population 19.4 and 19.3 thousand respectively.

Charleston is the home of Eastern Illinois University (EIU). Nearly half the population of Charleston is made up of EIU students. EIU has a major influence on Charleston's economy, affecting the types of businesses and the housing market in Charleston. Both Charleston and Mattoon have a broad base of manufacturing and wholesale facilities. Within the Charleston-Mattoon area, there is a low unemployment rate, and no urban blight or housing shortages with the exception of student housing. EIU is currently taking steps to increase the availability of student housing.

The City of Charleston utilizes the CSCR as source water for its public water supply. The CSCR is also an important sportfishing resource in the Charleston area. The recreational user population of the CSCR is dramatically affected by whether EIU is in or out of session. In warm weather the number of people visiting the parks around the CSCR has been estimated as high as 300 for a single afternoon. When EIU is not in session, high demand tends to be less than 75 visitors per day.

In complying data on user populations three main criteria were used (Table 4 and 5). First the population center had to be within 80 Km (50 miles) radius of the CSCR. Second, counties that: a.) have less than 20% of their land mass within that 80 Km radius and b.) have no population centers of at least 5,000 people were excluded. Third, population centers that have a population of 5,000 or greater and are within an 80 Km radius of the CSCR were listed as major cities.

Table 4. Per Capita Income of Counties near the Charleston Side-Channel Reservoir.

County	Per Capita Income (x 1,000 per year)
Illinois	
Champaign	7.3
Clark	6.7
Coles	6.7
Crawford	7.0
Cumberland	6.1
Douglas	7.4
Edgar	6.6
Effingham	6.9
Jasper	6.4
Macon	7.0
Moultrie	6.9
Piatt	7.9
Shelby	6.7
Vermilion	7.0
Indiana	
Sullivan	6.3
Vermillion	6.2
Vigo	6.7

Source: 1980 Census of Population, Bureau of the Census (U.S. Department of Commerce).

Table 5. Population and Economic Data for Areas near the Charleston Side-Channel Reservoir.

(Population & Employment figures are in thousands)

County and population		Major city within the county and its population		Major Employment sources and number of people employed	
Illinois					
Champaign	168.4	Champaign Urbana	58.4 36.0	Education, Food Products Eating and Drinking	78.5
Clark	16.9			Electrical machinery, Manufacturing, Agriculture	6.8
Coles	52.2	Charleston Mattoon	19.4 19.3	Education, Eating & Drinking, Printing, Construction	22.7
Crawford	20.8	Robinson	7.3	Manufacturing Food Products	8.2
Cumberland	11.0			Agriculture	4.1
Douglas	19.8			Agriculture, Chemicals	8.3
Edgar	21.7	Paris	9.9	Agriculture	8.7
Effingham	30.9	Effingham	11.3	Printing, Eating & Drinking	13.1
Jasper	11.3			Agriculture	4.4
Macon	131.4	Decatur	93.9	Machinery, Food Products	56.5
Moultrie	14.5			Agriculture	6.0
Piatt	16.6			Agriculture	7.4
Shelby	23.9	Shelbyville	5.3	Agriculture	9.1
Vermilion	95.2			Machinery	38.7
Indiana					
Sullivan	21.1			Construction	7.8
Vermillion	18.2	Clinton	5.3	Construction	6.9
Vigo	112.4	TerreHaute	61.1	Education	48.7

Source: 1980 Census of Population, Bureau of the Census (U.S. Department of Commerce)

Section (a) (5) Summary of Historical Lake Uses

1. Recreation

1.a. General

After the Riverview Dam was finished in 1947, LC recreational opportunities increased. The City constructed a beach above the spillway. The beach area contained lifeguard stands, playgrounds, picnic tables and a concession stand. A boat club and a Girl Scout cabin were also located on the lake. On a portion of land known as the Island Tract, the City leases land which was originally used to build summer cabins. The beach was closed in 1974 due to poor water quality. After construction was started on the CSCR, the buildings for the boat club and the Girl Scouts were torn down. It is interesting to note that when the spillway collapsed in 1985, sand from the beach washed down and was partly deposited below the spillway. This became a hot spot for sun bathers. The spillway collapse had a profound effect on water related activities at LC and CSCR in the summer of 1986. For all practical purposes from December 1985 until October of 1986, there was no LC. The pump intakes for the CSCR were high and dry and only portable emergency pumps could supply water to the CSCR. This, combined with a very dry summer, made it impossible for any but the smallest boats to be launched into the CSCR.

1.b. Fishing and Hunting

The city maintains no records for the purpose of tracking fishing or hunting activities in or around the CSCR. For many years the City has leased blind locations to duck hunters. Fishing is the main recreational activity at the CSCR. In 1983, the Illinois Department of Conservation began stocking the CSCR. The first five stockings were of channel catfish and were conducted between 1983 and 1988. In 1988, the City provided funding for stocking hybrid striped bass. In 1989, the CSCR received 1,500 largemouth bass and 1,730 channel catfish provided by the IDOC and 3,460 hybrid striped bass provided by the FishAmerica Foundation. The bass were added to the CSCR to offer a better predatory population in hope that it would reduce the over-abundance of gizzard shad.

1.c. Bird Watching

Bird watching is perhaps the second most popular activity at the CSCR. Unlike the seasonal nature of activities like sun bathing and recreational walking, bird watching is a year-round activity. Some individuals take time out of their daily commute to and from work to observe the latest change in the avian population. A testament to some bird watchers dedication to their pastime can be seen in Ron Bradley's report of Lake Charleston Birds (see Section (a) (11)).

2. Water Supply

In the 1830's, the ER was used to provide power for a gristmill. The gristmill enabled early Coles County settlers to grind their grain. In 1876, the City of Charleston began using water from the ER for a public water supply. A small dam was constructed in 1895 providing a depth of six feet. When the storage capacity became inadequate in the late 1930's, other sources of water were sought. With inadequate groundwater for Charleston's demand, a new dam was completed in 1947. This impoundment, known as Lake Charleston, suffered from a high sedimentation rate. In less than twenty years, sedimentation reduced the lake volume to a point where volume was again a problem. In 1981, the CSCR was completed alleviating Charleston's problem of low storage capacity. Shortly after completion, the CSCR became eutrophic and began to suffer from algal blooms and taste and odor problems. This condition led to the liberal use of copper sulfate in the CSCR and the use of activated carbon in Charleston's water treatment plant. An indication of how Charleston's demand for potable water has increased is reflected in the city's population growth (Figure 6).

3. Research and education

3.a. Department of Geology/Geography

The Eastern Illinois University (EIU) Department of Geology/Geography has been involved in a cooperative research effort with the City of Charleston to answer specific questions concerning the watershed of the CSCR.

1988-During August, 1988, depth measurements were taken which formed the basis for the bathymetric map of the CSCR. Field mapping was done by faculty and student research assistants from EIU and resulted in forty user-days at the CSCR. Laboratory preparation of the map involved fourteen days.

1989-Lake bottom sediment collection and analysis. Lake bottom sediments were collected for grain-size analysis, benthic organism studies and heavy metal concentrations. Sample collection involved five-user days. Grain-size analysis involved fourteen days.

1989-Shoreline erosion mapping. The height of erosional

bluffs was mapped for the entire shoreline of the CSCR. Field data collection required twenty user-days at the CSCR. Work is continuing on the production of a shoreline erosion map and vigil network map. This network will be used in evaluating the effects of shoreline restoration activates. The maps will allow determination of volume of surface flow into the CSCR. Faculty and students from EIU have collected and continue to collect surface flow volumes and suspended sediment concentrations in several tributaries to the CSCR. Total time spent in data collection is approximately 100 user-days.

The Department of Geology/Geography uses the watershed and the CSCR for field studies connected with several courses. Many of the sites currently being used for basic data collection for the City of Charleston are also used as examples for the students to observe. Yearly total user days for EIU field study components in Geology/ Geography courses is approximately 100 user days.

3.b. Department of Life Science

EIU Department of Life Science has long had an interest in the aquatic resources of the Charleston area. Past research has dealt with various aspects of the biotic communities associated with the ER, LC and the CSCR.

In 1988, the Life Science Department began providing graduate students and technical assistance for conducting studies to ascertain the current limnological condition of the CSCR. Since construction began on the CSCR, seven botany courses, two environmental biology courses and fifteen zoology courses have used the CSCR as a teaching aid. The CSCR has been the subject of seven masters theses from the Life Science Department.

Source: Charleston Chamber of Commerce, based on Bureau of Census data

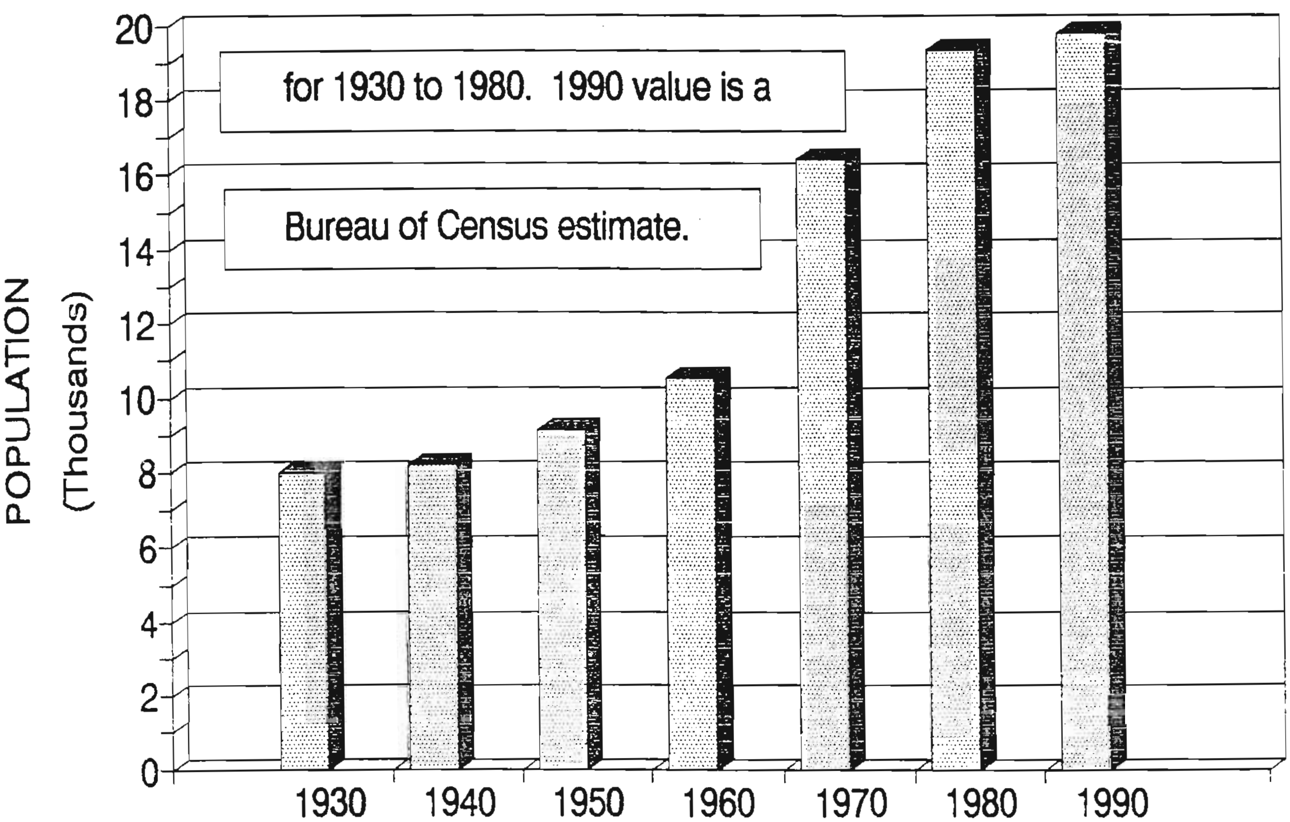


Fig. 6. Population Trend for Charleston, IL (U.S. Census Data)

Section (a) (6) Population Segments Adversely Affected by Reservoir Degradation

Sport fishers and those individuals that fish to supplement their food supply will be hard hit by continued degradation of the CSCR. As indicated in Section (a) (5), the City has no records regarding fishing activities. The best source of information on fishing quality at the CSCR can be gleaned from IDOC Fisheries Biologist Donald W. Dufford's reports on the CSCR. Mr. Dufford has indicated that the CSCR has an overabundance of gizzard shad and white crappie with the crappie being in poor condition. The "Volunteer Lake Monitoring Program, 1990" report indicated that that the mean transparency of the CSCR, from 1982 to 1990, had dropped by 8 inches (IEPA 1991). This could have a detrimental impact on breeding and feeding of some game fish.

Twice since the completion of the CSCR the boat ramp on the south shore has been dug out. This was necessitated due to the accumulation of sediments from shoreline erosion that obstructed the boat ramp. With additional degradation, the aesthetic appreciation of the CSCR will be diminished for all users.

The largest population segment that would be affected by reduced water quality are the consumers of drinking water from the Charleston Water Treatment Plant. Residential consumers of Charleston's water in 1980 were assessed $3.75/1000 gal. of water for both water and sewage fees. Due to increased operational cost, the rate was increased to $5.40/1000 in 1986.

Another indication of the impact of water degradation can be seen in the increase in taste and odor control chemicals used at the water treatment plant (Table 6). The City's water treatment plant has undergone numerous operational, chemical and physical changes to control the production of disinfection by-products, trihalomethanes (THMs). The THMs are produced when waters with high levels of organic matter are disinfected with chemicals like chlorine. The amount of organic matter (i.e. algae) in CSCR water has increased dramatically since completion of the reservoir. Some tests have suggested a possible carcinogenic or mutagenic hazard to humans from drinking tap water which contains THMs (Cook & Carlson 1989). The USEPA has proposed more stringent controls on disinfection by-products. The amount of money that the City has spent in controlling THMs is over 100,000 dollars thus far.

Table 6. Taste and Odor Control Chemical Usage at the Charleston Water Treatment Plant (in pounds).

Chemical	1981	1991	High
Activated carbon	2,100	1,000	14,700 (1989)
Copper sulfate*	0	0	6,000 (1988)
Sodium chlorite	0	14,125	16,950 (1986)
Potassium permanganate	0	1,320	2,640 (1988)

* used as an algal control in the CSCR

From 1948 to 1974, a bathing beach was maintained above the Riverview Dam. The beach was closed due to high concentrations of fecal coliforms. When the CSCR was completed, consideration was given to constructing a new bathing beach. High bacterial concentrations prevented the development of a beach. At this time there is no other public beach in the immediate Charleston area. Current bacterial data indicates that coliform levels are low enough to permit a beach within the CSCR. Without reductions in algae blooms and suspended sediment loads, a beach in the CSCR would be a less than desireable experience. Due to the basin morphometry of the CSCR there are only two locations where bottom slopes would be suitable for the development of a beach. Neither of these locations are supported by electricity, potable water or sanitary sewer. One location is along the CSCR dike. The dike location would be impractical as construction of required support facilities could prove detrimental to the integrity of the dike. The second location would be in the middle of the north shore. The soil type in this area is Tice silty clay loam. Information from the SCS makes the following statement about Tice soil: "Because it is subject to flooding, it generally is unsuited to use as a site for dwellings and septic tank absorption." Neither of these sites could be made suitable without major expenditures of revenues.

Section (a) (7) Comparison of Reservoir Uses to Uses of Other Lakes in the Area

There are 13 publicly-owned lakes within 50 miles (80 Km) radius of the CSCR that have a surface area of 20 acres or greater (Table 7). All of these lakes are located in Illinois (Figure 1). Table 7 provides information on the size, distance from the CSCR and facilities at these 13 lakes. Within a 10 mile radius of the CSCR, there is no other publicly-owned lake that has a surface area of 20 acres or greater. To enjoy bathing beaches and camping, which are unavailable at the CSCR, users must travel more than twenty miles. Eight of the thirteen lakes in the area can be reached by traveling thirty miles or less.

According to "The Illinois Outdoor Recreation Plan (IORP): 1988 - 1993", Coles county is rated as having a "high need" for Water Area Open to the Public. The IORP report expressed concern for this area in the following statement: "In rural Illinois, especially central Illinois, special resource areas are often few and far between, requiring a long trip to reach." The IORP shows that the Illinois Department of Conservation (IDOC) Region 3 has the lowest number of acres of water area open to the Public, the fewest boat launching ramps and the least feet of swimming beaches. Eleven of the thirteen lakes listed in Table 7 are part of IDOC Region 3. It is clear that there is a real need for maintaining and improving water-related recreation to this part of Illinois.

Table 7. **Facilities at Surrounding Lakes**

Name	County	Surface (acres)	Maximum Depth(ft)	Miles to lake	Recreational Facilities*
Decatur	Macon	3093.0	23.0	56	PWS,IWS,AWS,B, F,WS,IF,IS,P,R
Lincoln Trail	Clark	145.6	41.0	32	C,F,IF,P,HI,R,B
Mattoon	Coles	765.0	35.0	25	PWS,C,F,B,IF,IS
Mill Creek	Clark	811.0	70.0	21	F,B,C,HU,IF,S, P,WS,HT,R
Oakland	Coles	23.4	10.0	21	PWS,AWS,P,F,IF, B,R
Pana	Shelby	219.5	38.0	54	PWS,IWS,F,IF,B, R
Paradise	Coles	176.0	23.0	22	PWS,IWS,P,C,F, B,IF,R
Paris East	Edgar	162.8	26.5	30	PWS,IWS,AWS,B, P,S,F,IF,R
Paris West	Edgar	26.5	8.5	30	PWS,IWS,AWS,P, C,F,IF,R
Sam Parr	Jasper	183.0	28.0	33	B,C,F,HU,IS,IF, P,R
Sara	Effingham	765.0	52.0	45	S,P,C,B,G,F,R
Shelby-ville	Moultrie, Shelby	11,100.0	65.0	27	B,C,F,H,IS,F,S, HI,WS,IF,SK,HU, G,HT,R
Walnut Point	Douglas	59.0	32.0	24	B,C,F,HU,IS,IF, SK,R

*PWS=public water supply; IWS=industrial water supply; AWS=agricultural water supply; B=boating; C=camping; F=fishing; G=golf; HI=hiking; HT=horse trail; HU=hunting; IF=ice fishing; IS=ice skating; P=picnicking; R=boat ramp; S=swimming; SK=skiing; WS=water skiing

Sources: Illinois Volunteer Lake Monitoring Program Reports, 1984 (Vol. I: Statewide Summary Report), 1987 (Vol. V: East-Central Illinois Region) and Personal Contacts.

Section (a) (8) Inventory of Point Source Pollution Discharges

Within the direct watershed of the CSCR, there have been no NPDES permitted point source discharges in the past five years. There are a number of locations within the watershed where run-off from streets, roads and lawns makes its way via drainage ditches and storm drains to the ravines surrounding the CSCR. None of these discharge points are monitored for flow or water quality. Water quality data on the ravine system can be found under the Section (a) (10) (Table 26).

Prior to 1978, the Charleston Water Treatment Plant operated under an NPDES permit to discharge lime and alum sludge into what was then Lake Charleston. Construction of drying lagoons and a water recycling system decreased the need for a permit. The ravine that had been utilized for discharging treatment sludge was considered of little significance. Therefore, it was not selected as a routine monitoring site. In February of 1990, observations of new erosion in this ravine prompted an investigation of the sludge pumping station.

The investigation indicated that the pumping station worked properly under normal treatment conditions. However, backwashing of filters and cleaning of clarifiers overloaded the pumping station. On March 6, 1990, a 90 degree V-notch weir was placed in the receiving ravine and a single filter was backwashed. The rate of flow in the ravine was rapid enough that it exceeded the capacity of the weir. Calculations of flow were based on a greater than 1 foot flow value (3.10 $ft.^3$/sec., 2.00 M.G./day). The water passing through the weir was more than 66.3% of the water used in the backwash process.

How long the pump station has been malfunctioning is not known. In Table 8, there is a list of water quality results for samples taken from the discharge on March 6, 1990. Included in Table 8 is an estimate of the loading rate for this single event and an extrapolation of a loading rate for the full year of 1989. At this time, plans have been made to correct the problems with the pumping station.

Table 8. Discharge from Backwash Pump Station

Parameter	Value	Units	Load for Mar-6-89	Load for 1989
pH	9.6	pH		
Alk.MO	63	mg/L		
Turbidity	375	NTU		
Conductivity	340	umho\cm		
Solids				
Total	1400	mg/L	82.8 Kg	48,528 Kg/year
Total Susp.	1278	mg/L	75.6 Kg	44,299 Kg/year
Total Vol.	252	mg/L	14.9 Kg	8,735 Kg/year
Fixed	1148	mg/L	67.9 Kg	39,793 Kg/year
Vol.Susp.	98	mg/L	5.8 Kg	3,397 Kg/year
Phosphorus				
Total	.040	mg/L	2.37 gr.	1.39 Kg/year
Soluble	.020	mg/L	1.18 gr.	0.69 Kg/year
NO3-N	0.51	mg/L	30.2 gr.	17.7 Kg/year
NH3-N	.18	mg/L	10.6 gr.	6.2 Kg/year

Section (a) (9) Land Uses and Nonpoint Pollutant Loadings

Land Use

A land use map was prepared based on data taken from USGS quadrangle maps(1:24000 scale), aerial photographs taken in 1987 and field checks. The watershed described herein is that area that drains directly into the CSCR and is independent of the LC watershed. The watershed has an area of 1133 acres, which includes the 328 acre reservoir (see Figure 7). The CSCR occupies 29 percent of the watershed. Forests and grasslands cover 50 percent of the area, agriculture accounts for 8 percent and residential areas cover just over 10 percent of the watershed. The remaining 3 percent of the watershed is equally divided between: 1) industrial - a sand and gravel distribution facility with run-off stored in a sedimentation pond; 2) municipal - the Charleston Water Treatment Plant, and 3) commercial - several small professional offices and a storage rental facility.

The CSCR is situated on the far southeast edge of the watershed. Forestlands on the north and west buffer the CSCR from most human activities. The side-channel dike on the east and city-controlled land on the south provide additional buffers.

The primary land use in the LC watershed is agriculture. LC's watershed encompasses 811 square miles. LC and the CSCR are separated, and nutrient and sediment loading from the lake to the reservoir is dependent upon pumping. Therefore, consideration of pollutant loads from pumping from LC will be covered in the Limnological portion of this report.

Nonpoint Pollutant Loading

Estimates of sediment and nutrient loading in the CSCR watershed were prepared by the Soil Conservation Service of the U.S. Department of Agriculture. CSCR watershed soil erosion occurs as three main types: 1) sheet, rill and ephemeral cropland erosion, 2) channel and gully, and 3) shoreline erosion. Erosion from the first type genrates 1191 tons/yr. (Table 9). Gully and channel erosion (type 2) in the CSCR watershed is estimated to be 1,420 tons/year. Shoreline erosion (type 3) in the CSCR is estimated to be 875 cubic yards or 1000 tons/year. The total soil erosion in the watershed is 3,611 tons annually.

Not all of the 3,611 tons of annual erosion will make it to the reservoir. Type 1 erosion has only a 60% delivery rate which equals 715 tons/yr. The delivery rate of type 2 erosion is 95% or 1,349 tons annually. It is estimated that 100% of the shoreline erosion will be delivered to the CSCR. The total amount of sediment that is deposited into the CSCR from its watershed is estimated to be 3,064 tons/yr. These same types of erosion also affect the waters of LC. The sediment load, which is transferred from LC to the CSCR via pumping, would be between 64 and 300 tons/yr. If 1000 tons of sediments equals 1 acre/foot, then the amount of sediments deposited in the CSCR would be between 3.1 and 3.4 acre/foot.

The SCS estimated that 1238 lbs of nitrogen and 115 lbs (Table 10) of phosphorus are added yearly to the CSCR from watershed erosion. They also indicated that approximately 19.8 tons/yr. of nitrates are pumped from LC to the CSCR.

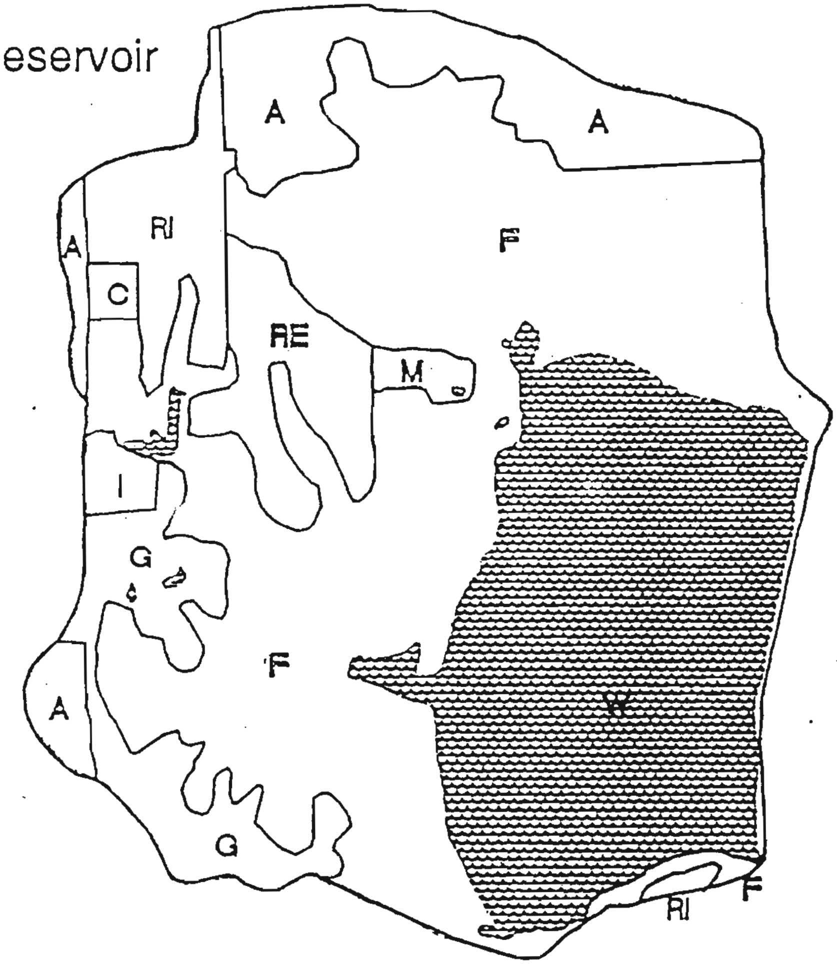
Existing zoning laws and their subsequent enforcement have done little to check the rate of residential development within the watershed. Most of the development has taken place near the edge of ravines and without the use of soil conservation technology that would slow construction related run-off.

LAND USE MAP

Charleston Side-Channel Reservoir

LEGEND	MI^2	ACRES	% OF TOTAL
A=AGRICULTURAL	.1450	92.8	8.2
C=COMMERCIAL	.0225	14.4	1.3
G=GRASSLAND	.1050	67.2	5.9
I=INDUSTRIAL	.0100	6.4	.6
F=FOREST	.7775	497.6	43.8
M=MUNICIPAL	.0150	9.6	.8
RE=RESIDENTIAL ESTATE	.0925	59.2	5.3
RI=RESIDENTIAL	.0900	57.6	5.1
W=WATER	.5125	328.0	29.0
TOTAL	1.770	1132.8	100.0

ALL BOUNDARIES DRAWN FROM USGS TOPOGRAPHIC MAPS AND AIR PHOTOS. V.P.G 4/3/88



N

0 1/2 1
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SD-1

Figure 7. Land Use Map, Charleston Side-Channel Reservoir Watershed.

Table 9. Nonpoint Pollutant Loading Estimated Erosion*/Suspended Solids from CSCR Watershed

Land use	# Acres	% Watershed **	Export Rate tons/acre	Loading ton/year		% of Total
Cropland	92.8	11.5	5.0	464		39.0
Woodland	497.6	61.8	0.5	249		20.9
Resident	147.2	18.3	0.75	310	***	26.0
Grassland	67.2	8.3	2.5	168		14.0
TOTAL	804.8			1191		100

* Export and loading rate provided by the U.S.D.A. SCS Champaign Il. office. Based on Universal Soil Loss Equation.
** open water is not included as a land use category
*** 200 tons added for those areas that are being developed

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Table 10. Nonpoint Pollutant Estimated Nutrient Loading *

Land use	Acres	Total Nitrogen Export Rate +	Total Nitrogen Loading ++	%	Total Phosphorus Export Rate +	Total Phosphorus Loading ++	%
Cropland	92.8	3.7	343	28	0.4	37	32
Woodland	497.6	1.2	597	48	0.1	50	43
Residential	147.2	1.2	177	14	0.1	15	13
Grasslands	67.2	1.8	121	10	0.2	13	11
TOTAL	804.8		1238	100		115	100

+ Export rates expressed in lbs/acre/year
++ Loading rates expressed in lbs/year
* Estimates of N & P export rates provided by the U.S.D.A. SCS, Champaign, IL. office. Based on E. E. Alberts and R. G. Sponer, Journal of Soil and Water Conservation, "Dissolved Nitrogen and Phosphorus in Run-Off From Watersheds in Conservation and Conservation Tillage", January and February 1985.

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Section (a) (10) Baseline and Current Limnological Data

1. Historical Baseline Limnological Data

The historical Baseline data for the LC/CSCR can be divided into two major portions. The first being the data collected before the construction of the CSCR and the second being data collected after construction.

1. a. Pre Side-Channel Reservoir

Five years after the completion of Riverview Dam, a severe drought began which lasted from 1952 to 1954. During this drought, the City became aware that LC was silting in at a rapid rate. A 1954 report prepared by the State Water Survey (SWS) gave estimates of sedimentation, trap efficiency, and a projection of when the Lake's storage capacity would become inadequate. Sedimentation surveys were conducted in 1960 and 1974 by the SWS. Yang's report (Yang 1974) showed that the lake had been reduced to 37.9% of its original capacity by 1974.

One of the potential solutions to Charleston's sedimentation problems would have been the development of U.S. Army Corps of Engineers project called Lincoln Lake. Lincoln Lake would have been dammed in Cumberland county, 11 miles south of Charleston. Water would have backed up to a point just south of Murdock in Douglas county. Water to a height of 591 feet A.S.L. would have covered the LC area. An environmental inventory of this project published in 1972 provides a wealth of biological and physiographic information.

A study of the benthic macroinvertebrate fauna was conducted in 1974. The benthic macroinvertebrate fauna was fairly diverse with no significant compositional variation over the lake (Barding 1974). As part of the IEPA ambient lake monitoring program, LC was monitored in 1977. The results of this sampling indicated that LC had high concentrations of nutrients and suspended solids. The tropic state index values for both secchi and total phosphorus were well into the hypereutrophic range. Phytoplankton samples depicted a non-bloom population nearly devoid of blue-green algae. The lack of a bloom population may have been due in part to a hydraulic residence time of less than one day. Table 11 includes portions of the results of the 1977 ambient monitoring.

1. b. Side-Channel Reservoir

Since 1979, the IEPA Division of Public Water Supplies has annually provided a detailed chemical analysis of the City's water source (Table 12). This record used in conjunction with the 1977, 1983 and 1984 IEPA ambient lake monitoring reports (Table 11) provide a means of tracking changes in water quality. A comparison of pre CSCR to post CSCR water quality shows a reduction in the concentrations of Barium, Calcium, hardness, Iron, Nitrate-Nitrite, Phosphorus, and Silica (see Table 12). Other transitional work showed that post CSCR water quality benefited from reduced turbidity and no significant population of blue-green algae (Lookis 1983). Lookis warned that with reduced water flow, the CSCR may be subject to algae blooms. Lookis also predicted an increased production of trihalomethanes in the City's potable water. By 1985, the City's public water supply exceeded the maximum allowable contaminant level for trihalomethanes.

The CSCR was randomly selected as a sampling site for a study conducted by Monsanto Chemical company. This study was conducted to determine the extent of pesticide contamination of potable water supplies that utilize surface water as their source. The results indicated that the concentations in the CSCR were below the limits of detection (0.20 ppb) for Alachlor, Cyanazine, Linuron, Metribuzin, Trifluralin and Simazine. Metolachlor was detected once out of 48 samples and only at 0.22 ppb. Atrazine was the only compound routinely detected with a mean concentration of 0.32 ppb.

The fish population was the subject of much study after the completion of the CSCR. The bluegill, largemouth bass and white crappie populations all experienced a population and growth rate increase in the first year after filling the CSCR (Lyon 1986, Durham 1983, Fairow 1989). In preceding years, the growth rates declined and some spawns were very poor. The presence of gizzard shad was considered detrimental to the bluegill population (Lyon 1986). IDOC fisheries biologist Don Dufford conducted population surveys of the CSCR in 1983, 1985, 1987 and 1989. The 1987 survey showed an abundant gizzard shad population. The stocking of largemouth bass and hybrid striped bass was recommended to control the gizzard shad. In 1988, the City stocked the first hybrid striped bass in the CSCR. This was done in the hope that it would bring about an improvement in both game fishing and water quality.

On November 21, 1985, while the ER was at flood stage, the spillway portion of Riverview Dam on LC collapsed. The resulting scouring action cut a new channel in the LC bottom. From November 21 to December 17, 1985, the head cut of this scour channel migrated upstream approximatly 2000 feet. Five finger dikes were constructed to keep the fast moving current and headcut away from the CSCR's dike. If the headcut would have caused the collapse of the dike, the CSCR would have quickly been reduced to a small pond. The spillway collapse and resulting scour channel left the CSCR's intake pump screens high and dry. From November 1985 to April 1986, no pumping was needed to maintain the water level within the CSCR. Starting in April and until October of that year, emergency pumps were used to maintain the water level in the CSCR. While under emergency conditions, water quality guidelines for selectively pumping were abandoned. Any and all water that could be pumped was pumped. A detailed study of the scour at the lake can be found in Illinois SWS contract report 409.

In 1987, the City performed routine dissolved oxygen and temperature profiles. Results indicated thermal stratification in the CSCR was a rare, isolated event. Periods of low oxygen (less than 5.0 p.p.m.) within the water column were common. Most sampling sites showed anoxic or near anoxic condition in mid-summer. This prompted the City to install a diffused aeration system in the northwest corner of the CSCR. The aerator surrounds the raw water intake for the City's water treatment plant.

Table 11. Illinois EPA Ambient Lake Monitoring Summary for 1977, 1983 and 1984.

YEAR	1977 LC	1983 CSCR	1984 CSCR
	(in mg/L or as marked)		
TEMP (C.)	25.7	23.5	22.8
D.O.	9.9	6.6	9.0
C.O.D.	-	19.3	22.3
COND	573.0	452.0	393.0
T-ALK.	181.0	161.0	165.0
P-ALK	-	3.0	10.0
pH (units)	-	7.6	8.3
SECCHI (inch.)	10.0	13.3	17.7
	SOLIDS	(in ftu or mg/L)	
TURBIDITY	-	6.7	1.85
TSS	63.0	34.5	31
VSS	11.0	18.6	14.3
NVSS	52.0	15.9	16.7
NVSS/TSS	0.817	0.563	0.545
VSS/TSS	0.181	0.437	0.455
	NUTRIENTS	(in mg/L)	
NO2-NO3	4.4	0.1	0.12
NH3-NITROGEN	0.033	0.15	0.135
TK-NITROGEN	-	1.075	1.200
T-PHOSPHORUS	0.217	0.079	0.119
D-PHOSPHORUS	-	0.021	0.018
TN/TP	-	15.273	10.036
IN/DP	-	25.027	13.966
DP/TP	-	0.24	0.154
	CHLOROPHYLL (in ug/L)		
A CORRECTED	-	21.815	93.84
A UNCORRECTED	-	25.605	102.56
B	-	3.213	29.99
C	-	4.858	7.93
PHEOPHYTIN A	-	6.298	12.37
	TROPIC STATE INDEX		
TSI-SECCHI	79.74	75.73	71.55
TSI-P	81.50	66.78	72.93
TSI-CHLA		60.00	74.57
TSI-MEAN	80.62	69.05	73.02

Source: IEPA Ambient Lake Monitoring STORET files.

Table 12. Chemical Analysis of Raw Water from the Charleston Side-Channel Reservoir

YEAR / MONTH	UNITS	1989 JAN	1988 JAN	1987 JAN	1986 FEB	1985 MAR	1984 MAR	1983 APR	1982 JUN	1981 APR	1980 MAY	1979 MAR
pH LABORATORY	UNITS	8.0	8.0	8.2	8.3	8.1	8.3	8.4	7.8	7.8	8	7.8
(ROE) TDS @ 180C	MG/L	285	249	330	219	270	292	305	346	346	376	340
HARDNESS, EDTA	MG/L	216	214	250	186	195	202	230	219	237	320	277
CHLORIDE, TOTAL	MG/L	28	26	22	15	18	18	17	19	22	28	25
CONDUCTIVITY	UM/CM	480	460	480	380	420	440	450	450	480	600	560
ALKALINITY	MG/L	151	172	193	149	160	157	184	179	155	225	164
FLUORIDE, TOTAL	MG/L	0.18	0.17	0.24	0.17	0.15	0.17	0.13	0.2	0.35	0.23	0.2
SULFATE, TOTAL	MG/L	44	38	37	31	34	43	40	36	34	50	41
NITRATE & NITRITE, N-TOTAL	MG/L	2.1	<0.1	0.96	0.18	1.1	0.69	0.39	<0.1	5.6	8.7	37
SILICA, TOTAL	MG/L	<1.0	1.6	<1.0	<1	1	<1	1	1	5.7	4.4	8.2
ARSENIC, TOTAL	UG/L	1	1	1	1	2	<1	<1	4	2	2	<1
MERCURY, TOTAL	UG/L	<0.05	<0.05	0.11	<0.01	<0.01	<0.1	<0.05	<0.05	<0.1	<0.05	<0.02
AMMONIA-N, TOTAL	MG/L	0.25	0.11	<0.1	<0.1	0.11	0.17	<0.1	0.23	0.1	<0.1	0.1
CYANIDE, TOTAL	MG/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
LEAD, TOT. FURNACE	UG/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<10	<5
SELENIUM, TOTAL	UG/L	<1	<1	<1	<1	<1	<1	<1	<1	1	1	<1
CIUM, TOTAL	MG/L	41	43	48	36	44	45	50	37	54	81	63
IUM,TOTAL	MG/L	14	14	11	7	11	9	8	7	8	8	5
ALUMINUM, TOTAL	UG/L	180	492	106	80	570	220					
BORON, TOTAL	UG/L	54	<50	<50	20	40	<50	40	30	190	40	100
MAGNESIUM, TOTAL	MG/L	29	27	27	21.3	22.5	25.3	29.1	26.6	23.8	34	27
POTASSIUM, TOTAL	MG/L	1.4	2.1	1.3	1.6	2	2.3	1.9	2.7	1.9	1.3	2.1
BARIUM, TOTAL	UG/L	44	55	47	44	46	42	55	50	66	70	100
BERYLLIUM, TOTAL	UG/L	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	
CADMIUM, TOTAL	UG/L	<3	6	<3	<3	<3	<3	<3	<3	4	<0.5	<0.5
COPPER, TOTAL	UG/L	<5	15	<5	<3	4	<5	<8	<3	4	11	<5
IRON,TOTAL	UG/L	279	473	160	150	900	410	780	270	1040	990	1420
NICKEL, TOTAL	UG/L	<5	23	<5	6	<3	<5	5	<3	8	<5	<50
CHROMIUM, TOTAL	UG/L	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
COBALT, TOTAL	UG/L	<5	13	<5	<5	<5	<5	<5	<5	6	<5	
MANGANESE, TOTAL	UG/L	52	68	47	43	118	58	191	138	108	140	90
SILVER, TOTAL	UG/L	<3	19	<3	<5	<5	<5	<5	<5	<5	<5	<5
STRONTIUM,TOTAL	UG/L	105	110	112	85	35	93	107	83	120		
ZINC, TOTAL	UG/L	<50	<50	<50	<2	6	<5	4	<2	6	<5	10
ANION / CATION BALANCE	Y / N	Y	Y									
VANADIUM, TOTAL	UG/L	<5	21	<5	4	<4	<5	<4	<4	5		
HARDNESS, CALC.	MG/L	219	218	229	178	203	217	245	202	233	342	268

Source: IEPA Division of Public Water Supplies

2. Recent Baseline Limnological Data

The collection of data for a diagnostic study of the CSCR began in May of 1988. Primary data collection continued until September 1990. Five primary sampling sites were used in the CSCR (Figure 8). One primary site was used in LC and two in the watershed. Secondary sites were used for special sampling or to augment the data base.

All top or surface samples were collected at a depth of one foot. All bottom samples were collected with the use of a Kemmerer sampler at a depth one foot above the bottom. Samples collected for chlorophyll analysis were collected with a column sampler to a depth twice the secchi depth. Data collected for dissolved oxygen and temperature was taken at one foot below the surface and at each meter below the surface down to one from the bottom. Unless otherwise stated, the methods utilized will be described in Appendix A.

Reservoir Measurements

Limnological data was collected from direct measurements and from USGS topographic maps. A map of reservoir depths was produced by plane table survey techniques; reservoir volume was calculated from this map (Figure 9). Due to problems with obtaining a clear line of sight, the three coves on the west shoreline were not included in the mapping of the CSCR. By using a planimeter, 1988 SCS aerial photos and construction blueprints of the CSCR, a total surface area of the three coves was estimated at 11 acres. Volume for these 11 acres was estimated at 1,655,280 $ft.^3$ which is less than 2% of the volume calculated from the reservoir map (Table 13). Area of the watershed was determined by planimeter techniques using USGS topographic maps and aerial photographs taken in 1987.

Table 13. Dimensions of the Charleston Reservoir.

	Exclusive of coves	
Reservoir surface area, acres (sq km)	328	(1.33)
Volume, cu ft (cu m)	123,409,320	(3,494,952)
Average depth, ft (m)	8.6	(2.6)
Maximum depth, ft (m)	16	(4.9)
Area of watershed, acres (sq km)	1,133	(4.58)
Shoreline length, ft (m)	14,800	(4511)
Hydraulic Residence Time (year)	1.1	

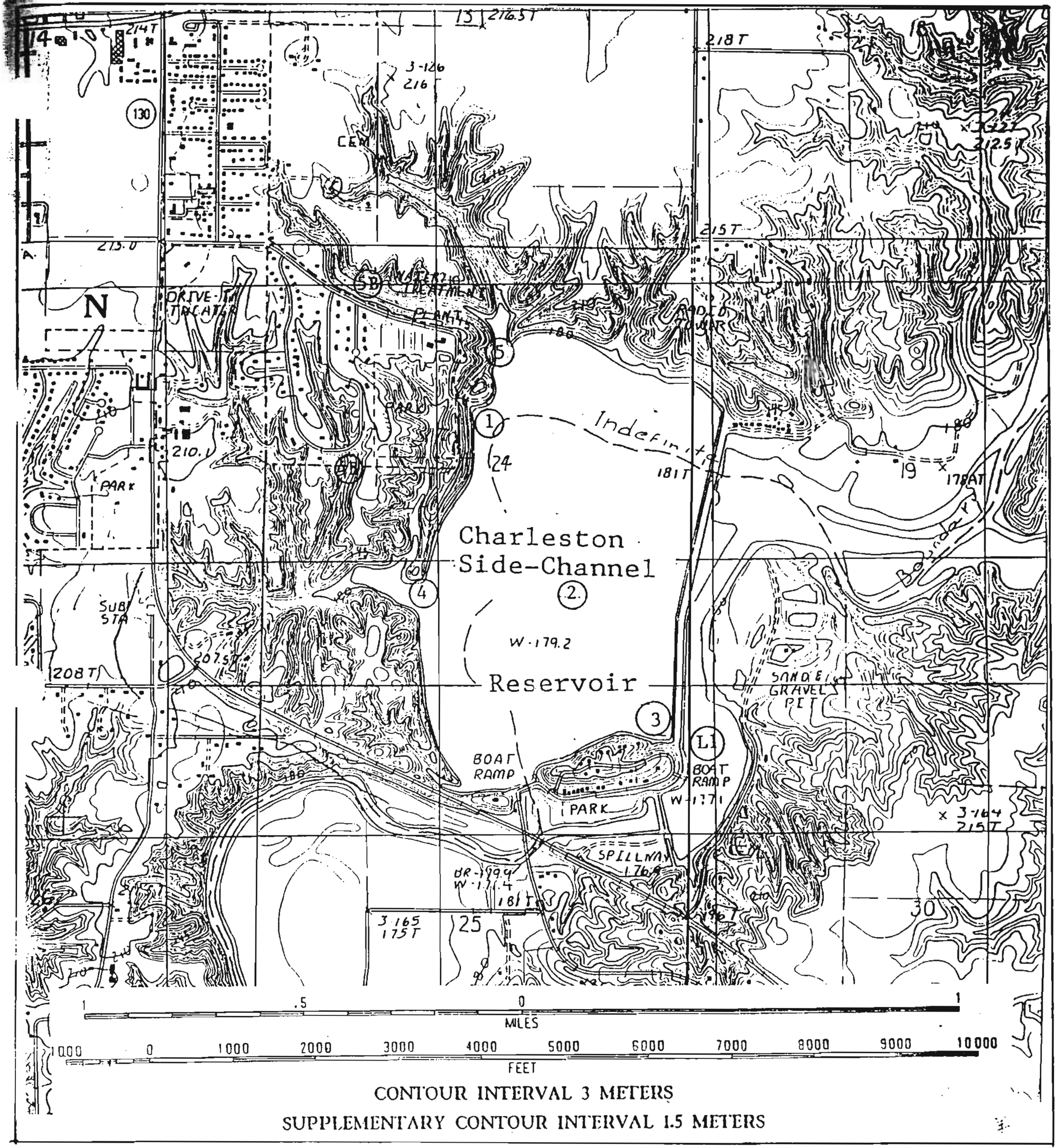


Figure 8. Sample Site Location Map

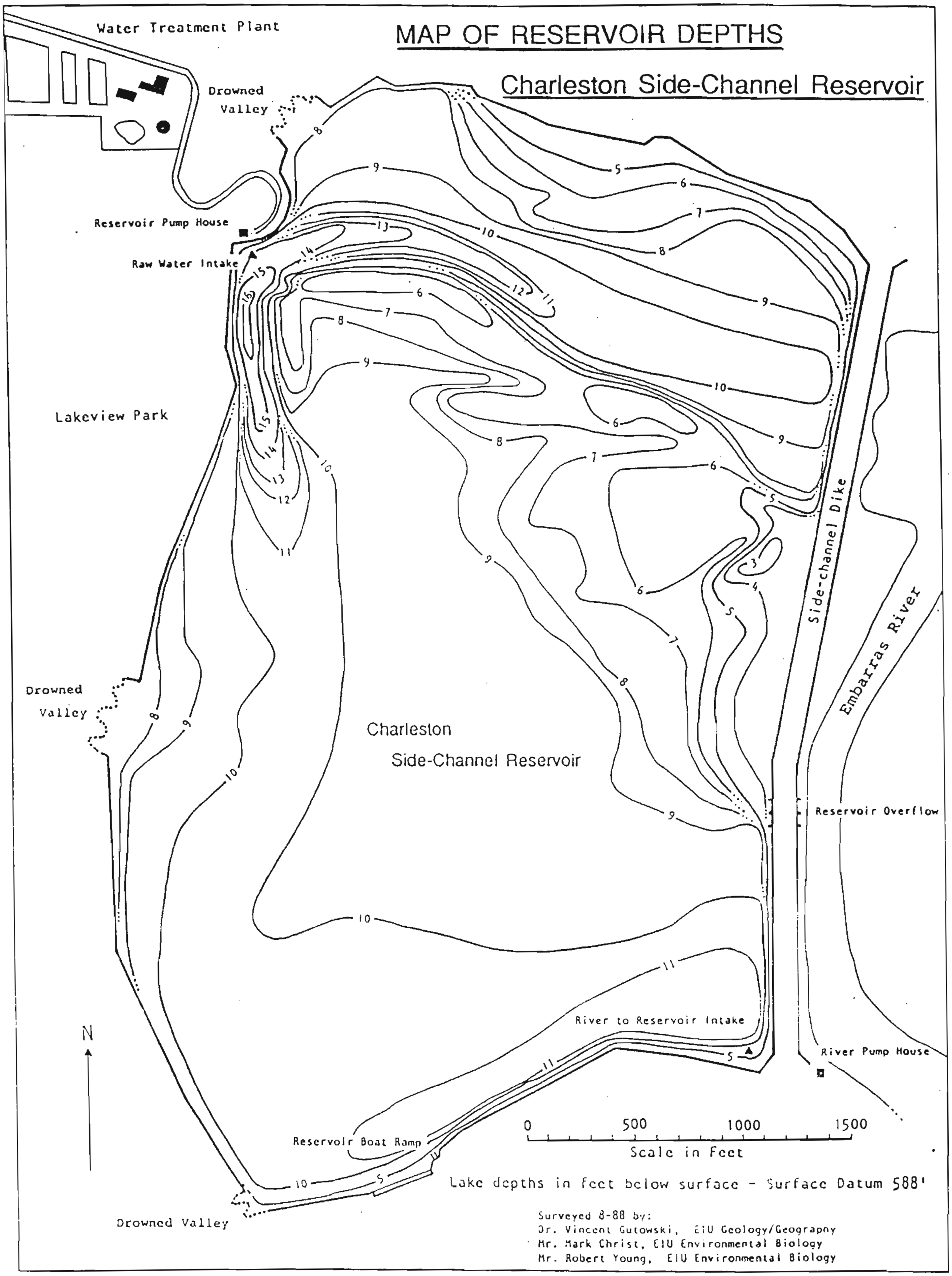


Figure 9. Map of Reservoir Depths, Charleston Side-Channel Reservoir.

Water Quality Characteristics

Comparison of Illinois Water Quality Standards

The CSCR is subject to the "General Use Standards" (GUS) and "Public and Food Processing Water Supply Standards" (PFP) as set forth by the Illinois Pollution Control Board (IPCB). The purpose of the general use standards is to protect the State's water for aquatic life, wildlife, agricultural use, secondary contact use and most industrial uses and to ensure the aesthetic quality of the State's aquatic environment. Public and food processing water supply standards are cumulative with the general use standards. Water quality characteristics that are germane to the IPCB standards will be commented on where appropriate in the following sections. Applicable Pollution Control Board standards can be found in Appendix B.

Physical Characteristics

Dissolved Oxygen and Temperature: Most lakes in Central Illinois are manmade and are usually the result of the damming of a stream (Singh and Sefton 1985). In most instances, this produces a body of water with a serpentine shape. If the CSCR is viewed from aerial or satellite photos, it appears oval to rectangular in shape. The CSCR is also a shallow reservoir with an average depth of less than 10 feet. The combination of the CSCR's shape and depth contribute to produce some atypical oxygen and temperature characteristics.

The circulation of the water column is assisted by the use of a diffused aeration system and the removal of water by pumping at site 1. Circulation at site 3 may or may not be affected by the pumping of water from LC into the CSCR, depending on the conditions in both bodies of water.

After water temperatures have increased, thermal stratification will develop whenever winds are calm. Due to the shape and depth of the CSCR, a large wind event will cause the CSCR to turn over. It is rare for the reservoir to stay stratified for long. A common misconception is that the CSCR is dimictic (undergoes normal spring and fall turnovers). It is more likely that the CSCR turns over whenever the energy of a wind-induced mixing event exceeds the stability of the water body. The result is that the CSCR has multiple, aseasonal turnovers, and thus it is polymictic.

DO and temperature profiles have been conducted at numerous sites in the CSCR since 1987. For this report the data from 1988 to 1990 at sites 1 and 3 will be considered. The General Use water quality standards states: "Dissolved oxygen shall not be less than 6.0 mg/l during at least 16 hours of any 24 hour period, nor less than 5.0 mg/l at any time." The profiles show that 53% of the profiles at site 1 and 36% at site 3 have some portion of the water column with a DO less than 5.0 mg/l. Likewise 27% of the profiles at site 1 and 7% at site 3 were below 1 mg/l DO. Isothermal and iso-dissolved oxygen plots (Figures 10 and 11) were developed from monthly averages of temperature and dissolved oxygen profiles. The low DO levels are the indirect result of a highly productive phytoplankton population.

Secchi Disk Transparencies: The USEPA Lake and Reservoir Restoration Guidance Manual states that "Secchi depth is probably the most frequently used parameter in limnology" and "Secchi depth of...eutrophic lakes may only have a reading of 3 to 4 feet or less during summer algal blooms." Within the study years of 1988 to 1990, the overall average secchi disk transparency was 14.5 inches. The range of sample site averages was a high of 15.8 at site 3 to a low of 13.2 inches at site 1. The lower mean transparencies at site 1 as compared to site 3 may be due to the use of the aeration unit at site 1. The minimum and maximum secchi values for a single reading was 7 and 24 inches respectively (Table 14).

In 1982, the CSCR became a participating lake in the IEPA Volunteer Lake Monitoring Program (VLMP). The 1990 VLMP report indicated that there is a significant difference between the mean 1990 CSCR transparencies and the mean for 1982 and 1983 CSCR transparencies ($p < 0.05$). The difference between the 1982 (21") and 1990 (13") means amount to an 8 inch drop in transparency. Of the 139 lakes participating in 1990 VLMP, 120 lakes had higher transparency values than the CSCR.

Turbidity: The 15th Edition of Standard Methods states, "The clarity of a natural body of water is a major determinant of the condition and productivity of the system. Turbidity in water is caused by suspended matter, such as clay silt, finely divided organic and inorganic matter, soluble colored organic compounds, and plankton and other microscopic organisms."

The average surface turbidity for the CSCR for the sampling periods of 1988, 1989 and 1990 was 15.1 NTU and 18.8 for bottom samples. The range for this time period for both surface and bottom samples was 2.8 to 76 NTU. The highest average turbidity for surface and bottom was found at site 1 with 18.2 and 22.9 NTU respectfully (Table 14). Analysis of 1989 data found a positive correlation between turbidity and the total number of algae at site one (Surratt 1990).

The average surface sample turbidity for LC in 1989 was 28.5 NTU with a range of 3.3 to 230 NTU. The average turbidity values recorded from the two watershed sampling sites were 3.4 NTU (SD $\pm$ 4.3) at site 4b and 4.3 NTU (SD $\pm$ 5.1) at 5b when storm event data was delineated. If storm event data is included, the values jump to 7.4 NTU (SD $\pm$ 16.7) at site 4b and 13.1 NTU (SD $\pm$ 29.1). The averages for LC data can be found in Table 23. Table 24 contains the averages for CSCR Watershed data.

Site 1

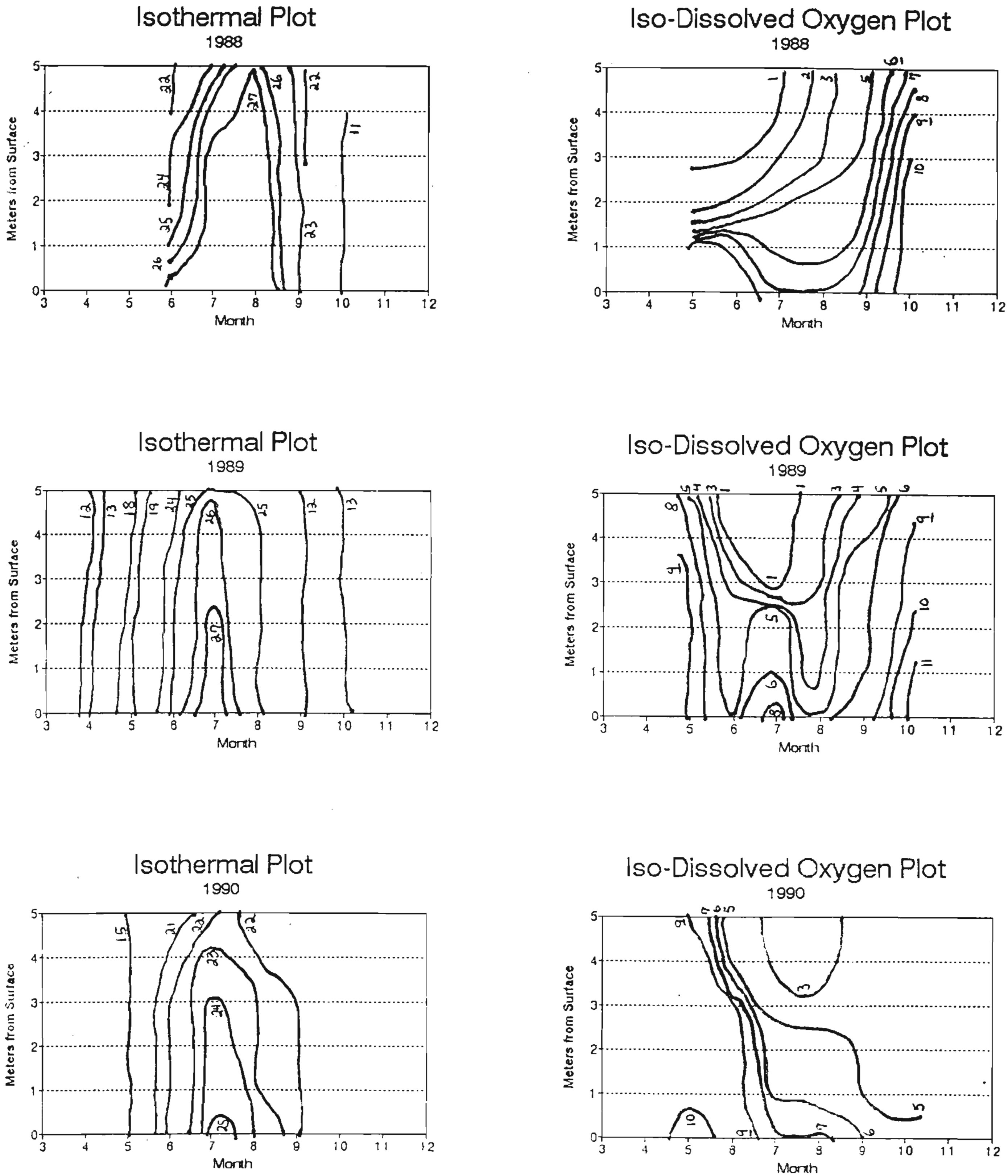


Figure 10. Isothermal (in degrees Celsius) and Iso-Dissolved Oxygen (in ppm) Plots for Site 1.

Site 3

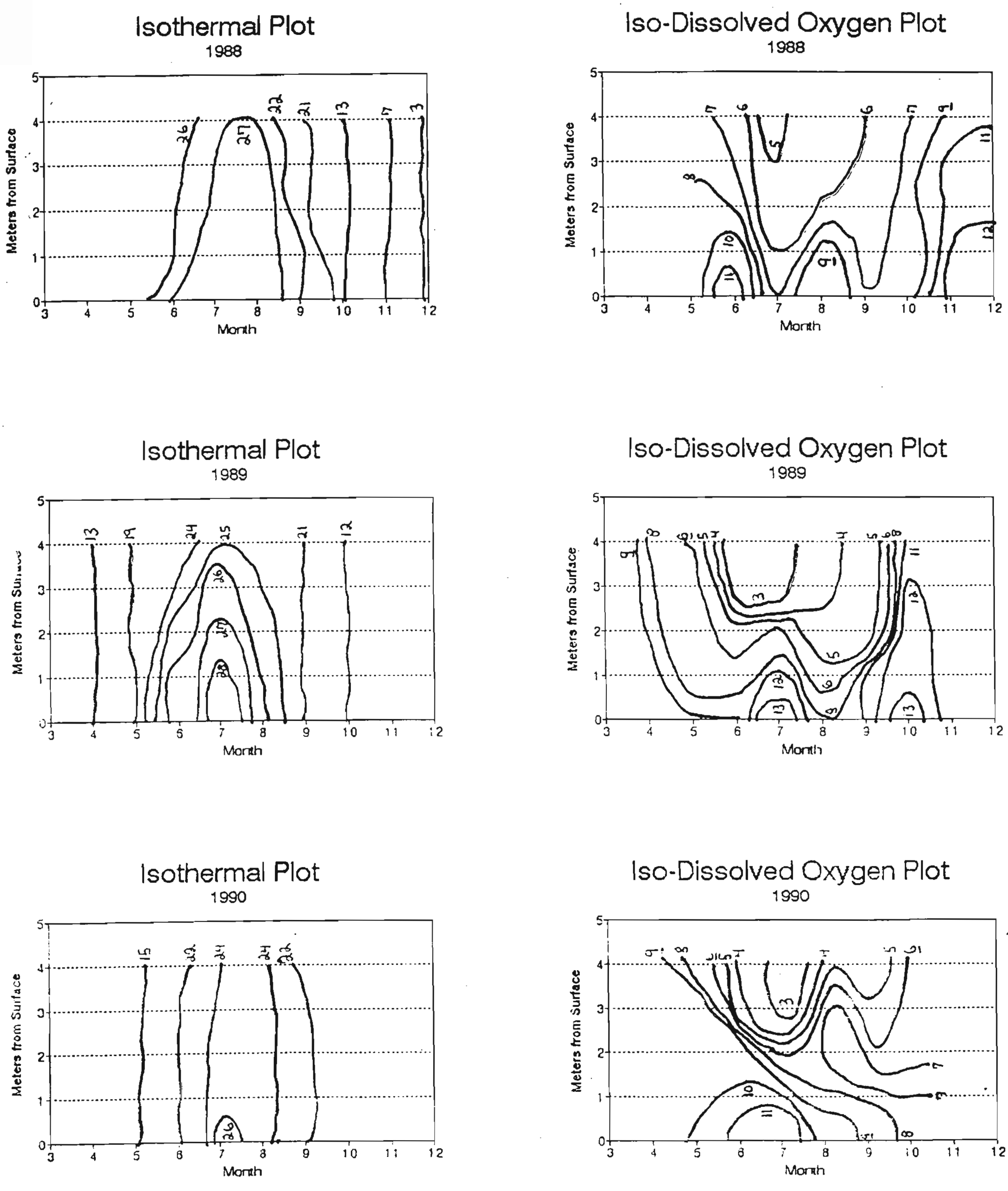


Figure 11. Isothermal (in degrees Celsius) and Iso-Dissolved Oxygen (in ppm) Plots for Site 3.

Table 14. Transparency and Turbidity of the CSCR

		Site 1	Site 2	Site 3	Site 4	Site 5
Transparency (inches)	*N*	57	49	53	31	34
	Average	13	15	15	14	15
	Min	7	8	8	8	8
	Max	22	22	22	24	22
Turbidity (NTU)	*SURFACE*					
	N	50	29	46	21	22
	Average	18.2	12.3	14.2	14.7	13.9
	Min	4.0	2.7	2.7	5.5	6.0
	Max	40	23	76	26	27
Turbidity (NTU)	*BOTTOM*					
	N	44	20	36	18	20
	Average	22.9	17.5	16.9	18.5	16.0
	Min	2.8	10.0	7.0	8.0	8.0
	Max	71	34	39	33	27

Table 15. Total Alkalinity and pH of the CSCR
(Data from 1988 to 1990)

		Site 1	Site 2	Site 3	Site 4	Site 5
Total Alk.	*SURFACE*					
(mg/L)	*N*	50	29	46	20	22
as CaCO3	*Average*	134	135	135	132	132
	Min	113	119	109	110	112
	Max	159	160	168	154	159
Total Alk.	*BOTTOM*					
(mg/L)	*N*	45	20	36	18	20
as CaCO3	*Average*	136	135	137	133	133
	Min	113	118	115	112	113
	Max	160	159	168	153	159

		Site 1	Site 2	Site 3	Site 4	Site 5
pH	*SURFACE*					
	N	50	29	46	21	22
	Average	8.4	8.5	8.6	8.6	8.5
	Min	7.9	8.0	8.0	8.0	8.0
	Max	9.0	9.0	9.2	9.2	9.2
pH	*BOTTOM*					
	N	45	20	36	18	20
	Average	8.2	8.4	8.3	8.4	8.4
	Min	7.5	7.9	7.8	7.9	8.0
	Max	8.9	8.9	8.7	9.2	9.3

Table 16. Conductivity of the CSCR (Data from 1988 and 1989)

		Site 1	Site 2	Site 3	Site 4	Site 5
Conductivity	*SURFACE*					
(umhos/cm)	*N*	32	15	28	16	17
	Average	401	388	397	409	410
	Min	350	354	350	360	364
	Max	480	430	563	489	482
Conductivity	*BOTTOM*					
(umhos/cm)	*N*	28	8	21	12	15
	Average	395	392	405	412	405
	Min	350	360	350	360	362
	Max	450	430	551	492	493

Table 17. Total Phosphorus and Total Dissolved Phosphorus of the CSCR

		Site 1	Site 2	Site 3	Site 4	Site 5
Total	*SURFACE*					
Phosphorus	*N*	58	25	54	15	18
(mg/L)	*Average*	0.134	0.158	0.155	0.136	0.126
*	*Min*	0.022	0.025	0.050	0.060	0.070
	Max	0.255	1.200	2.300	0.285	0.218
Total	*BOTTOM*					
Phosphorus	*N*	34	13	26	12	15
(mg/L)	*Average*	0.181	0.140	0.143	0.173	0.154
*	*Min*	0.003	0.110	0.102	0.110	0.078
	Max	0.540	0.235	0.235	0.230	0.218

Total	*SURFACE*					
Dissolved	*N*	20	13	20	7	5
Phosphorus	*Average*	0.028	0.023	0.025	0.026	0.027
(mg/L)	*Min*	0.003	0.001	0.001	0.015	0.018
**	*Max*	0.076	0.051	0.063	0.047	0.047
Total	*BOTTOM*					
Dissolved	*N*	18	8	15	5	5
Phosphorus	*Average*	0.027	0.024	0.026	0.024	0.027
(mg/L)	*Min*	0.004	0.011	0.012	0.010	0.012
**	*Max*	0.070	0.038	0.062	0.040	0.042

* = Data from 1988 to 1990
** = Data from 1989 to 1990

Table 18. Nitrate-Nitrite and Nitrate Nitrogen of the CSCR

(Data from 1988 to 1990)

		Site 1	Site 2	Site 3	Site 4	Site 5
Nitrate -	*SURFACE*					
Nitrite	*N*	25	12	25		
(mg/L)	*Average*	0.10	0.02	0.10		
*	*Min*	0.10	0.01	0.01		
	Max	0.22	1.20	0.19		
Nitrate -	*BOTTOM*					
Nitrite	*N*	4				
(mg/L)	*Average*	0.10				
*	*Min*	0.10				
	Max	0.10				

		Site 1	Site 2	Site 3	Site 4	Site 5
Nitrate	*SURFACE*					
(mg/L)	*N*	45	22	41	20	21
**	*Average*	0.52	0.56	0.59	0.57	0.56
	Min	0.50	0.50	0.50	0.50	0.50
	Max	1.14	1.90	3.25	1.29	1.04
Nitrate	*BOTTOM*					
(mg/L)	*N*	41	20	37	18	20
**	*Average*	0.51	0.50	0.60	0.54	0.53
	Min	0.50	0.50	0.50	0.50	0.50
	Max	0.69	0.51	3.32	1.30	0.91

* = IEPA data only, detection limit 0.01 mg/L

** = City data only, detection limit 0.50 mg/L

Table 19. Ammonia and Kjeldahl Nitrogen of the CSCR

		Site 1	Site 2	Site 3	Site 4	Site 5
Ammonia	*SURFACE*					
(mg/L)	*N*	66	33	64	19	19
	Average	0.19	0.13	0.15	0.15	0.14
	Min	0.01	0.03	0.02	0.10	0.10
	Max	1.00	0.69	0.57	0.33	0.24
Ammonia	*BOTTOM*					
(mg/L)	*N*	43	16	34	17	19
	Average	0.20	0.19	0.14	0.17	0.15
	Min	0.10	0.10	0.10	0.10	0.10
	Max	0.53	0.76	0.24	0.37	0.26

Kjeldahl	*SURFACE*					
(mg/L)	*N*	20	10	19		
*	*Average*	1.6	1.7	1.4		
	Min	1.0	1.0	1.1		
	Max	2.6	4.0	2.8		
Kjeldahl	*BOTTOM*					
(mg/L)	*N*	4				
*	*Average*	1.5				
**	*Min*	1.3				
	Max	1.7				

* = IEPA data only
** = Data from 1989

Table 20. Total, Volatile, and Fixed Solids of the CSCR

(Data from EIU, 1988 to 1990)

		Site 1	Site 2	Site 3	Site 4	Site 5
Total	*SURFACE*					
Solids	*N*	39	18	36	18	20
(mg/L)	*Average*	306	304	295	279	286
	Min	215	225	218	2	200
	Max	395	458	395	355	368
Total	*BOTTOM*					
Solids	*N*	34	16	30	16	17
(mg/L)	*Average*	319	293	306	306	300
	Min	253	253	245	235	230
	Max	393	385	430	388	368

		Site 1	Site 2	Site 3	Site 4	Site 5
Total	*SURFACE*					
Volatile	*N*	29	17	29	15	14
Solids	*Average*	121	113	105	115	114
(mg/L)	*Min*	25	15	5	37	10
	Max	300	235	228	225	240
Total	*BOTTOM*					
Volatile	*N*	26	15	25	12	13
Solids	*Average*	110	119	112	125	125
(mg/L)	*Min*	30	40	40	68	62
	Max	260	268	352	243	240

		Site 1	Site 2	Site 3	Site 4	Site 5
Total	*SURFACE*					
Fixed	*N*	33	17	32	17	13
Solids	*Average*	200	193	193	195	195
(mg/L)	*Min*	38	135	130	125	155
	Max	278	320	258	263	260
Total	*BOTTOM*					
Fixed	*N*	30	14	27	14	12
Solids	*Average*	208	189	194	206	188
(mg/L)	*Min*	35	145	23	168	138
	Max	275	298	325	258	225

Table 21. Suspended and Volatile Suspended Solids

(Data from CSCR, 1988 to 1990)

		Site 1	Site 2	Site 3	Site 4	Site 5
Suspended	*SURFACE*					
Solids	*N*	62	30	60	18	18
(mg/L)	*Average*	33.4	25.4	23.3	30.1	28.6
	Min	4.0	8.0	2.0	11.0	4.0
	Max	88.6	45.2	66.0	49.0	57.0
Suspended	*BOTTOM*					
Solids	*N*	37	16	30	14	15
(mg/L)	*Average*	48.1	30.9	31.2	39.6	34.6
	Min	8.0	9.0	6.0	6.0	3.0
	Max	108.0	53.0	60.0	66.0	59.0

Volatile	*SURFACE*					
Suspended	*N*	45	25	44	8	5
Solids	*Average*	9.3	8.4	9.0	8.8	13.9
(mg/L)	*Min*	1.0	1.0	0.0	1.0	6.0
	Max	28.0	19.0	26.0	21.7	23.8
Volatile	*BOTTOM*					
Suspended	*N*	21	10	17	5	5
Solids	*Average*	9.1	7.5	10.6	10.9	14.6
(mg/L)	*Min*	0.0	0.0	1.0	1.0	9.0
	Max	24.0	14.5	21.0	28.0	19.0

Chemical Characteristics

pH and Alkalinity: The GUS states, "pH shall be within the range of 6.5 to 9.0 except for natural causes:" In the course of this study, pH levels were never below pH 6.5 but were occasionally above 9.0 (Table 15). The range of pH values for surface samples was 7.9 to 9.2 with 8.5 being the average. The average bottom pH was 8.3. When the pH values were at 9.0 or higher, the oxygen level in the surface water was at or near saturation.

The alkalinity of water is its quantitative capacity to react with a strong acid to a designated pH (APHA 1980). If water contains large amounts of $Ca(HCO3)2$ and is at equilibrium, and $CO2$ is removed from that water, then the equilibrium will be disrupted. The process of photosynthesis consumes $CO2$ and when the $CO2$ is consumed in large quanities, the pH of a water will increase and its total alkalinity will decrease.

The average total alkalinity for 1988, 1989 and 1990 for samples of the CSCR surface and bottom water was 134 and 135 mg/L $CaCO3$ respectively. The overall range was 109 to 168 mg/L $CaCO3$ (Table 15). Analysis of 1989 data found a negative correlation ($p < 0.05$) between pH and total algae population at site 1 ($r = -0.71$) and between alkalinity and blue-green algae at site 1 ($r = -0.70$) and 3 ($r = -0.77$) (Surratt 1990).

Conductivity: Conductivity is a numerical expression of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, their total concentration, mobility, valence and relative concentrations, and on the temperature of measurement (APHA 1980). The ability of water to conduct an electrical current is directly proportional to the amount of materials dissolved in it. Therefore, total dissolved solids (TDS) content can be estimated from conductance values using the formula $KA = S$, where K is conductance in umhos per centimeter, S is dissolved solids in milligrams per liter, and A is a conversion factor (0.6 is used for Illinois lakes) (IEPA 1986).

The average conductivity for surface and bottom samples from the CSCR was 400 and 401 umhos/cm respectfully. The overall range was a low of 350 to a high of 563 umhos/cm (Table 16). Surface water conductivity for the 36 Illinois lakes sampled in 1984-1985 ranged from 82-798 umhos/cm (49-479 mg/l TDS). The grand mean of lake mean surface conductivities was 363 umhos/cm (IEPA 1986). The IPCB GUS and PFP standards do not have a standard for conductivity. The IPCB does have a standard for TDS. The GUS for TDS maximum contaminate level (MCL) is 1000 mg/L and the PFP MCL is 500 mg/L.

Phosphorus: The GUS states "Phosphorus as P shall not exceed 0.05 mg/L in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more". The concentration of total phosphorus in CSCR samples almost always exceeded the 0.05 mg/L limit. The overall average for total phosphorus in the CSCR for 1988 to 1990 is 0.144 mg/L for surface samples and 0.160 mg/L for bottom samples. The maximum concentration observed was 2.300 mg/L (Table 17).

The total phosphorus concentrations in samples collected in LC frequently exceeded the 0.05 mg/L limit with an average of 0.098 and 0.141 mg/L surface and bottom samples respectively. The levels of total phosphorus in the watershed tributaries were below this limit except during storm events. The maximum storm event phosphorus level recorded was 1.073 mg/L.

Nitrogen: In this study, nitrogen was measured as nitrate-nitrite, ammonia, and Kjeldahl nitrogen. The IEPA performed analysis on the three latter nitrogen types. Due to a lack of adequate digestion capabilities, the nitrogen forms that were analyzed by the City of Charleston were limited to electrode methods of nitrate and ammonia.

Nitrate-Nitrite: Serious and occasionally fatal poisonings of infants have occurred following ingestion of water containing concentrations of nitrate which are greater than 10 mg/L (IEPA, 1982). The IPCB has set a PFP standard for nitrate-nitrite at a maximum of 10 mg/L. The CSCR grand mean for analysis performed by the IEPA was 0.11 mg/L for surface samples and below detection limits for bottom samples. The range for surface samples was from 1.20 mg/L to below detection limits.

Data from samples analyzed by the City of Charleston for nitrate were separated from IEPA data (Table 18). This was due to the City's use of a method that was less sensitive to low level detection (i.e. detection limit of 0.5 mg/L NO3-N). The average for the City's analysis was 0.58 and 0.54 mg/L NO3-N. The high was 3.25 and 3.32 mg/L NO3-N for surface and bottom samples respectively. This was calculated using a value of 0.50 for samples that were below the detection limit.

Ammonia: The GUS states that "Ammonia nitrogen concentrations of less than 1.5 mg/L are lawful regardless of un-ionized ammonia concentration." None of the samples collected for the CSCR, LC and the CSCR watershed had an ammonia level that exceeded the 1.5 mg/L limit (Table 19). The average CSCR ammonia concentration was 0.16 and 0.19 mg/L N for surface and bottom samples respectfully. The highest recorded concentration was 1.05 mg/L in a LC sample.

Kjeldahl: For both surface and bottom samples, the grand mean for Kjeldahl nitrogen was 1.5 mg/l (Table 19). The range of surface sample values was between 1.0 and 4.0 mg/l N for 49 samples collected from 1988 to 1990. The bottom sample values ranged from 1.3 to 1.7 mg/L N for 4 samples in 1989. The IPCB does not have a specific standard for Kjeldahl nitrogen.

Total Dissolved Solids: In addition to the total dissolved solids (TDS) data listed previously with the GUS in Table 22, there is TDS data in Table 12. None of the samples for TDS exceeded the 1000 mg/L GUS or 500 mg/L PFP water standard.

Suspended and Volatile Suspended Solids: The depth to which light can penetrate a column of water can be severely limited by suspended solids. This reduction of light penetration can act as a limiting factor in the growth of aquatic macrophytes. This can in turn limit fish populations as the competition for adequate habitat increases.

The CSCR's mean total suspended solids (TSS) for surface samples was 28.1 mg/L and 38.3 mg/L for bottom samples. Dammed stream type inpoundments generally have higher TSS values at site 3 (input side of LC) with more than a 50% drop in TSS values at the outlet site (site 1) (IEPA 1986). This did not hold true for the CSCR. The surface mean at site 3 was 23.3 mg/L while site 1 had a surface mean of 33.4 mg/L. This difference is perhaps due to two main causes. The first is the difference between a dammed stream and a side-channel reservoir, and the second may involve the use of the diffused air aeration system at site one. The first would reduce the annual loading of solids, and the second, due to operational problems, has acted to pump more solids up into the water column at site 1. In addition to the above mentioned solids, total, volatile, and fixed solids were analyzed (Table 20 and 21).

Heavy Metals: As was previously stated, each year the IEPA Division of Public Water Supplies performs an analysis of raw water from the Charleston Water Treatment Plant. A major portion of their analysis is an examination for metals. This sample is drawn from a raw water tap that transports water from an intake structure near site 1. The intake structure was modified during construction of the side-channel. All intake ports that are 14 or more feet below normal pool were closed and abandoned. Two new intake ports at a depth of 5 feet below normal pool were installed with barrel screens. The two other intake ports are at 9 feet and 12 feet below normal pool. The valves for the top two ports are fully opened. The two lower ports are at least 70% closed, but some unknown cause prevents their full closure. Past dissolved oxygen readings have indicated that the raw water is a mixture from two or more of these depths.

Table 22 compares selected results from the IEPA and Daily Analytical Laboratories with "General Use" and "Public & Food Processing Water" standards. The analysis performed by IEPA was on reservoir water and the analysis performed by Daily was on two tributary water sources. The comparison shows that the only metal that exceeded the Public & Food Processing standard was iron. A review of Table 12 shows that from 1982 to 1989, the Public and Food Processing water standard set for iron was exceeded 50% of the time. The Lake pumphouse sample in Table 22 and pre side-channel closure data (pre 1982) in Table 12 show values for iron that are greater than the GUS. The Lake pumphouse sample has a substantially higher concentration of iron, so much so that it invites speculation of possible sample contamination.

Table 22. Chemical Analysis of Raw Water from the Charleston SCR.

YEAR MONTH	UNITS	General Use standards	Public & Food Processing H2O standards	IEPA 1990 FEB Site 1	IEPA 1989 JAN Site 1	IEPA 1988 JAN Site 1	Daily 1989 JAN Lake Pump House	Daily 1989 JAN Hidden Lake
pH LABORATORY	UNITS	6.5-9.0		8.4	8.0	8.0		
(ROE) TDS @ 180C	MG/L	1000	500	280	285	249		
CHLORIDE, TOTAL	MG/L	500	250	27	28	26		
FLUORIDE, TOTAL	MG/L	1.4		0.2	0.18	0.17		
SULFATE, TOTAL	MG/L	500	250	37	44	38		
NITRATE & NITRITE, N-TOTAL	MG/L		10	0.68	2.1	<0.1		
ARSENIC, TOTAL	UG/L	190	50	1	1	1	<5	<5
[illegible]CURY, TOTAL	UG/L	0.5		<0.05	<0.05	<0.05	<0.2	<0.2
AMMONIA-N, TOTAL	MG/L	15&1.5		<0.1	0.25	0.11		
CYANIDE, TOTAL	MG/L	5.2		<0.005	<0.005	<0.005		
LEAD, TOT. FURNACE	UG/L	100	50	<5	<5	<5	<10	<10
SELENIUM, TOTAL	UG/L	1000	10	<1	<1	<1		
BORON, TOTAL	UG/L	1000		<50	54	<50		
BARIUM, TOTAL	UG/L	5000	1000	48	44	55		
CADMIUM, TOTAL	UG/L	50	10	4	<3	6		
COPPER, TOTAL	UG/L	*		<5	<5	15	10	10
IRON,TOTAL	UG/L	1000	300	409	279	473	3300	270
NICKEL, TOTAL	UG/L	1000		10	<5	23	<10	<10
CHROMIUM, TOTAL	UG/L	*	50	<5	<5	<5	<10	<10
MANGANESE, TOTAL	UG/L	1000	150	65	52	68	60	120
SILVER, TOTAL	UG/L	5		<3	<3	19		
ZINC, TOTAL	UG/L	1000		<50	<50	<50	70	60
HARDNESS, CALC.	MG/L			220	219	218		

* based on calculation

Source: IEPA Division of Public Water Supplies and State of Illinois Rules and Regulations

Table 23. Lake Charleston - 1989 and 1990 Combined Averages

DATA	(INCH) SECCHI DEPTH	(FEET) TOTAL DEPTH	pH	ALK-P	ALK-MO	HARD-NESS	TURBIDITY NTU	NITRATE	AMMONIA	COND.	SUSPEND SOLIDS	TOTAL SOLIDS	VOLATILE SOLIDS	FIXED SOLIDS	VOL-SUS SOLIDS	(Phosphorus) DIS-SOLVED	TOTAL
			Surface Sample								Surface Sample						
TOTAL	116	69	185.7	2	4635	4813	619	153.64	3.374	10380	1065.5	8970	3160	5877	111.0	0.428	1.556
N	12	12	23	23	23	17	23	23	17	17	19	19	19	19	10	10	17
AVG	10	6	8.1	0	202	283	27	6.68	0.198	611	56.1	472	166	309	11.1	0.043	0.092
STD	3	1	0.2	0	41	60	44	3.52	0.228	108	126.1	97	42	90	18.9	0.023	0.044
MAX	13	8	8.4	2	267	350	230	12.60	1.050	700	587.0	740	250	613	66.7	0.094	0.168
MIN	2	4	7.7	0	98	138	3	0.65	0.047	300	3.6	248	90	158	1.3	0.002	0.024

	FECAL COLI	FECAL STREP	FC/FS	pH	ALK-P	ALK-MO	HARD-NESS	TURBIDITY NTU	NITRATE	AMMONIA	COND.	SUSPEND SOLIDS	TOTAL SOLIDS	VOLATILE SOLIDS	FIXED SOLIDS	VOL-SUS SOLIDS	(Phosphorus) DIS-SOLVED	TOTAL
				Bottom Sample								Bottom Sample						
TOTAL	7012	28992	15.60	88.6	0	2324	1539	318	74.39	1.408	3160	357.9	3493	1115	2378	26.5	0.182	0.900
N	16	17	12	11	11	11	5	11	11	9	5	7	7	7	7	3	4	7
AVG	438	1705	1.30	8.1	0	211	308	29	6.76	0.156	632	51.1	499	159	340	8.8	0.046	0.129
STD	1412	6127	1.96	0.1	0	27	29	9	3.81	0.109	31	17.7	41	39	24	2.8	0.026	0.056
MAX	5900	26200	6.50	8.2	0	258	351	48	12.30	0.420	680	88.0	565	225	380	12.7	0.072	0.190
MIN	2	6	0.02	7.8	0	151	268	18	0.62	0.048	600	32.3	430	95	310	6.2	0.004	0.018

Table 24. Charleston Side-Channel Reservoir Watershed - 1989 and 1990 Combined Averages

	pH	ALK-P	ALK-MO	HARD-NESS	TURBIDITY NTU	NITRATE	AMMONIA	FC	FS	FC/FS	COND.	SUSPEND SOLIDS	TOTAL SOLIDS	VOLATILE SOLIDS	FIXED SOLIDS	VOL-SUS SOLIDS	(Phosphorus) TOTAL SOLUBLE	TOTAL
Site 4B																		
TOTAL	145.6	0	5853	5269	126	9.00	1.820	4666	9492	5.99	9060	165.8	6168	1542	4616	25.8	0.252	0.236
N	18	18	18	15	17	18	13	13	13	7	13	13	13	13	13	9	8	11
AVG	8.1	0	325	351	7	0.50	0.140	359	730	0.86	697	12.8	474	119	355	2.9	0.032	0.021
STD	0.1	0	41	52	17	0.00	0.000	688	1275	1.09	82	28.2	32	31	37	2.3	0.035	0.017
MAX	8.2	0	371	399	72	0.50	0.140	2460	4690	3.50	770	110.0	530	172	455	9.0	0.118	0.06
MIN	7.9	0	176	205	0	0.50	0.140	2	2	0.13	430	1.4	405	68	310	1.1	0.006	0.008
Site 5B																		
TOTAL	190.9	0	8140	7127	301	12.37	2.260	6612	14094	7.52	13780	657.3	13523	2802	10618	264.1	0.59	2.013
N	24	24	24	20	23	24	17	17	18	10	19	19	19	19	19	13	11	16
AVG	8.0	0	339	356	13	0.52	0.133	389	783	0.75	725	34.6	712	147	559	20.3	0.054	0.126
STD	0.1	0	78	85	29	0.04	0.015	542	1334	0.51	156	78.1	783	38	744	56.9	0.054	0.252
MAX	8.1	0	478	496	120	0.66	0.140	1860	5930	1.50	850	316.0	4028	216	3710	216.4	0.202	1.073
MIN	7.6	0	81	109	1	0.50	0.100	0	10	0.00	160	1.5	410	90	303	0.0	0.02	0.01

ALL DATA GENERATED BY THE EFFORTS OF THE CHARLESTON WATER TREATMENT PLANT AND MEMBERS OF THE ENVIRONMENTAL BIOLOGY PROGRAM AT EASTERN ILLINOIS UNIVERSITY

Biological Characteristics

<u>Algae:</u> During the planning stage of this Phase I study, arrangements were made to use the expertise of Dr. Smith, a phycologist in Eastern Illinois University's (EIU) Botany Department, for the phytoplankton study. Before funding was approved by the USEPA, Dr. Smith passed away. A two phase approach was developed to overcome the unfortunate loss of Dr. Smith. First, samples were collected and preserved for later analysis. Analysis would begin after EIU hired a replacement phycologist. Second, with the help of Dr. Raman K. Raman of the Illinois State Water Survey (SWS), the City was able to contract for the timely analysis of phytoplankton samples. This allowed the City to use the phytoplankton analysis as the basis for copper sulfate treatments.

The two sets of data are not directly comparable due to differences in collection and counting. The first method (EIU) utilized a grab sample collected at a depth of less than one foot. The second method (SWS) called for the collection of water with a column sampler to a depth of twice the secchi disk depth. Counts for the EIU approach involved the use of filtration membranes, and the SWS method utilized Sedgewick-Rafter cells. This methodology difference accounts for the differences in total counts and type dominance, due to the difficulty in enumerating nannoplankton with Sedgwick-Rafter cells.

Mr. Davis B. Beuscher performed the counts for the SWS (Figures 12 & 13). Based on his results, a decision was made in early August of 1989 to treat the CSCR with $CuSO_4$. There was a dramatic change in total population and composition after treatment (Figure 12). The use of phytoplankton analyses to determine when to treat with $CuSO_4$ reduced the number of treatments from three in 1988 to one in 1989. The total cost of treatment plus analysis in 1989 was less than two-thirds of the cost of treatment alone in 1988.

EIU samples were preserved and cataloged by Ms. Kaye Surrett. Dr. Charles Pederson was hired as a replacement phycologist at EIU. Phytoplankton analysis for the EIU samples was then completed by Dr. Pederson and Ms. Surrett. The following information was obtained from their work.

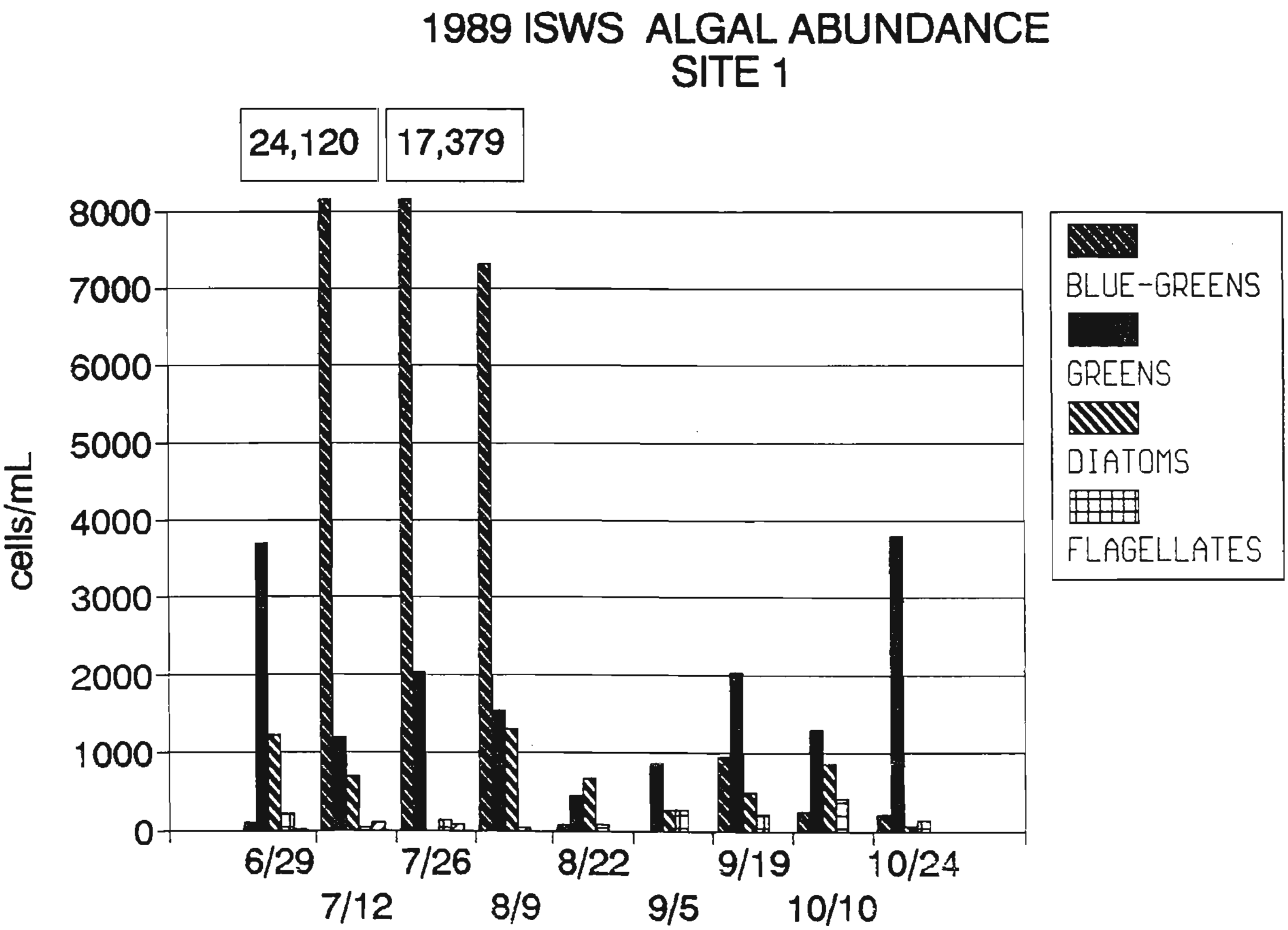


Figure 12. Site 1 1989 Algal Abundance
Source: Illinois State Water Survey

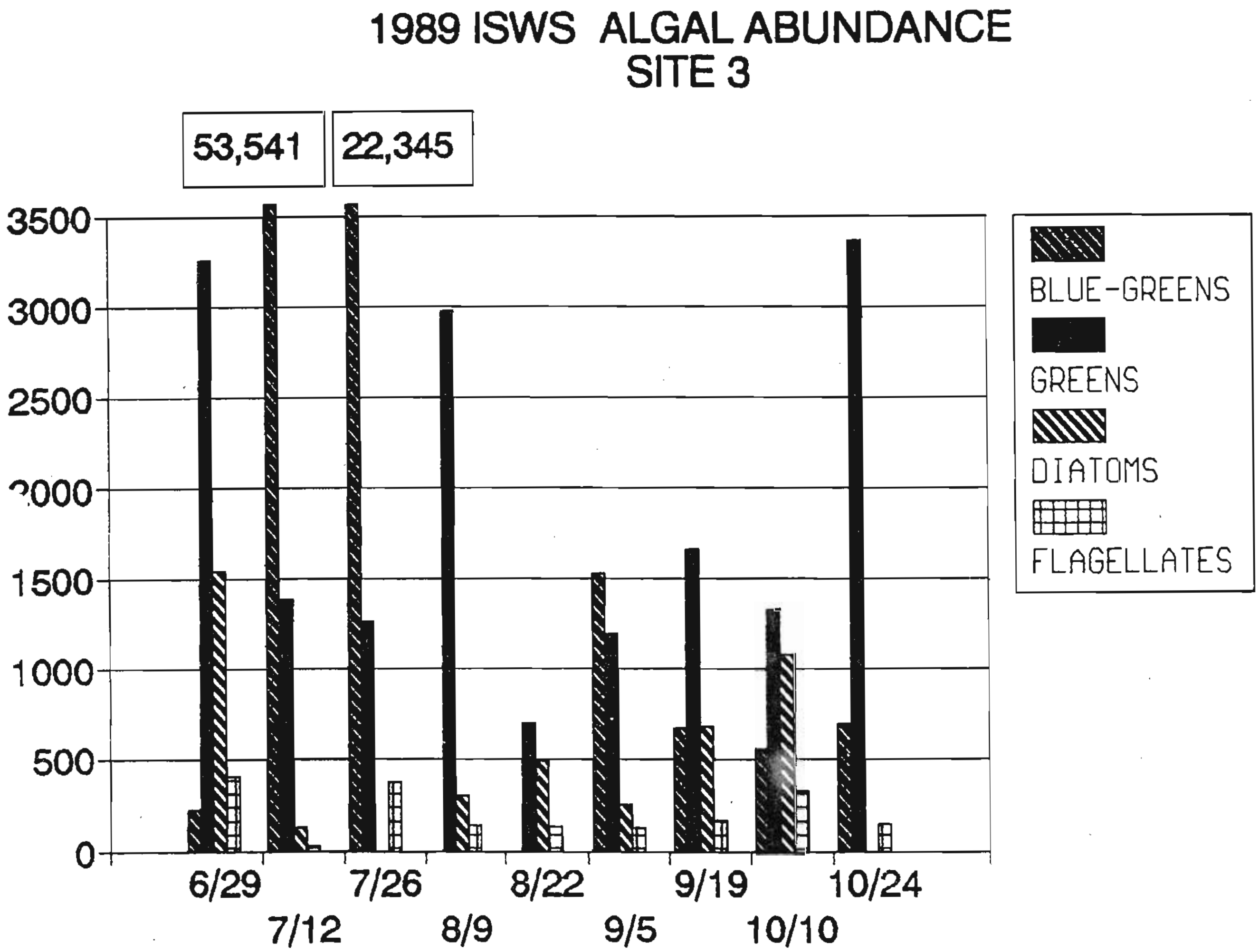


Figure 13. Site 3 1989 Algal Abundance
Source: Illinois State Water Survey

Phytoplankton density, species diversity and community dominance.

Lake Charleston was classified as eutrophic in 1973 and supported 702-8,980 algal units per mL from May through October (Morris et al. 1978). Following conversion to a side-channel pump storage reservoir in 1982, algal density in the reservoir ranged from 10-20,000 units per mL during the summer months, but no blue-green algal blooms were observed (Lookis 1983). By 1987, the Charleston Side-Channel Reservoir (SCR) was classified as hypereutrophic by the IEPA Volunteer Lake Monitoring Program with nutrients and suspended solids the major causes of impairment (Hawes et al. 1988). Phytoplankton density during 1989 at site 3 normally ranged from 55,022 to 140,994 units per mL with numbers reaching as high as 312,939 on July 26 (Figure 15). At site 1, algal density ranged from 61,126 to 174,528 units per mL with the highest numbers being recorded in late August (Figure 14).

In 1972, twenty-four algal taxa were identified from Lake Charleston and algal diversity ranged from 0.608 to 0.716 (Morris et al. 1978). Fifty-seven taxa were identified from the reservoir during 1989 (Table 25) and increased diversity, ranging from 0.695 to 1.077, was observed. Algal diversity at site 1 was typically lower than diversity at site 3, except during the bloom (Figure 16). Fluctuations in diversity generally followed patterns of species richness (Figure 17A). Blue-green algae became dominant during the bloom at site 3 (Figure 18A), thereby producing a decline in both species richness and evenness (Figures 17A, 17B). Higher species richness and evenness values, which were observed at site 1 (Figures 17A, 17B), resulted from the codominance of blue-green and green algae (Figure 18B).

Aeration at site 1 is presumed to be responsible for differences in the patterns of algal diversity and community dominance observed at sites 1 and 3. The inability of the blue-green algae to become dominant at site 1 may be attributable to increased circulation at that site brought about by the aerator. Increased circulation can result in elevated carbon dioxide levels and decreased pH in the euphotic zone by vertical transport of bottom water which has a high carbon dioxide content due to bacterial respiration and lack of photosynthetic activity. Blue-green algal dominated cultures shift to ones dominated by green algae in response to decreased pH and associated increases in free carbon dioxide concentrations (Shapiro 1984). This phenomenon is due to the possible lysing of the blue-green algae by viruses favored at low pH and the lack of the advantage blue-green algae have over green algae in their capacity to absorb carbon dioxide when present at low concentrations (Shapiro 1982).

CONCLUSIONS

The SCR is a hypereutrophic reservoir which continues to increase its capacity to support large populations of phytoplankton with 55,022-312,939 algal units per mL. From Carlson's Trophic State Index, it appears that phosphorus is the limiting nutrient at unaerated site 3. Algal biomass is probably limited mostly by light at site 1 where nutrients may be supplied by the circulation of water from the hypolimnion and algal cells may be dispersed throughout the water column.

Application of copper sulfate as an algicide was effective at reducing algal numbers, but treatment is costly and the benefits are temporary. Algal biomass increased again after application, especially at site 1, but was probably controlled by cooler temperatures in September. It has been suggested that rebound of algal populations after copper sulfate treatment, as seen in this study, may be due to toxic effects of copper on zooplankton (Cooke et al. 1986). One way in which aeration can decrease phytoplankton densities depends on higher zooplankton grazing rates attainable when algal community dominance shifts from blue-green algae to green algae. Thus, with simultaneous use of copper sulfate and aeration as lake management techniques, aeration may not decrease phytoplankton biomass as expected.

Between-site comparisons can provide insight into usefulness of aeration in this lake as a management scheme. Figure 17 shows the ideal effects of aeration. Although aeration did not decrease phytoplankton biomass at site 1, it may have served to increase carbon dioxide concentration in the euphotic zone which could allow green algae to be co-dominant with blue-green algae. Algal diversity was lower at the aerated site except during the bloom.

While circulation has served to improve dissolved oxygen concentrations in most studies (Cooke et al. 1986), site 1 had a lower oxygen concentration than unaerated site 3 . Possible reasons for this are increases in oxygen demanding substances and a decrease in photosynthesis in the epilimnion with both conditions conceivably resulting from circulation. Dissolved oxygen concentration should increase at site 1 with continued aeration (Fast et al. 1975, Garrell et al. 1977, LaBaugh 1980).

Except during the bloom in July and during early October, secchi depth was lower at site 1 as expected. The decrease in secchi depth could be a result of increased algal cells below the surface and/or increased sediments in the water column. There were significant correlations between turbidity and total suspended solids at both sites, but the algae were also significantly correlated with turbidity at site 1. Decreased secchi depth values signify a decrease in light penetration. As light intensities decrease and as mixing depth increases, net photosynthesis should approach zero and in some cases might even be negative due to light limitation. As long as phytoplankton are circulated out of the euphotic zone, light limitation should eventually cause a decrease in biomass.

Site 1 had pH values lower than site 3 as expected with one exception. This probably resulted from circulation of hypolimnetic water with low pH and high carbon dioxide content to the surface waters. These two factors may have combined to prevent blue-green algae from becoming dominant at site 1. Since circulated water contained higher concentrations of suspended solids and total phosphorus, it is logical that pH at site 1 also correlated with turbidity, total suspended solids, secchi depth, total algae and blue-green algae.

Total phosphorus is also apparently supplied to the photic zone via circulation. As long as nutrients are not limiting production, algal biomass should eventually decrease due to light limitation (Cooke et al. 1986). If nutrients are limiting, algal densities could potentially increase and result in lower transparencies and carbon dioxide levels as well as higher pH values. These in turn would support dominance of a community by "nuisance" blue-green algae.

Table 25. ALGAE IDENTIFIED IN CHARLESTON SCR WATER SAMPLES

GREEN ALGAE

Actinastrum sp.
Ankistrodesmus sp.
Aphanothece sp.
Chlamydomonas sp.
Chodatella quadriseta
Closteridium sp.
Coelastrum sp.
Crucigenia alternans
Crucigenia apiculata
Crucigenia fenestrata
Crucigenia quadrata
Crucigenia rectangularis
Crucigenia tetrapedia
Dictyosphaerium sp.
Eudorina sp.
Golenkinia sp.
Gonium sociale
Kirchneriella lunaris
Oocystis sp.
Pandorina sp.
Pediastrum duplex
Pediastrum tetras
Polydriopsis sp.
Scenedesmus acuminatus
Scenedesmus bijuga
Scenedesmus dimorphis
Scenedesmus quadricauda
Selenastrum sp.
Tetrastrum elegans
Tetrastrum staurogeniform
Tetraedron sp.

DIATOMS

Cyclotella meneghiniana
Diatoma sp.
Fragilaria sp.
Melosira distans
Melosira granulata
Navicula sp.
Nitzschia acicularis
Nitzschia holsatica
Pinnularia sp.
Synedra tenera
Tabellaria sp.

BLUE-GREEN ALGAE

Anabaena sp.
Aphanizomenon flos-aquae
Merismopedia sp.
Microcystis sp.
Oscillatoria sp.
Spirulina sp.

OTHER ALGAE

Ceratium sp.
Closterium sp.
Cosmarium sp.
Euglena sp.
Peridinium sp.
Phacus sp.
Staurastrum sp.
Trachelomonas hispida

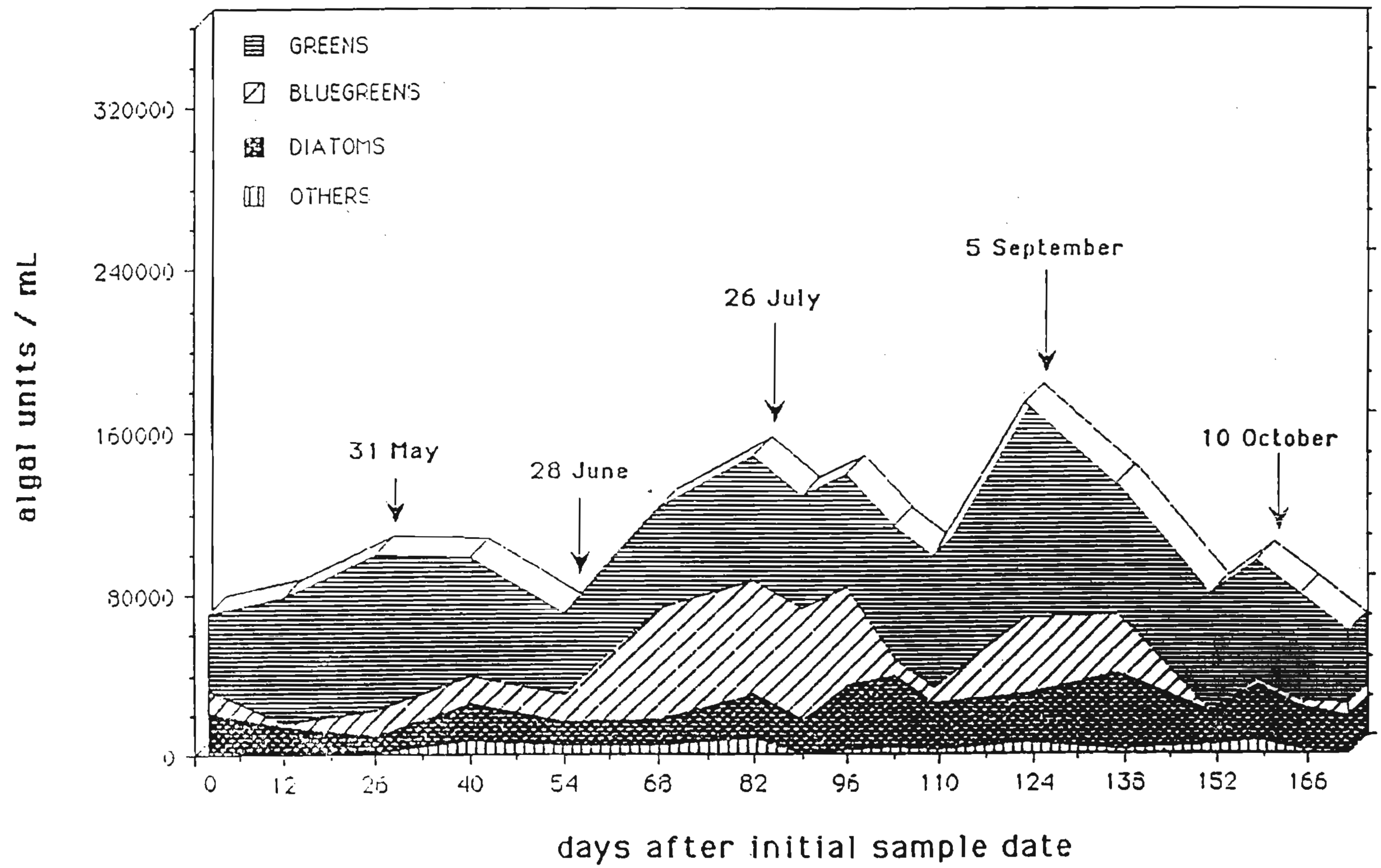


Figure 14. Phytoplankton density and community structure fluctuations with time at site 1.

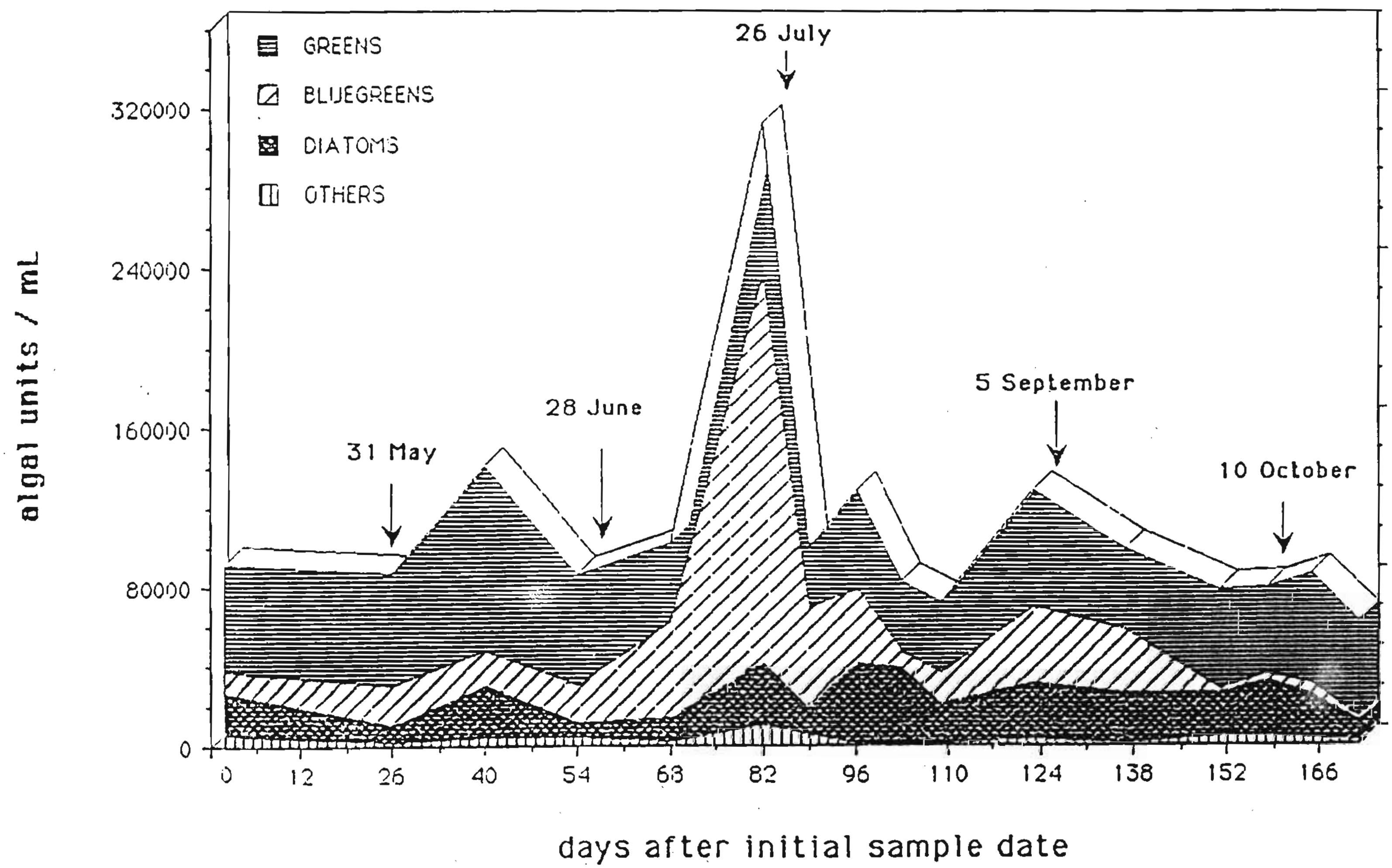


Figure 15. Phytoplankton density and community structure fluctuations with time at site 3.

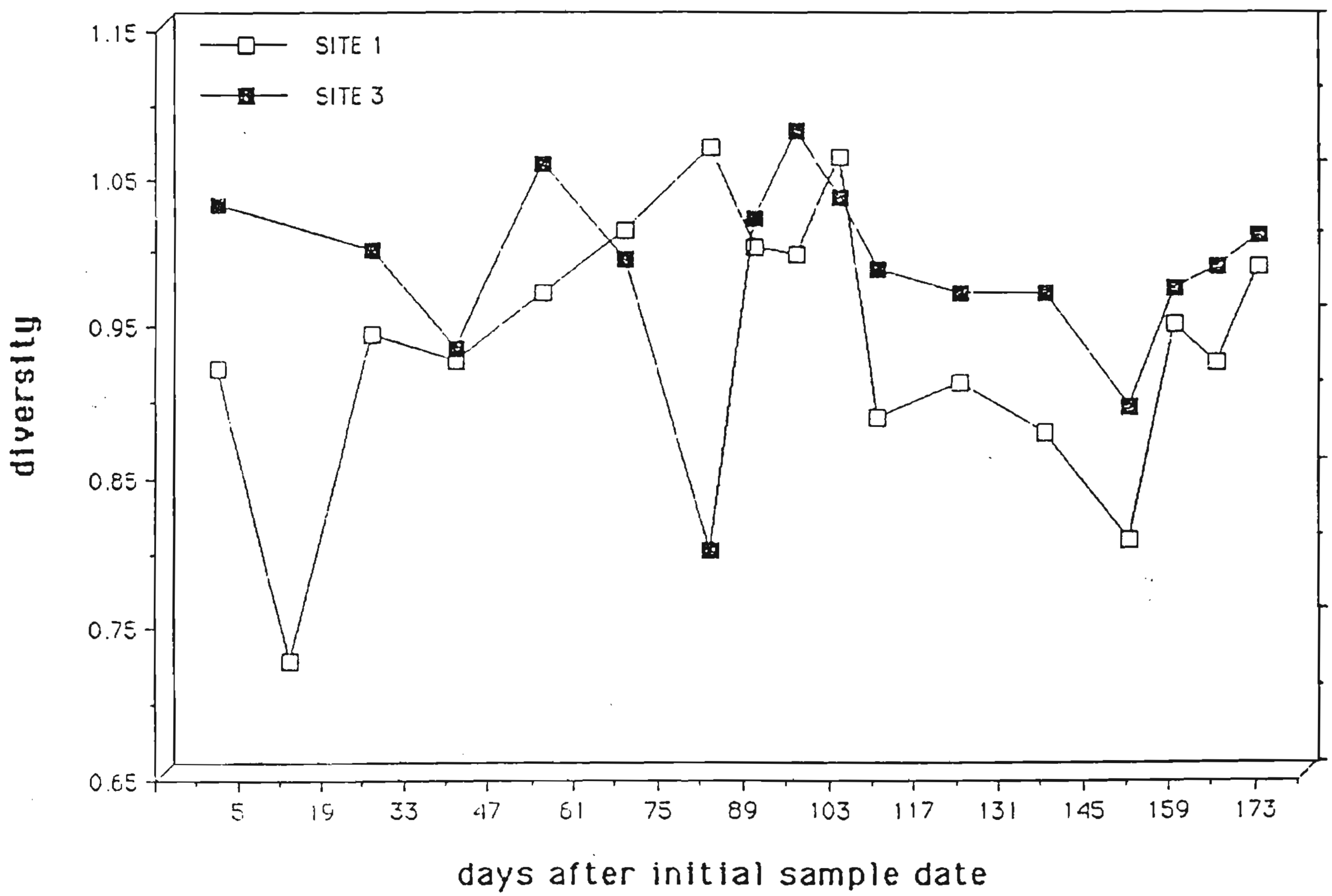
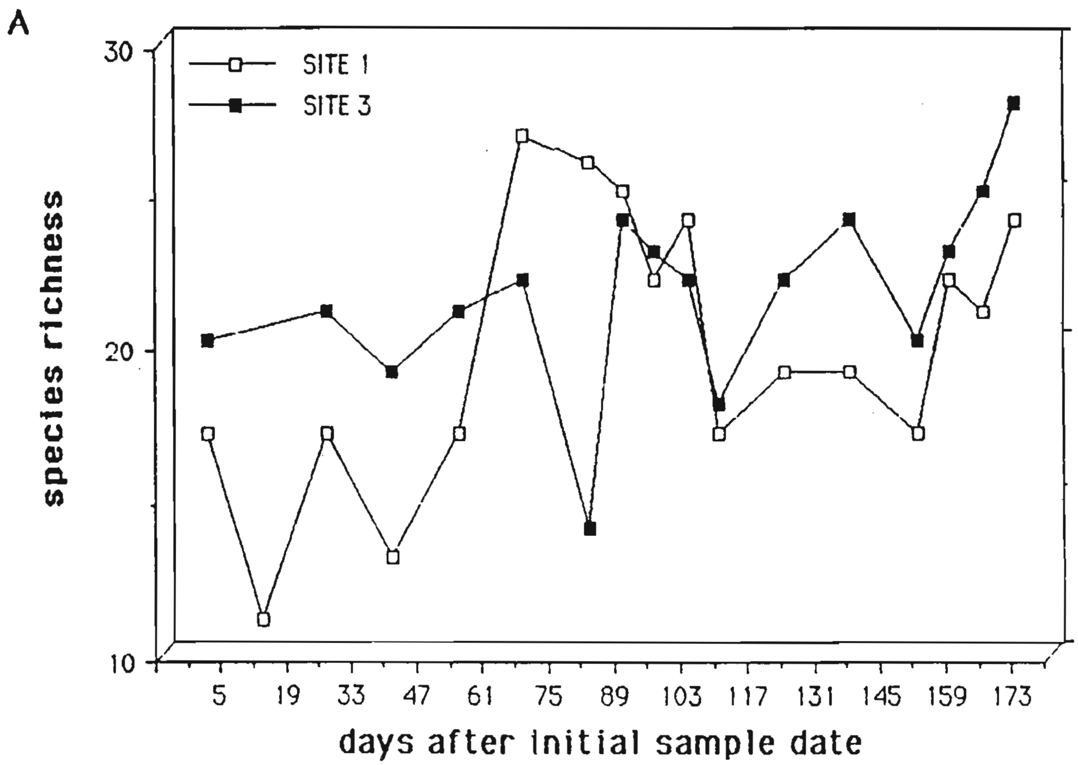


Figure 16. Algal diversity differences between sites 1 and 3.



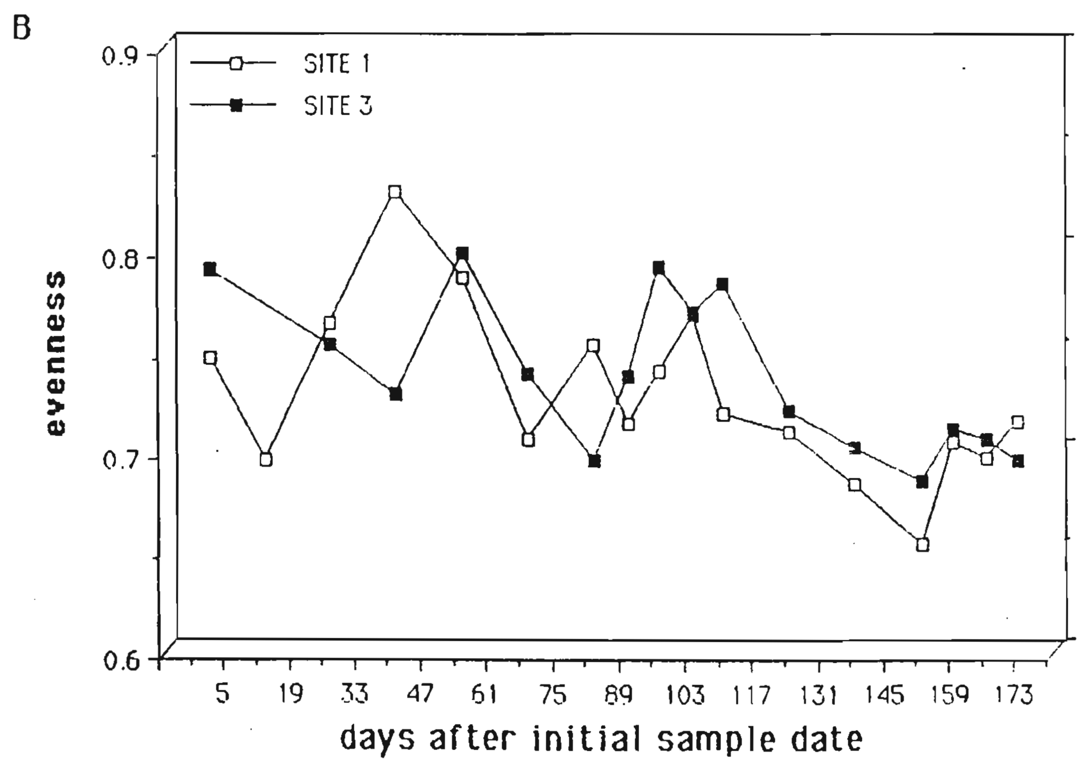
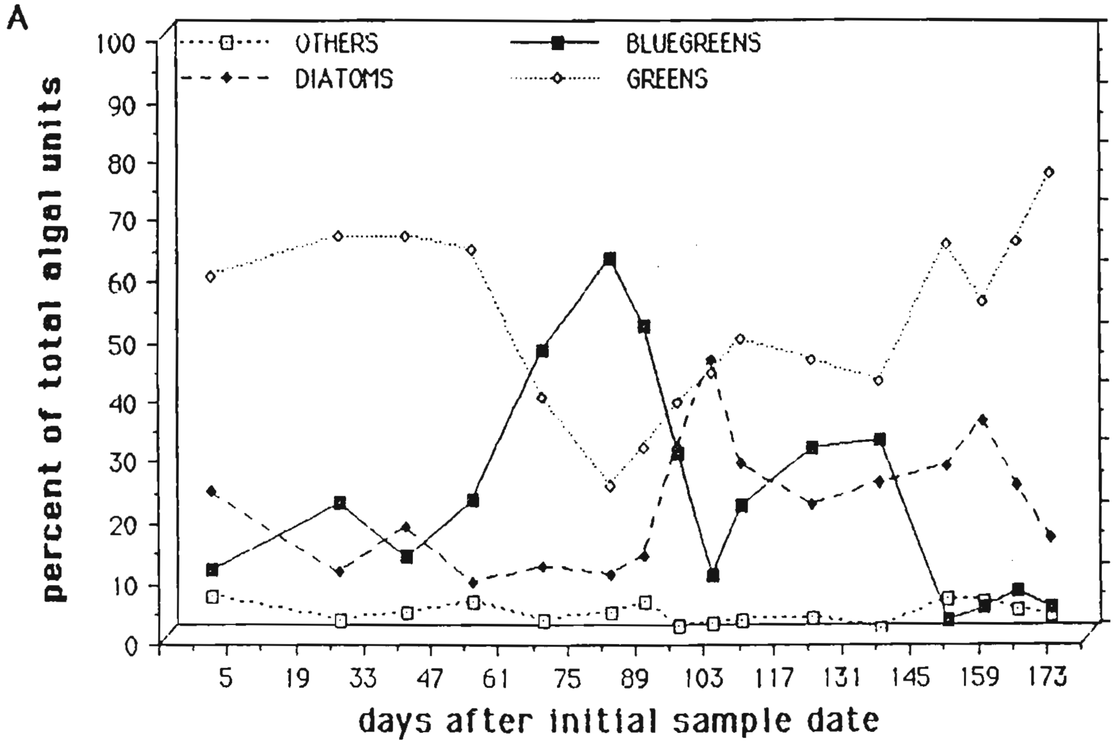


Figure 17. A) Species richness fluctuations with time atsite 1
B) Evenness fluctuations with time at sites 1 and 3.



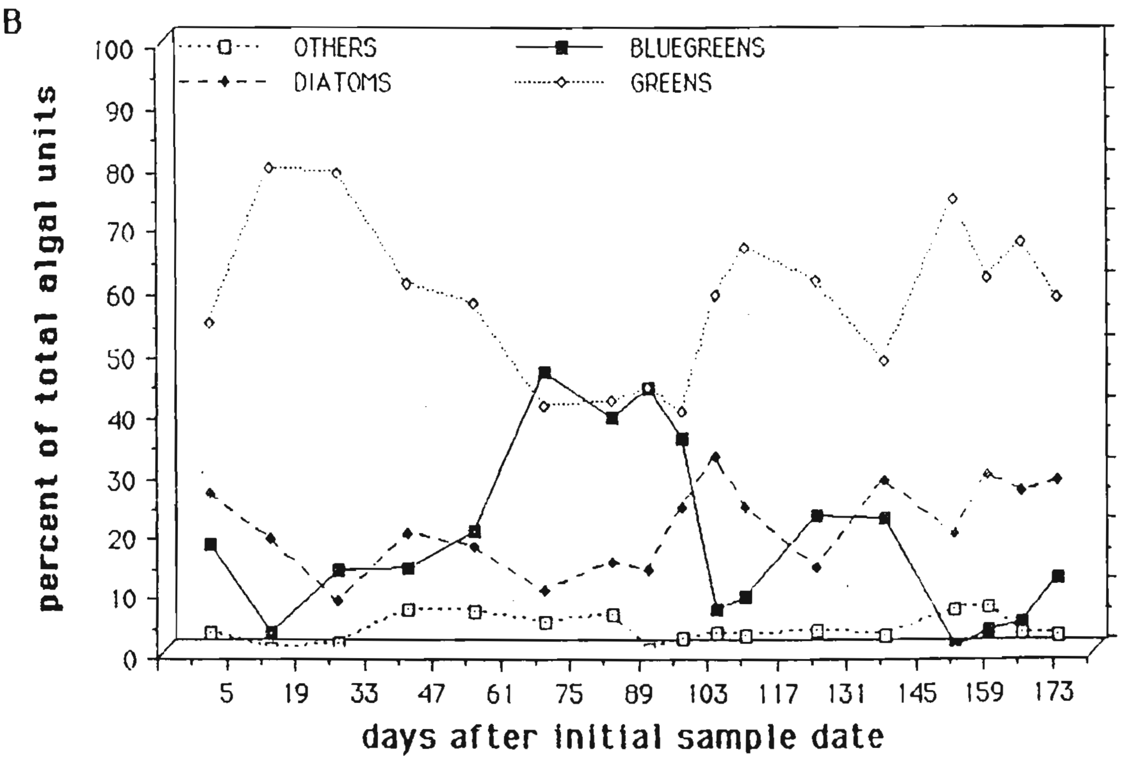


Figure 18. A) Percentage composition of algal groups at site 3
B) Percentage composition of algal groups at site 1.

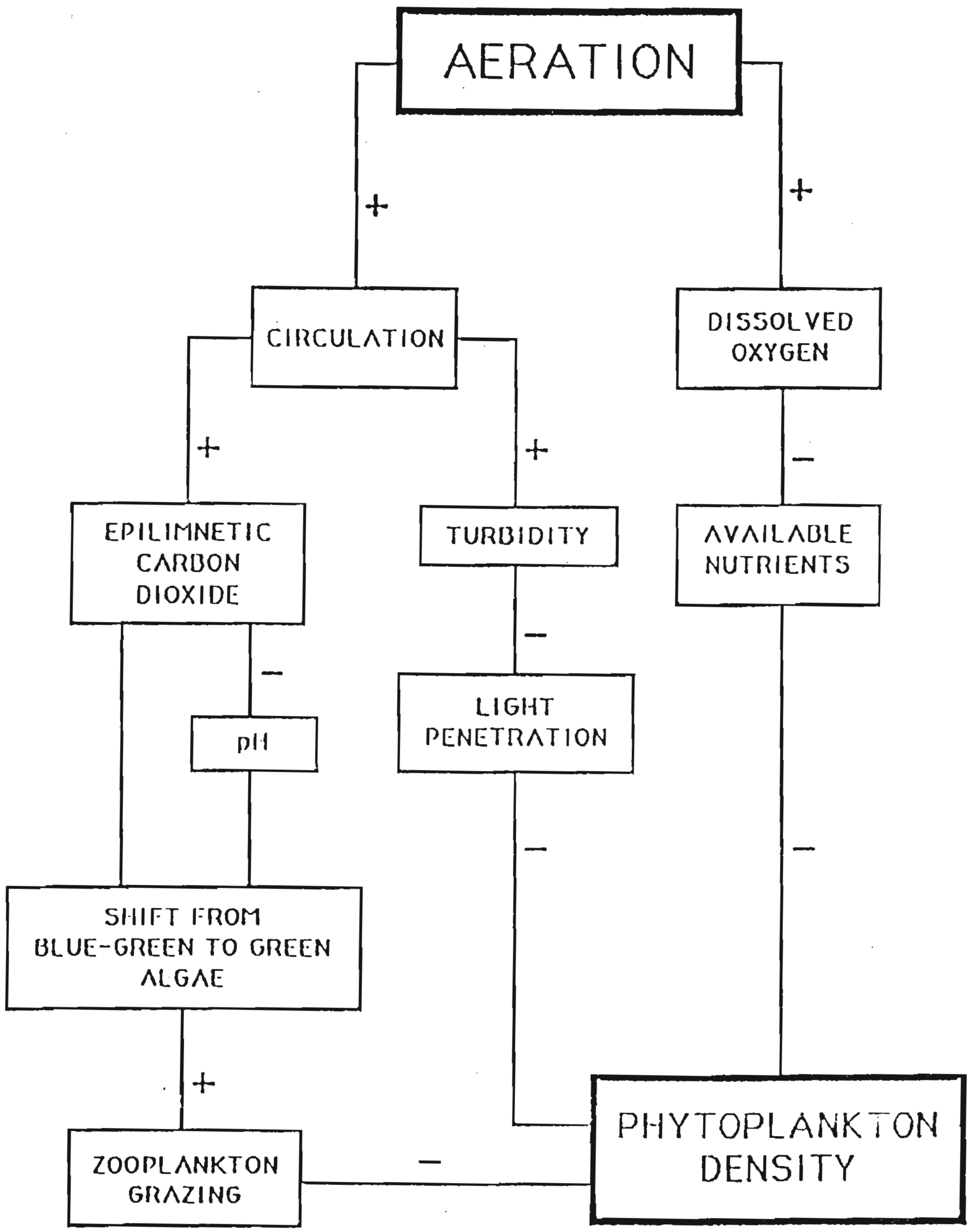


Figure 19. Possible beneficial effects of aeration (modified from Shapiro, 1979).

Chlorophyll:

Algal pigments are made up of chlorophylls, xanthophylls and carotenes. Chlorophyll is a green pigment essential for photosynthesis. Three commonly analyzed chlorophylls are chlorophyll *a, b,* and *c*. Besides these chlorophylls pheophytin *a* is a degradation product of chlorophyll *a* and must be corrected for in order to obtain accurate results.

Results from chlorophyll analysis can be used with several lake management tools. Chlorophyll *a* makes up about 1.5% of the dry weight of the organic matter in algal cells. By multiplying the chlorophyll *a* concentration by 67 you can estimate the algal biomass.

Extraction and quantification of chlorophyll *a, b,* and *c* can be used to indicate the type of algae that may be present. For example if concentrations of chlorophyll *a* and *b* are found but not *c*, then you might expect to find blue-green and green algae but not diatoms.

Chlorophyll *a* values are widely used as part of Carlson's trophic state index (Carlson 1977). The chlorophyll *a* value can be associated with a tropic index number. This index number will indicate trophic status of a body of water. A later section (page 120) deals with this index in more detail.

Chlorophyll samples were analyzed by the IEPA in 1988 and 1989 (Table 26). In 1989, the City and EIU began successfully running the chlorophyll spectrophotometric method in-house. Due to logistical problems in dry ice shipments, analysis of CSCR samples by the IEPA was discontinued after 1989. Monthly average chlorophyll concentrations were calculated for 1989 and 1990 data analyzed by the City and EIU (Table 27).

All of the chlorophyll values regardless of site or year correspond to Carlson Trophic State Index numbers in the eutrophic to hypereutrophic range. The overall chlorophyll *a* range was from 21.4 to 155.5 ppb. When compared to other Illinois lakes that were part of the "Illinois Water Quality Report 1984-1985 "(IWQR), we find the CSCR values are much higher (IEPA 1986). The IWQR grand mean (SD$\pm$) is 35.6 ($\pm$29.1). The grand mean for IEPA and City CSCR corrected chlorophyll *a* data was 70.25 and 68.7 respectively. Both IEPA and City values are greater than one standard deviation higher than the IWQR values.

Table 26. I.E.P.A. Chlorophyll Analysis
For: Charleston Side-Channel Reservoir
Sample analysis performed by the I.E.P.A.

SITE	DATE	Chlorophyll A CORREC	A UNCOR	(ug/l) B	C	PHEOPHYTIN A
1	JUL-25-88	64.24	69.49	10.86	1.14	6.02
1	AUG-30-88	86.78	94.07	7.32	6.08	7.61
1	SEP-27-88	74.17	81.50	10.76	5.87	8.90
1	OCT-28-88	34.12	38.39	2.90	4.97	5.39
1	JUN-14-89	51.87	56.96	5.11	1.43	5.80
1	JUL-13-89	85.05	95.72	7.65	3.21	13.25
1	JUL-26-89	152.19	160.62	9.97	5.08	5.74
1	AUG-10-89	74.76	78.40	11.25	2.50	2.80
1	AUG-22-89	58.74	72.29	9.16	1.71	19.76
1	SEP-12-89	114.81	126.03	14.70	4.84	13.22
1	SEP-19-89	76.10	85.43	8.77	3.57	11.75
1	OCT-05-89	36.17	42.96	5.76	2.33	9.65
1	OCT-24-89	42.72	42.86	6.07	2.07	0.00
AVG.		73.21	80.36	8.48	3.45	8.45
2	APR-20-89	68.23	70.76	9.68	10.35	1.34
2	JUN-14-89	58.41	62.40	4.28	2.04	3.50
2	JUL-13-89	65.03	73.01	5.26	2.69	9.68
2	AUG-10-89	77.52	85.15	11.88	4.77	9.30
2	OCT-05-89	39.67	43.10	6.82	5.17	4.12
2	OCT-24-89	45.39	46.94	7.32	2.64	0.71
AVG.		59.04	63.56	7.54	4.61	4.78
3	JUL-25-88	62.53	69.15	10.34	2.89	8.34
3	AUG-30-88	105.36	110.23	9.06	7.23	2.74
3	SEP-27-88	85.37	89.31	8.96	3.36	2.36
3	OCT-28-88	30.25	34.03	2.44	5.61	4.74
3	JUN-14-89	70.68	77.32	6.67	1.91	7.38
3	JUL-13-89	80.10	84.30	5.81	1.21	2.67
3	JUL-26-89	135.28	137.54	10.81	5.42	0.00
3	AUG-10-89	91.30	96.57	16.61	3.87	5.17
3	AUG-22-89	48.95	59.91	7.29	0.10	15.84
3	SEP-12-89	82.77	90.88	12.10	2.90	9.75
3	SEP-19-89	68.83	72.46	6.80	3.61	2.61
3	OCT-05-89	43.07	49.32	8.71	5.24	8.79
3	OCT-24-89	37.38	39.07	5.95	1.75	1.25
AVG.		72.45	77.70	8.58	3.47	5.51

Samples collected by I.E.P.A. or City of Charleston staff

Table 27. Chlorophyll Values for the CSCR (1989-1990)
Data taken from the City of Charleston

SITE	MONTH	1989 > A COR	Chlorophyll (ug/l) A UNCOR	B	C	< PHEO A	1990 > A COR	Chlorophyll (ug/l) A UNCOR	B	C	< PHEO A
1	May	44.5	57.4	11.1	17.6	8.2					
1	June	39.5	47.5	4.5	5.2	9.1	31.5	58.1	36.6	40.3	6.0
1	July	109.5	119.1	6.4	8.8	8.8	43.9	67.2	28.1	29.5	7.2
1	Aug.	69.1	82.0	7.3	7.5	15.9	78.3	96.4	11.9	16.5	16.8
1	Sept.	98.8	113.8	10.0	9.6	16.8	81.9	96.4	10.4	12.7	13.4
1	Oct.	50.7	57.5	8.5	8.8	5.4	68.5	79.1	7.3	11.1	11.2
2	April	68.2	70.8	9.7	10.4	1.3					
2	June	47.2	54.2	4.5	5.6	7.4	36.5	59.3	31.8	33.5	4.1
2	July	104.8	116.9	7.4	14.4	7.9	50.3	75.1	31.5	33.2	7.7
2	Aug	87.7	99.7	7.8	11.6	11.7	94.2	112.3	13.1	18.2	12.6
2	Sept.	87.0	99.2	7.1	12.3	10.3	67.8	77.9	6.2	8.5	9.3
2	Oct.	53.7	60.2	7.1	9.0	5.0	91.9	102.2	7.7	14.8	7.8
3	May	51.6	63.9	9.4	16.5	8.1					
3	June	59.4	67.6	6.9	7.4	8.2	22.7	47.6	28.9	32.5	1.0
3	July	105.9	110.7	6.2	8.4	3.4	51.1	85.6	43.7	50.7	10.1
3	Aug.	84.9	97.7	10.9	9.9	13.3	87.4	103.3	9.5	14.7	9.0
3	Sept.	81.3	91.2	8.8	9.2	8.9	75.4	85.7	7.1	8.8	10.7
3	Oct.	54.9	61.9	7.1	9.0	6.0	87.0	96.9	6.9	12.4	8.5
Grand Mean for A COR = 68.7											

A COR = Chlorophyll A corrected
A UNCOR = Chlorophyll A uncorrected
PHEO A = Pheophytin A

Bacteriological Analyses:

Analyses for total heterotrophs, total coliforms, fecal coliforms, and fecal streptococci were begun in June of 1988 on selected sites in the CSCR. Samples were collected for bacteriological analyses in 6 ounce wide-mouthed bottles verified for sterility. All were surface grab samples. Analyses were performed using Standard Methods for the Examination of Water and Wastewater, 16th Ed. Heterotrophs were estimated by the plate count method using Difco R2A Agar incubated at 35 C for 72 hrs (Method 907.7.b). Total coliforms were estimated by membrane filtration using Difco m-Endo Broth MF (Method 909.2.b) Fecal coliforms and fecal streptococci were similarly enumerated using Difco m-FC and Difco KF Streptococcus membrane filtration media (Methods 909.C and 910.B., respectively). For fecal coliform and fecal streptococcus membrane filtration procedures, 1 ml, 10 ml and 50 ml portions of each sample were filtered. For total coliform counts, 0.1 ml, 1.0 ml and 10 ml portions were filtered. Counts reported were from those membranes within or closest to the direct count range for the organism being enumerated. Filtration of all samples was completed within six hours of collection, and appropriate positive and negative controls verified that the apparatus/reagents were sterile and that the conditions of incubation would grow the organism in question.

Results for heterotrophs showed nothing unusual. Counts ranged from a few hundred to over 10000 per ml of sample. Since there did not seem to be a relationship between date collected and count, heterotrophic counts were discontinued after the first year. Total coliform counts were similarly discontinued. Counts for total coliforms ranged from a few 100 per 100 ml to 3000 per 100 ml during the first year of testing. Fecal coliform and fecal streptococcus enumeration, however, continued at the various sites until the end of October, 1989. During this time, fecal coliforms exceeded 400 per 100 ml only once and at only one site (Table 28) while they were undetected (< 1 per 50 ml) 37 times (out of 122 total tests). Fecal streptococcus counts tended to range higher. Seven of 122 total tests showed fecal streptococci to exceed 100 per 100 ml while in only 14 of the samples were they undetected. Generally the highest fecal coliform and fecal streptococcus counts were encountered at the mouths of the two ravines feeding the CSCR (sites 4 and 5), with the highest counts at the mouth of the ravine feeding site 5. Examination and bacteriological sampling up the course of that ravine suggested that the source of the contamination was probably agricultural rather than human since the counts increased the further upstream the sample was taken and the FC:FS ratio tended to favor non-human contamination as the likely source (FC/FS < 0.7).

The results of the fecal coliform enumeration suggest that the reservoir bacteriological water quality conforms to the GUS and PFP water quality standards. The GUS states in part, "fecal coliform shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10% of the samples during any 30 day period exceed 400 per 100 ml in protected waters". The PFP states, "at no time shall the geometric mean, based on a minimum of five samples taken over not more than a 30 day period, of fecal coliform exceed 2000 per 100 ml". In addition, the results suggest that the bacteriological quality of the CSCR conforms to the 1987 criteria for bathing beaches (Illinois Department of Public Health (IDPH), "Minimum Sanitary Requirements for the Design and Operation of Swimming Pools and Bathing Beaches"). The IDPH standard states, "Coliform bacteria counts of 1,000 per 100 ml or fecal coliform bacteria counts of 100 per 100 ml in any two samples shall be considered sufficient grounds to require additional investigation, etc.".

Improvements to the bacteriological water quality of the CSCR include reducing or eliminating non-point sources related to agricultural runoff at the headwaters of the two ravines feeding the CSCR and further investigation of the effect of Island Tract home septic systems on the CSCR.

Table 28. Fecal Coliforms and Fecal Streptococci in the Charleston Side-Channel Reservoir

DATE	Site 1		Site 2		Site 3		Site 4		Site 5	
	FC	FS	FC	FS	FC	FS	FC	FS	FC	FS
1988										
MAY31			2	<2	33	55	8	5		
JUN07	<2	2							28	14
JUN20	25	33	<2	<2	2	<2	5	8	33	48
JUL11	6	110	4	28	14	126	14	56	>400	>400
JUL25	<2	16			8	58			4	76
AUG01			<2	8						
AUG08	<2	2	6	2	2	<2	10	26	14	16
AUG26	4	12	<2	2	<2	<2	4	8	6	8
SEP02	<2	12								
SEP09	4	34	<2	<2	<2	2	2	56	4	26
SEP16	<2	3								
SEP23	6	14	<2	6	4	10	20	30	4	14
OCT14	10	264								
OCT21	<2	4			<2	4			14	38
NOV11	2	6			2	2	2	14	4	28
DEC02					30	120	8	40	202	82
1989										
APR21	<2	<2							<2	<2
MAY05	<2	10	<2	6	<2	8				
MAY05	<2	10	<2	6	2	8				
MAY17	2	16					14	36	2	8
MAY17	2	16					14	36	2	8
MAY31	<2	48	<2	4	<2	30			44	50
MAY31	<2	48	<2	4	<2	30			44	50
JUN14	48	88			<2	12	2	14	22	44
JUN28	42	120	18	20	8	2			122	148
JUL12	2	4			2	<2	94	14	6	12
JUL26	12	26			4	4	32	130	4	8
AUG02	2	18			<2	<2				
AUG09	2	<2			<2	<2			6	4
AUG16	2	4	2	4	10	22	2	4		
AUG22	10	14	4	8	8	12				
SEP05	2	2	14	8	<2	2	2	<2		
SEP19	16	20			<2	12	16	4	8	2
OCT03	<2	8	<2	4	2	4				
OCT10	12	4			2	2				
OCT17	2	12			<2	16	10	18	6	28
OCT24	2	2	<2	2	<2	<2				

FC: Fecal Coliforms; FS: Fecal Streptococci
<2: no organisms detected in 50 ml sample
>400: more than 40 organisms detected in 10 ml

Macrophytes:

The CSCR was surveyed for vascular aquatic macrophytes on three occasions during the summer and fall of 1989. This survey was conducted by taxonomist Dr. John Ebinger, from the Department of Botany at Eastern Illinois University.

No submersed aquatic macrophytes were observed during the surveys, though all of the shallow shoreline of the CSCR was examined. Also, the shallow areas in the CSCR were examined by boat with negative results. Floating aquatic macrophytes were occasionally found, and large numbers were observed in the inlet at the northwest corner of the CSCR. A list of the species encountered can be found in Table 29. Emergent aquatic macrophytes are common along the shallow north shore of the CSCR and at a few scattered places in other areas. The most common species encountered is Justicia americana which forms colonies up to 6 meters across in areas where the water is less than 40 centimeters deep. The emergent species are listed in Table 29. The numerous shoreline vascular plant species are encountered around the reservoir. The most commonly encountered species are listed in Table 29.

Table 29. Vascular Plants of the Side-Channel Reservoir

Submersed Aquatic Macrophytes: None

Floating Aquatic Macrophytes:

Duckweed (Lemna minor L.)
Water Meal (Wolffia columbiana Karst.)

Emergent Aquatic Macrophytes:

Water Willow (Justicia americana L.)
Creeping Primrose Willow (Ludwigia peploides L.)
Water Smartweed (Polygonum amphibium L.)
Swamp Dock (Rumex verticillatus L.)
Bulrush (Scirpus atrovirens Willd.)
Bulrush (Scirpus tabernaemontanii K. C. Gmel)

Shoreline Vascular Plants:

Buttonbush (Cephalanthus occidentalis L.)
Privet (Ligustrum obtusifolium Sieb. & Zucc.)
Sycamore (Platanus occidentalis L.)
Cottonwood (Populus deltoides Marsh.)
Multiflora Rose (Rosa multiflora Thunb.)
Sandbar Willow (Salix exigua Nutt.)
Crack Willow (Salix fragilis L.)
Black Willow (Salix nigra Marsh.)

Herbaceous Plants:

Swamp Marigold (Bidens aristosa [Michx.] Britt.)
Nodding Bur Marigold (Bidens cernua L.)
Common Begger-tick (Bidens frondosa L.)
Sedge (Carex comosau Boott).
Sedge (Carex vulpinoidea Michx.)
Fog-fruit (Phyla lanceolata [Michx.] Greene)
Reed Canary Grass (Phalaris arundinacea L.)
Pale Smartweed (Polygonum lapathifolium L.)
Common Arrowleaf (Saittaria latifolia Willd.)
Bulrush (Scirpus atrovirens Willd.)
Bulrush (Scirpus tabernaemontanii K.C. Gmel.)

Information Provided by: Dr. John Ebinger, Eastern Illinois University

Fish:

The Illinois Department of Conservation biennially conducts a fish survey and creel count of the CSCR. These surveys are executed under the supervision of Fisheries Biologist Donald W. Dufford. On July 6, 1989 Mr. Dufford conducted a survey of the CSCR, and the following information is extracted from his "Lake Periodic Report" (IDOC 1990).

Discussion of Biological Surveys and Creels Completed: The biennial summer fish population survey was conducted on July 6, 1989. At 1300 hours the Air Temp. = 31.1C (88F), Water Temp. 29.4C (85F), pH + 9.1, Total Alkalinity = 145 ppm, Specific Conductance = 380 micromhos/cm, Secchi Disc = 61 cm (24 inches).

The fish population was sampled with a boat shocker for 90 minutes during daytime. Efficiency was average. A total of 2,429 fish representing 14 species and 2 hybrid crosses were collected, weighed and measured, and returned to the lake. A species catch summary is shown in Appendix C Table 29. The stock index table for selected species is shown in Appendix C Table 32. I was assisted by Mike Welker, Eastern Illinois University Intern; and Brad Taylor, Sangamon State University Intern.

LARGEMOUTH BASS (LMB) - 36 were collected ranging from 3.0 to 51.6 cm t.l. (1.2-20.3 in.) of which 12 were young-of-year. Largemouth bass made up 1.5% of the total number of fish collected. Catch per minute of electrofishing (CPUE) (1+ and older fish) was 0.27, down from the 0.58 found on July 10, 1987, and about the same as the 0.24 found on August 14, 1985, but well below the desired 1.0. Proportional stock density (PSD) was 69.6, above the desired 40-60 range, about the same as the 72.2 in the 1987 survey and up from the 55 in the 1985 survey. Most of the high PSD can be accounted for by 2 weak year-classes (1+ and 2+) both of which are of stock size (8 inch) but not yet of quality size (12 inch). There were only 3 individuals of these two year-classes collected. Relative stock density (RSD14) was 56.5, above the desired 10-25 range, about the same as the 58.3 in the 1987 sample and above the 31.8 in the 1985 survey. Two dominant year-classes (5+ and 6+) were both above the 14 inch size. The average relative weight (Wr) was 105, a slight increase over the 102 found in 1987 and the 97 found in 1985, with all years within the desired 90-110 range. The collecting of only two 2+ largemouth bass in this sample does indicate that the 1987 year-class was a weak year-class as indicated in the 1987 sample and periodic report. Hopefully the collecting of 12 young-of-year largemouth bass in this sample indicates a stronger year-class. Growth compared to the midsummer average growth rate of fish in Illinois was average or good for all year-classes. Length frequency is shown in Appendix C Table 5 and Appendix C Figure 1. Length frequency by year-class is shown in Appendix C Table 6. Size at age data is shown in Appendix C Table 7 and App. C Figure 2. A largemouth bass summary is shown in Table 30.

BLUEGILL - 317 were collected ranging from 2 to 18.9 cm t.l. (0.8-7.4 inches). Bluegill were the second most abundant species in this sample with 13.1% of the total numbers collected. PSD was 23.7, a decrease from the 36.9 found in the 1987 collection, and still above the 11.6 found in the 1985 collection, and within the preferred range of 20-40. RSDB was zero, the same as in 1985 and 1987. Average Wr was 122, an increase over the 107 in 1987, and over the 94.5 in 1985, but above the desired 90-110 range. Growth compared to the midsummer average growth rate of fish in Illinois was average for all year-classes. Length frequency is shown in App. C Table 8 and App. C Figure 3. Length frequency by year-class is shown in App. C Table 9. Size at age data is shown in App. C Table 10 and App. C Figure 4. A bluegill summary is shown in Table 30.

WHITE CRAPPIE (WHC) - 74 were collected (3.0% of the sample) ranging from 2 to 27.0 cm t.l. (0.8-10.6 inches) of which 91.9% (68) were 2+ fish. PDS was 9.6, well down from the 21.4 found in 1987, and from the 24.3 found in 1985, and below the preferred range of 20-40. RSD10 was 5.5, again down from the 14.3 found in 1987, and from the 8.1 found in 1985 and still within the desired range of 5-20. Average Wr was 84, a slight improvement from the 82 found in 1987, and below the 86.5 found in 1985, and still well below the desired condition of 90-110. These fish are in poor condition, probably caused by overabundance. Growth compared to the midsummer average growth rate of fish in Illinois, was average for all year-classes collected. Only 1 young-of-year white crappie was collected and no 1+ white crappie were collected. Length frequency is shown in App. C Table 11 and App. C Figure 5. Length frequency by year-class is shown in App. C Table 12. Size at age data is shown in App. C Table 13 and App. C Figure 6. A white crappie summary is shown in Table 30.

BLACK CRAPPIE (BLC) - No black crappie were collected during this sampling.

CHANNEL CATFISH (CCF) - 39 were collected ranging from 24 to 68.2 cm t.l. (9.4-26.9 inches). Channel catfish made up 1.6% of the sample. PSD was 16.7, slightly below the desired range of 20-40 but an improvement over the 9.1 found in 1987. RSD18 was 10.0, slightly up from the 9.1 found in 1987. Average Wr was 103, an improvement over the 87 found in 1987 and the 78.5 found in 1985 and within the desired range of 90-110. Aging was done by using the length frequency and growth of known age channel catfish in nearby lakes. Growth compared with midsummer average growth of fish in Illinois was good for all year-classes collected. Length frequency is shown in App. C Table 14 and App C Figure 7. Length frequency by year-class is shown in App. C Table 15. Size at age data is shown in App. C Table 16 and App. C Figure 8. Annual stockings of this species is building up the channel catfish population. A channel catfish summary is shown in Table 30.

STRIPED BASS HYBRIDS - None of the 2,000 striped bass X white bass hybrids that were stocked on October 17, 1988 were collected in this sample. However, striped bass hybrids are difficult to collect with a boat shocker and no gill nets were set. A supplemental survey was conducted in July of 1990 to sample the striped bass hybrid population and the channel cat population. Gill nets were used in the supplemental survey but also failed to yield any striped bass hybrids.

OTHER SPECIES - 1 flathead catfish (FCF) (App. C Table 17), 1710 gizzard shad (GZS) (App. C Table 18), 34 green sunfish (GSF) (App C Table 19), 92 longear sunfish (LOS) (App. C Table 20), 23 warmouth (WAM) (App. C Table 21), 2 longear sunfish X green sunfish hybrids (LGH) (App. C Table 22), 1 warmouth X green sunfish hybrid (WGH) (App. C Table 23), 22 carp (CAP) (App. C Table 24), 38 yellow bass (YLB) (App. C Table 25), 16 quillback (ULL) (App. C Table 26), 9 yellow bullhead (YEB) (App. C Table 27), and 15 brook silversides (BRS) (App. C Table 28), were also collected. Gizzard shad was by far the most abundant species by numbers and by total weight in this sample. Shad made up 70.4% of the total numbers of fish collected.

FISH TISSUE ANALYSIS - Fish tissue samples were taken to the IEPA office in Springfield, Illinois, on August 17, 1989. The results of the IEPA analysis showed that all monitored compounds were below the USFDA action levels. Table 31 list the USFDA action levels, the laboratories detection limits and the levels found in a carp from the CSCR.

MANAGEMENT ACTIVITIES COMPLETED - Approximately 5,190 non-vulnerable (7.6 inch) channel catfish were stocked on June 23, 1988. Their condition was good. This is a stocking rate of 15 per acre. Approximately 1,730 non-vulnerable (8 inch) channel catfish were stocked on July 25, 1989. Their condition was good. This is a stocking rate of 5 per acre.

Approximately 2,000 striped bass X white bass hybrids (4-5 inches) were stocked on October 17, 1988. These fish were purchased by the City of Charleston from Fountain Bluff Fish Farm. Their condition was good. This is a stocking rate of 5.78 fish per acre. Approximately 3,460 striped bass X white bass hybrids (5 inch) were stocked on September 19, 1989. These fish were purchased by the City of Charleston with FishAmerica Foundation Grant funds from Fountain Bluff Fish Farm. The fish were in good condition and the stocking rate was 10 per acre.

Approximately 1,500 largemouth bass fingerlings (2 inch) were stocked on July 12, 1989. These fish were initially intended to be stocked into Black Widow Lake near Greenup, IL, but Bill McMorris agreed to stock them into the CSCR. Their condition was good. The stocking rate was 4.3 per acre.

A minimum length limit was set for both largemouth bass and striped bass hybrids. A fourteen inch limit for largemouth bass and a seventeen inch limit for striped bass hybrids were put into effect on April 1, 1989. Also a daily creel harvest limit was set at 3 fish for striped bass hybrids.

Copper in Shad: In 1989 and 1990, a study of the copper content of gizzard shad in the CSCR was performed by Mark Christ. Gizzard shad from nearby Lake Shelbyville were used as a control since copper sulfate treatments are not used there. The result of this study indicated that shad from Lake Shelbyville had a higher concentration of copper than shad taken from the CSCR (Christ 1990). Christ concluded that further research on piscivores was needed to determine the scope of copper accumulation in these higher carnivores.

Table 30. Charleston Side Channel Reservoir Fish Summary
(mean length (cm), mean weight (gm),
number collected, percentage collected).

YEAR	0+	1+	2+	3+	4+	5+	6+	7+	8+
LARGEMOUTH BASS 1987									
cm	9.5	18	26	33.6	39.4	43.5	49	53.5	
gm	11	81	252	566	931	1260	1834	2408	
number	1	15	10	6	15	2	2	1	
%	1.9	28.8	19.2	11.5	28.8	3.8	3.8	1.9	
LARGEMOUTH BASS 1989									
cm	4.2	19.5	23.5	27.3	33.1	36.5	42.1	47.5	51.5
gm	1	107	192	307	559	752	1179	1703	2188
number	12	1	2	5	3	6	5	1	1
%	33.3	2.8	5.6	13.9	8.3	16.7	13.9	2.8	2.8
BLUEGILL 1987									
cm	7	11.4	14	15.8					
gm	8	30	60	91					
number	13	52	108	99					
%	4.8	19.1	39.7	36.4					
BLUEGILL 1989									
cm	2.5	9.4	13.6	16					
gm	0	20	59	100					
number	1	178	60	78					
%	0.3	56.2	18.9	24.6					
WHITE CRAPPIE 1987									
cm		16.8	22.5	28.5					
gm		56	136	274					
number		33	3	6					
%		78.6	7.1	14.3					
WHITE CRAPPIE 1989									
cm	2.5		17.6	23.5	26				
gm	0		65	153	209				
number	1		68	1	4				
%	1.4		91.9	1.4	5.4				
CHANNEL CATFISH 1987									
cm			32.1	37.2	47.5		65.5		
gm			275	417	836		2107		
number			16	4	1		1		
%			72.7	18.2	4.5		4.5		
CHANNEL CATFISH 1989									
cm		27.5	33.5	37.5	44	53.5	57.5	68.5	
gm		200	356	502	810	1460	1815	3078	
number		15	4	15	2	1	1	1	
%		38.5	10.3	38.5	5.1	2.6	2.6	2.6	

Table 31. Results of Fish Tissue Screening of Whole Fish from Four Coles County Lakes.

Parameter (*)	Charleston SCR	Mattoon	Oakland	Paradise
Aldrin (0.3)	0.010u	0.010u	0.010u	0.010u
Chlordane (0.3)	0.024c	0.660	0.010m	0.430
DDT + Analogs (5.0)	0.027c	0.200	0.043m	0.060
Dieldrin (0.3)	0.008m	0.110	0.048c	0.010
PCB's (2.0)	0.020u	0.220	0.200u	0.170
Heptachlor (0.3)	0.010u	0.010u	0.010u	0.010u
Hept. Epoxide (0.3)	0.010u	0.010m	0.006m	0.010m
Toxaphene (5.0)	1.000u	1.000u	1.000u	1.000u
Methoxychlor **	0.050u	0.050u	0.050u	0.050u
Hexachlorbenzene **	0.010u	0.010u	0.010u	0.010u
Lindane **	0.010u	0.010u	0.010u	0.010u
Benzene Hexachloride(0.5)	0.010u	0.010u	0.010u	0.010u
Mirex (0.1)	0.050u	0.010u	0.050u	0.010u
Endrin (0.3)	0.010u	0.010u	0.020u	0.010u
Fish Type	Carp	Carp	Carp	Carp

* USFDA Action Level
** No established USFDA Action level in fish
u = not detected, c = value calculated, m = presence of material verified but not quantified

Source: IEPA

Sediment Characteristics

Hydrology and Sediment Load of Tributaries to the Reservoir

Baseline data were collected on the characteristics of stream discharge and suspended sediment load of tributaries to the CSCR. Figure 20 illustrates the boundaries of four drainage basins sampled within the reservoir watershed. Suspended sediment samples were collected at all four sites, while discharge was measured at sites 1 and 3.

Table 32. Areas of Drainage Basins Used in Sediment Load and Streamflow Studies.

Site Number	Area sq mi	Area acres
1	0.091	58
2	0.239	153
3	0.090	58
4	0.210	134
Total	0.630	403

Figure 21 shows the relationship between precipitation, tributary discharge (sites 1 and 3), and sediment load (sites 1, 2, 3 and 4) for the period of February, 1989 to April, 1990. Discharge was measured by periodic reading of the water surface elevation in v-notch weirs installed in the streambeds at sites 1 and 3. No stream had any sustained base flow from late June to late December. Tributaries 1 and 3 had peak baseflow periods in March and April with sustained flow in each being approximately 50,000 gallons per day. Peak flows were difficult to determine as the sites did not have continuous recorders. Peak flows occurred for only a few hours per storm and overtopped the weirs on several occasions during the sample period. Flow would need to exceed 2 million gallons per day to top the weirs.

Suspended sediment loads were measured at sites 1, 2, 3 and 4 by using wading-rod sediment samplers. Sediment was captured on pre-weighed fiberglass filters that were dried and re-weighed with the captured sediment. Values are in grams of sediment per liter of water. Figure 22 illustrates the sediment delivery profile from February, 1989 to March, 1990. Sediment loads in the tributaries under baseflow conditions were generally less than 0.05 gm/L, and during the dry season there was no sediment transport except during episodic storm flow.

Tributaries to the CSCR contribute almost no sediment to the CSCR under baseflow conditions. Figure 23 shows the annual baseflow curves for tributaries 1 and 3. It also shows the relationship between discharge and suspended sediment load. It appears as though there is little change in suspended sediment volumes until a flow of 40,000 to 50,000 gallons per day is exceeded.

Sediment and streamflow measurements were not monitored continuously, but were taken approximately once per week or as soon as possible after a storm event. Data is best used as a determinant of baseflow and minimum sediment load values. Sediment load data may be used to rank the study basins according to average sediment load. Data on discharge and suspended sediment load is presented in Appendix D.

Table 33. Average Sediment Load in Reservoir Tributaries

Site	Sediment Load (gm/L)
1	0.103
2	0.285
3	0.164
4	0.093

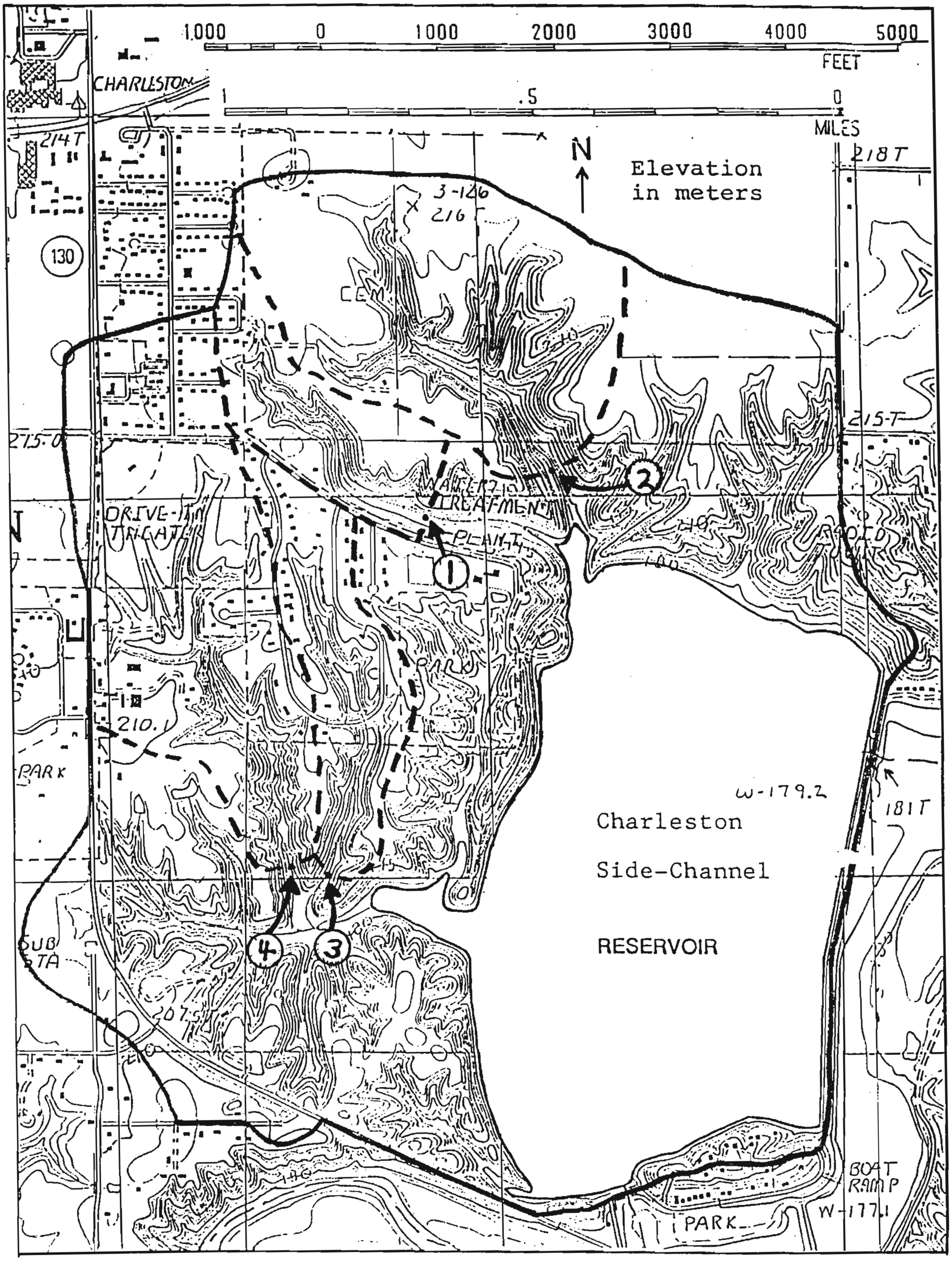


Figure 20. Suspended Sediment and Streamflow Sample Sites.

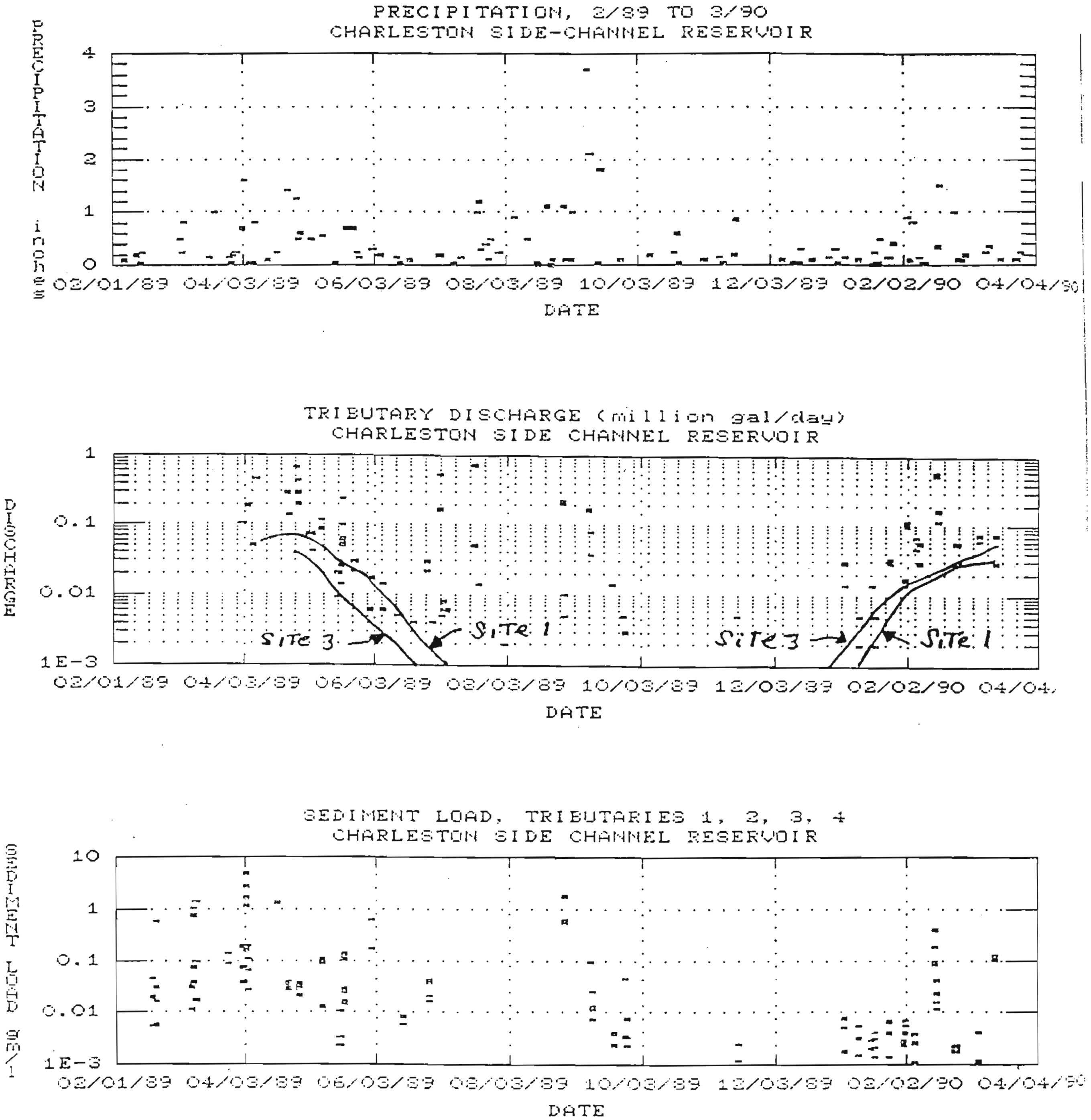


Figure 21. Precipitation, Tributary Discharge and Tributary Sediment Load in the Reservoir Watershed.

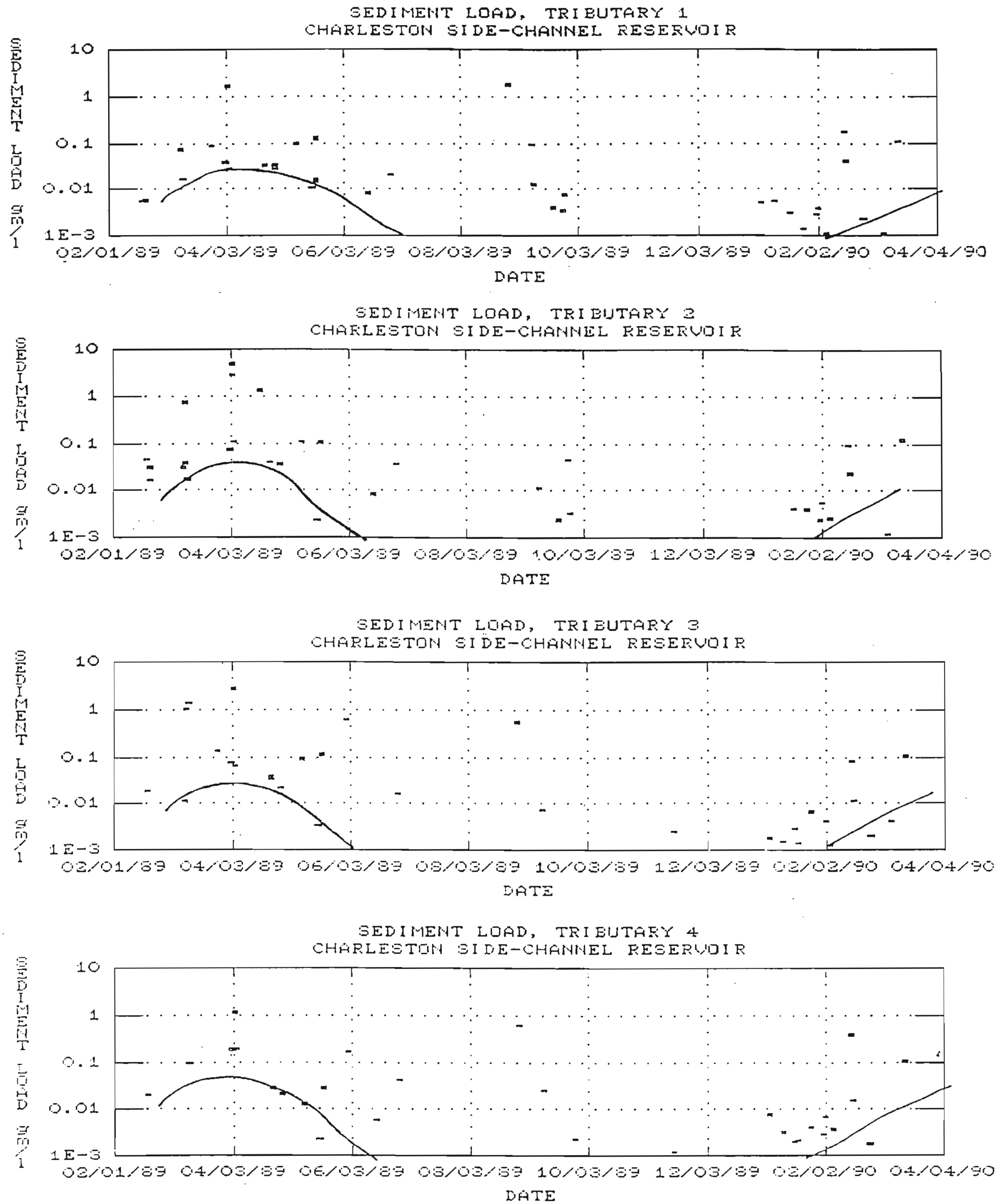


Figure 22. Sediment Loads in Tributaries to the Reservoir.

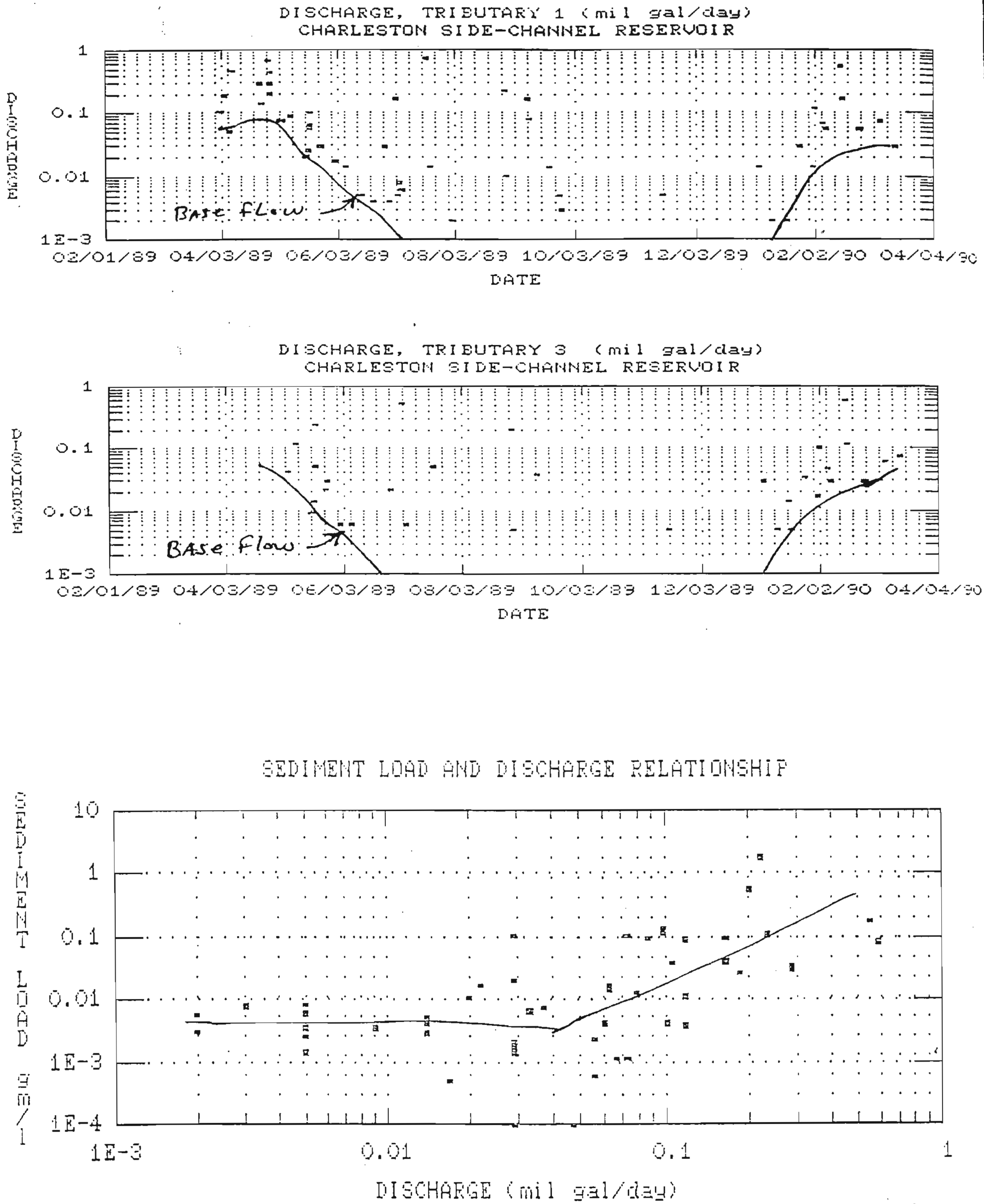


Figure 23. Relationship Between Discharge and Sediment Load, Tributary 1 and 3.

Shoreline Erosion

Areas of shoreline erosion were mapped according to distance along the shore and height of actively-eroding, unvegetated, steep slopes. Shorelines in the inlets on the southwest, northwest and west-central portion of the CSCR were not mapped. Figure 24 shows the areas where the height of erosional cliffs were measured; these areas correspond to those undergoing active erosion. Figure 25 through Figure 28 illustrate the height of the erosional cliffs above the reservoir water surface. It is apparent that the south shore of the CSCR has the highest erosional cliffs. The south shore is composed of easily erodible glacial till, allowing strong north and northwest winds to create wave action which undermines the slopes. Here we find many cliffs with heights over 20 feet and some reaching 50 feet in height. Other areas where cliffs have reached 20 feet in height are on the southwest, northwest and north shore of the CSCR. Table 34 lists the areas of low, high and non-erodible shoreline around the perimeter of the CSCR.

The area of shoreline erosion that most directly affects reservoir management is the northwest shore at location I-J-K. Along this shoreline, bedrock forms vertical erosional cliffs. The overlying glacial till is continually sloughing off into the deepest portion of the CSCR where the raw water intakes are located.

The process of shoreline erosion in the CSCR is wave activity undercutting poorly consolidated materials. As the cliff retreats, the higher slopes lose their basal support and the upper 2 to 4 feet of soil undergoes mass movement into the CSCR. There is ample evidence of this activity on the southwest and northwest shores. Another method of shoreline erosion occurs when large trees on the edge of the cliffs fall into the CSCR. This causes large masses of soil to be carried into the water and creates a large scar on the shore which contributes significant sediment to the CSCR. If the trees on the edge of the cliffs were removed these large scale inputs of sediment to the CSCR could be slowed.

Table 34. Erosional Classification of the Perimeter of the Charleston Side-Channel Reservoir.

Shoreline Classification	Shoreline Length (ft)	Percent of Total
Non-Erodible:		34
Dike	4000	
Raw Water Intake Apron	700	
Dam	400	
Total	5100	
Low Erosion:		27
West Shore (H to I)	2000	
Northwest Corner	300	
Northeast Shore	1700	
Total	4000	
High Erosion:		39
South Shore (A to D)	1700	
West Side of Dam	400	
Southwest Shore (E to H)	1600	
Northwest Shore (I to K)	1000	
North Shore (L to N)	1000	
Total	5700	

Grain-Size Analysis of Reservoir Sediments

Approximately 50 samples used for grain-size analysis were taken of sediments from the bottom of the reservoir (Appendix E). Pippette analysis was used to determine the grain-size distribution of sediments within the reservoir. Sample locations included: the mouths of the drowned valleys (coves) in the northwest corner and west-central area; near the northwest shore by the raw water intakes; on the submerged peninsula and several deep water locations. A summary of the results is presented in Table 35.

The data indicate that in deep, quiet water the bulk of the sediments deposited are in the silt and clay size range (Figure 29). This is a very common characteristic of low-energy freshwater lake environments. Outside both of the coves there is an increase in sand as well as the highest percentage of organics found anywhere in the reservoir. Close proximity to the forested ridge and ravine topography in the immediate watershed explains the nature of the deposits in this area. The grain-size distribution of sediments on the submerged peninsula suggests that there has been little deposition of lake sediments on it since the creation of the side-channel reservoir. The peninsula contained farm fields and forest on it before it was submerged; at that time the soil was classified as a loam. Analysis shows that the materials can still be classified as a loam (Figure 30). Near areas of high shoreline erosion values, the sediments are high in sand and contain a very low percentage of organics. This area is constantly receiving new sediments from the glacial till and bedrock shoreline. Samples from the area near the side-channel dike are almost 90% sand. This area was severely impacted during construction of the dike in 1980 and subsequently there has been little cover by clays, silts and aquatic plants.

Table 35. Grain Size Analysis of Reservoir Bottom Sediments.

		Percent			
	Site	Sand	Silt	Clay	Organic
1.	Deepwater	1	61	30	8
2.	Mouth, northwest cove	13	61	15	11
3.	Mouth, west-central cove	3	62	22	13
4.	Old penininsula, submerged	33	43	14	10
5.	Near erosional cliffs	27	53	14	6
6.	Near side-channel dike	89	7	3	1

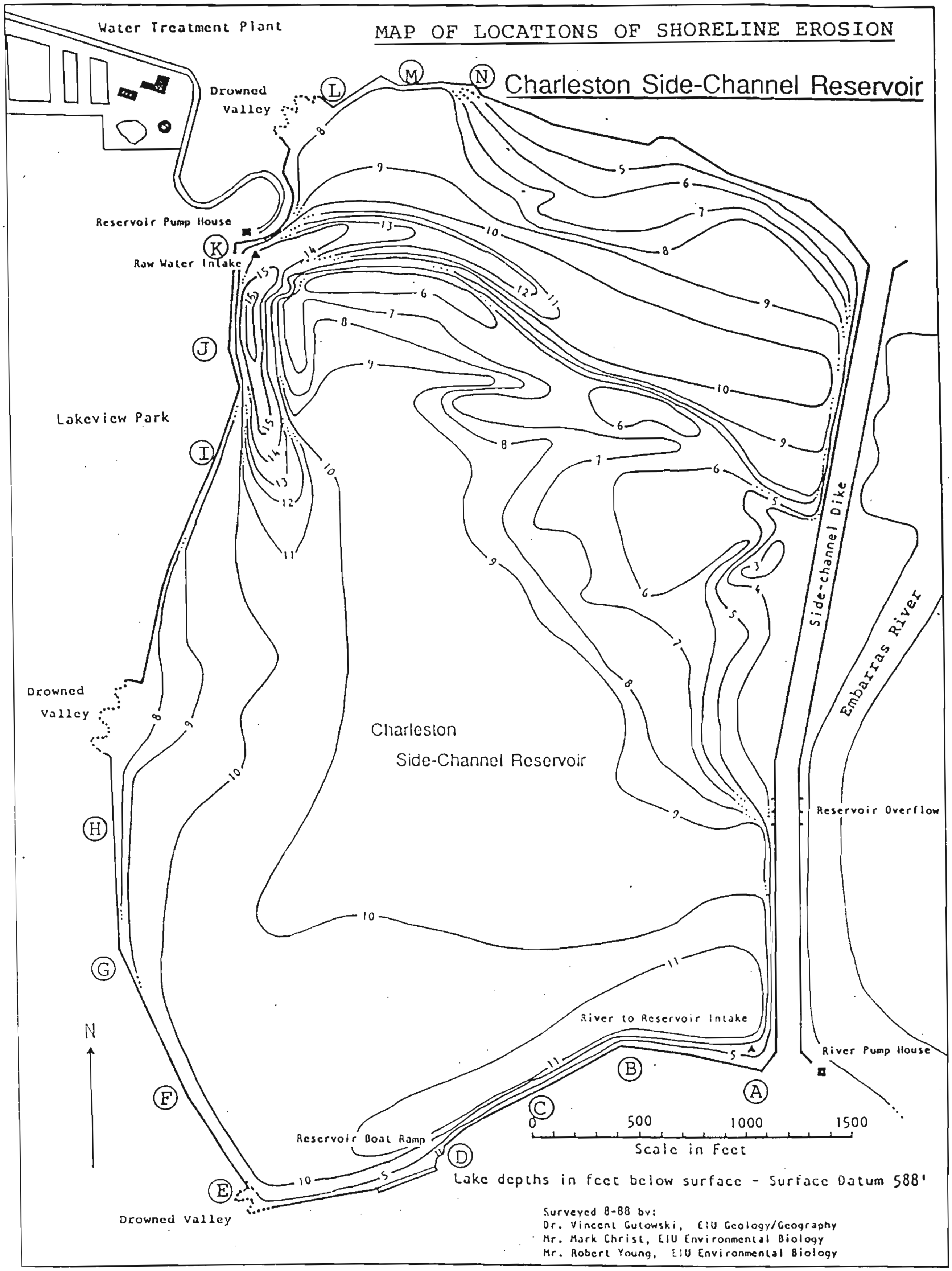


Figure 24. Map of Locations of Active Shoreline Erosion.

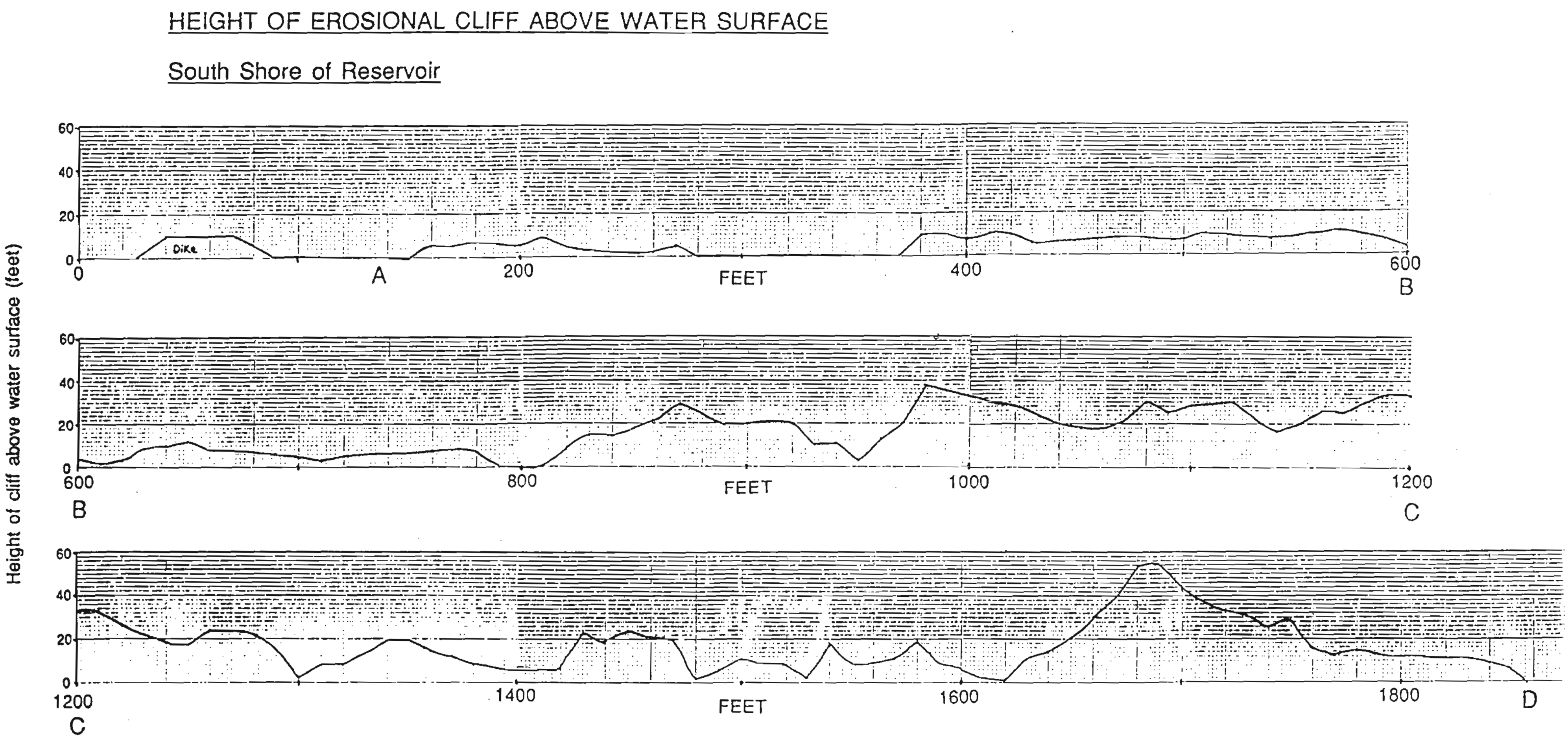


Figure 25. Shoreline Erosion - South Shore of Reservoir.

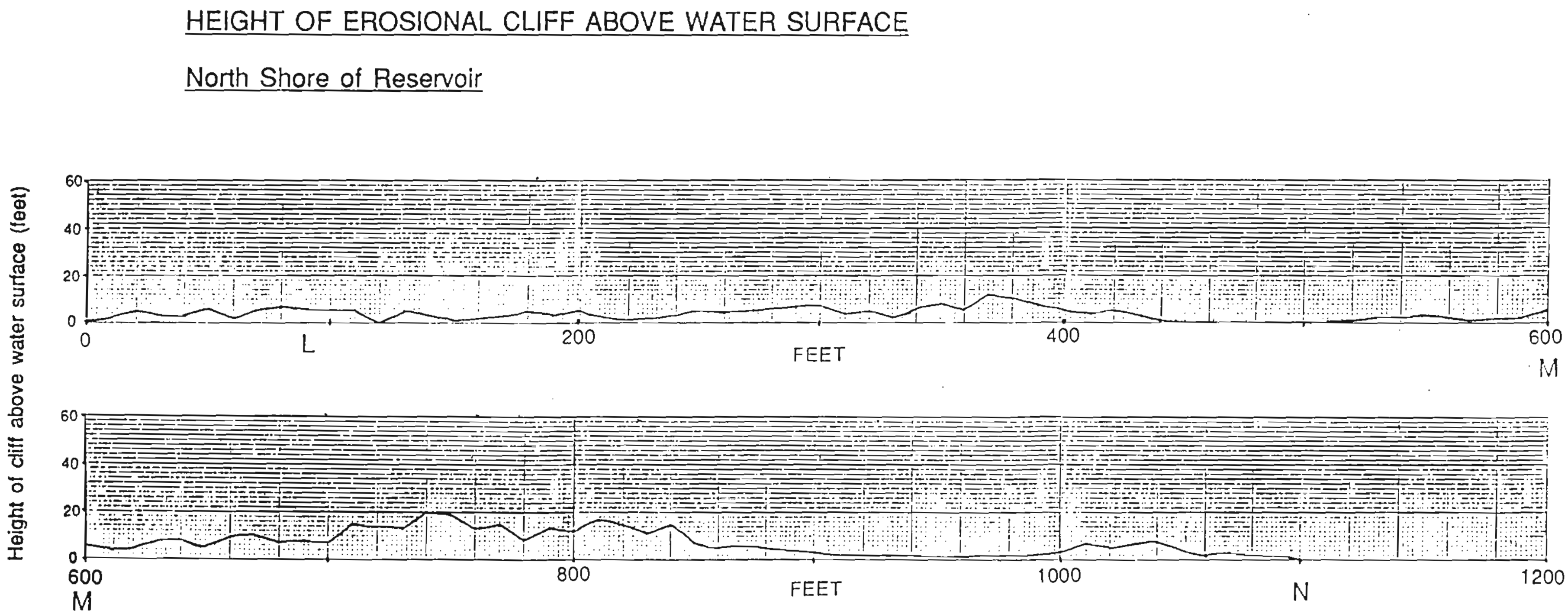


Figure 26. Shoreline Erosion - North Shore of Reservoir.

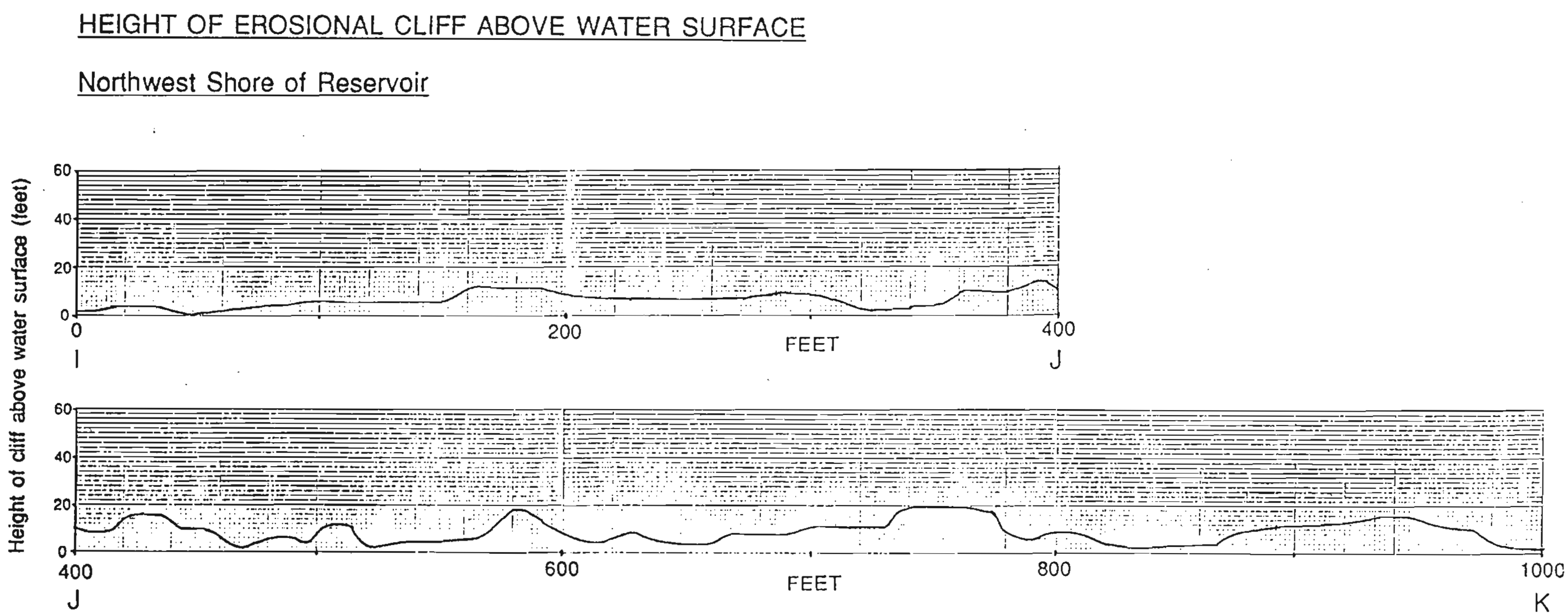


Figure 27. Shoreline Erosion - Northwest Shore of Reservoir.

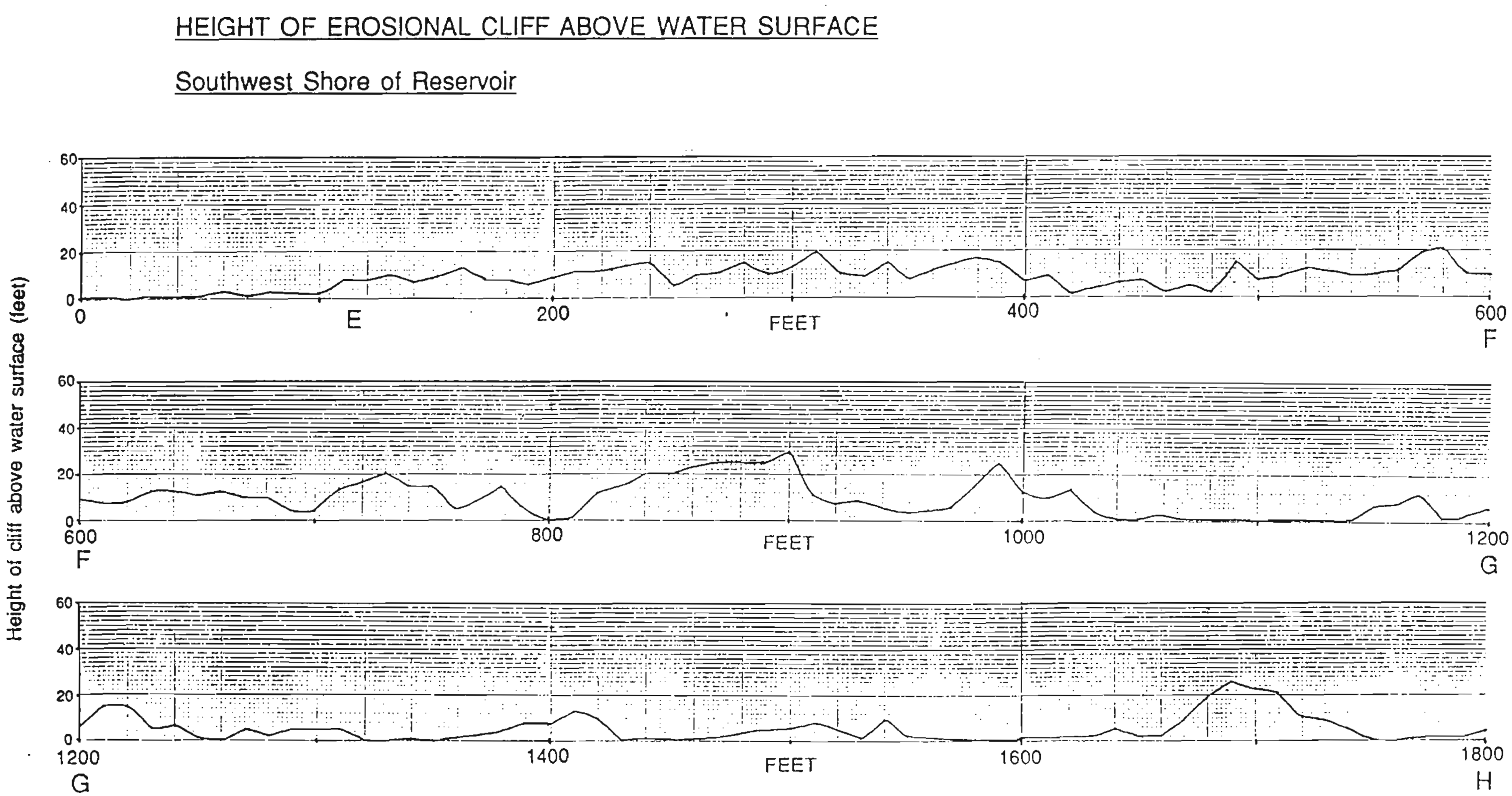


Figure 28 . Shoreline Erosion - Southwest Shore of Reservoir.

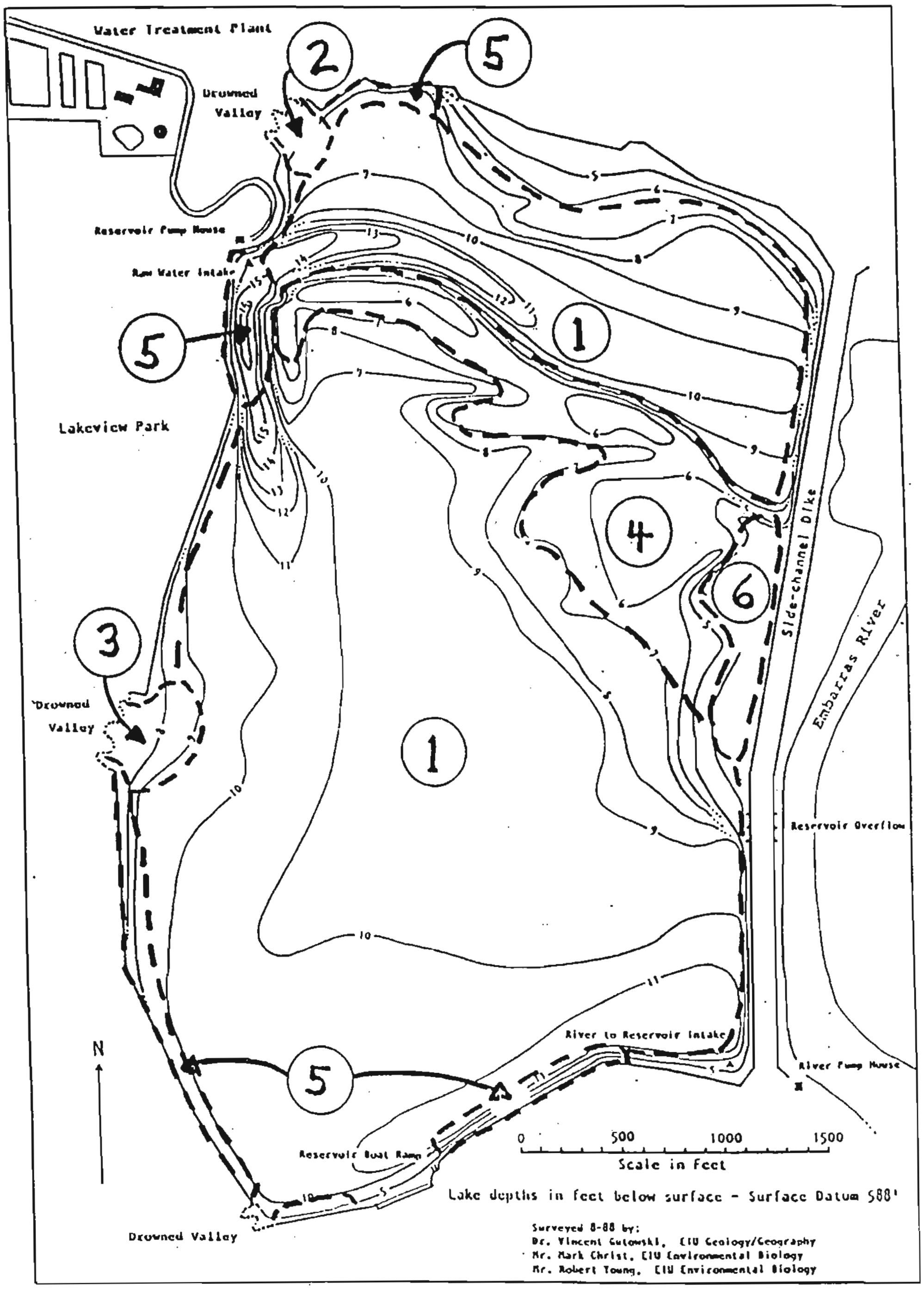


Figure 29. Spatial Distribution of Bottom Sediments, Charleston Side-Channel Reservoir.

	sand %	silt %	clay %	organics %
1. Deepwater	1	61	30	8
2. Mouth, northwest cove	13	61	15	11
3. Mouth, west-central cove	3	62	22	13
4. Old peninsula, submerged	33	43	14	10
5. Near erosional cliffs	27	53	14	6
6. Near side-channel dike	89	7	3	1

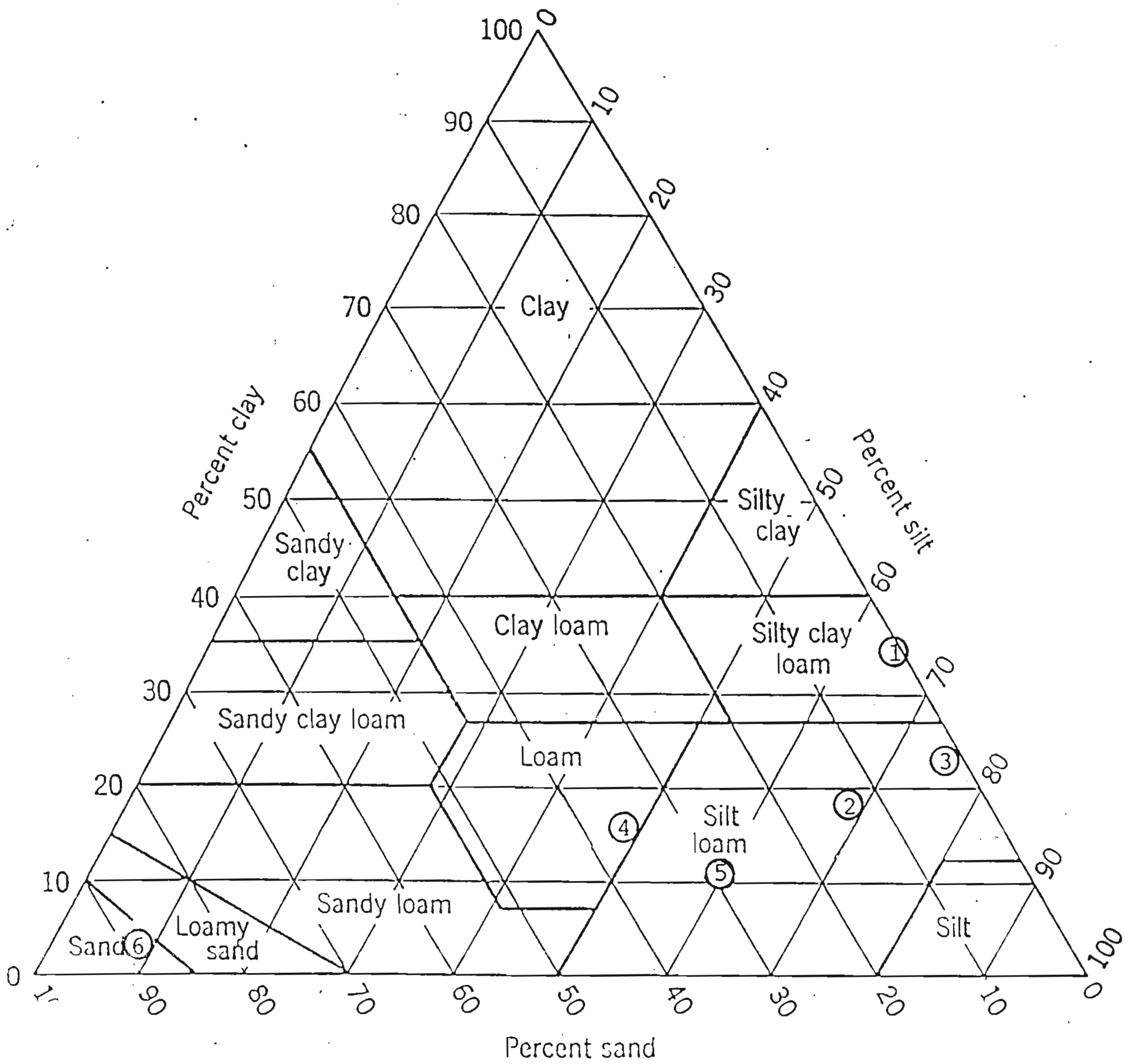


Figure 30. Soil Textural Triangle Illustrating Types of Bottom Sediments Found in Charleston Side-Channel Reservoir (see Figure 27 for locations of sediment types).

Chemical Content of Sediments

The chemical content of the reservoir sediments was studied by three investigative groups. The first group was made up of IEPA staff. On April 20, 1989 they collected a total of three surficial sediment samples. These samples were then sent to the IEPA laboratory in Champaign for analysis of metals and organics. The results of this sampling were discarded when it was learned that the sampling team had collected the samples in an area several thousand feet away from the intended location. On June 14, 1989 this team returned and obtained a surficial sample at site 1 and 3 for organics analysis (Table 36). The June 14, 1989 organics sampling provided results of "at or below detection limits" for all parameters.

The main investigators in the second group were Bonnie Allison and Dr. John R. Marquart. This group used six sites in the CSCR and three sites in LC. Each sample was analyzed for 21 elements. Sample analysis was performed in chemistry laboratories at both the University of Illinois and Eastern Illinois University. Due to a number of problems that developed for this group, it became questionable whether they could meet their goals.

In order to avert a possible short fall of data, a third group, made up of City staff, collected a total of five samples at sites one through five. These samples were analyzed by Daily Analytical Laboratories of Peoria, Illinois. Results of this sampling can be found in Table 37.

After completion of the analysis, the investigators of group two submitted a formal report of their findings. The following is extracted from that report and the complete text may be found in Appendix F. It should be noted that in this excerpt, as in their report, Sites L-1, L-2, and L-3 are reported as Embarras River sites. They are in that portion of the Embarras River system known as Lake Charleston, hence the "L" prefix on the site number.

Metal and Metalloid Analysis

Sediment samples were taken from six reservoir sites (Site 1-Site 6 in Fig. 31). Samples were also taken from three river sites (L1-L3 in Fig. 31).

The samples were treated to extract metals and metalloids and analyzed for concentrations of lead and copper by a Perkin-Elmer Model 2380 Atomic Absorption Spectrophotometer (AAS) with a deuterium lamp background correction. This analysis involved the use of lab space, equipment, and materials from the Chemistry Departments of Eastern Illinois University and the University of Illinois. Forty milliliters of each digested sample were submitted to the

University of Illinois (Urbana-Champaign) Microanalytical Lab (Thomas P. McCarthy) for quantitative analysis of 21 elements by atomic emission on a Perkin-Elmer Plasma 2, Inductively Coupled Plasma Spectrophotometer (ICP).

Comparison of data was made regarding element concentration versus sample site. Comparisons were also made with previously reported results obtained by the IEPA and Daily Analytical Laboratories (Peoria, IL) on a few sediment samples from the Charleston Reservoir, and an extensive study of sediment conducted by the IEPA on 63 Illinois lakes in 1979.

Concentrations of all elements from sediment analysis of the reservoir are summarized in Table 38. Table 38 includes results from analysis performed by the IEPA and Daily Analytical Laboratories on a few sites in the reservoir and data from a 1979 IEPA study of 63 Illinois lakes. Site 3 was excluded from the data shown in Table 38 because the significantly low concentrations at this site were probably due to the scouring action of pumped water which left a sandy texture of the sample instead of sediment.

Comparisons of the AAS and ICP analysis of copper and lead gave predictable results. Copper concentrations agreed within about 10% with the AAS results, usually higher. Lead concentrations were consistently higher by about 25% as determined by AAS. The Perkin-Elmer AS manual states "large excesses of other elements may interfere with the lead signal (e.g., 10,000 mg/L iron enhances the lead signal)". Our extracts contained very high concentrations of iron, aluminum, and calcium. ICP emission analysis operates at about 2500K. The higher temperatures for ICP eliminate most chemical interferences. The ICP data should be relied on over the AAS data. The latter is presented here for information only.

It is known that cadmium, copper, iron, lead, and zinc are toxic at certain concentrations. These 5 metals will be elaborated upon later. The degree of toxicity for each depends upon water conditions such as pH, temperature, hardness, etc. At the reservoir pH, approximately 8-8.5, these metals are insoluble and probably settle in the bottom sediments. Furthermore, it is possible that "heavy metals in sediments can be passed along successive trophic levels (e.g., from heterotrophic bacteria to tubificids to fish)" (IEPA 1979). Both copper and zinc cause death in fish when they precipitate at pH=8-9 and accumulate in the gills. Sublethal effects of zinc have also shown retardation of growth in bluegill and fathead minnows. Thus, it is important that such potentially hazardous metals be monitored, especially in regard to the static condition of the reservoir.

The results indicate that for most of the 21 elements analyzed, there was no significant difference between the concentrations of most metals and metalloids found in the reservoir and those found in the river sediments with a few exceptions (Table 38). Arsenic, calcium, magnesium, manganese and sodium were most abundant in the reservoir by factors ranging from 1.2 to 1.9. Elevated levels of each of these could have come from nearby human activities. Copper was significantly higher in the reservoir due to periodic use of copper sulfate as an algicide. Sampling sites throughout the reservoir showed similar concentrations; therefore, there is no notable increase in metal and metalloid concentrations at sites where water run-off into the reservoir from surrounding high ground is greater. Interestingly, but unexplained, is the apparent trend for the metal and metalloid concentrations in the reservoir sediment to be somewhat higher in June than in September. The possibility that some release of these elements into the water has occurred by September should be considered for further investigation.

Finally, the data obtained for this study should prove to be useful in determining the extent and causes of reservoir pollution and possible solutions for control and management. They should also serve as valuable baseline data from which to ascertain future changes in concentrations. Earlier analyses of metals and metalloids in the sediment are sparse and inconsistent. In October 1988, three samples were analyzed by Daily Lab for six elements. Comparison with our current analysis would suggest that concentrations have increased substantially since then. However, in April 1989, the Illinois Environmental Protection Agency analyzed two samples for 13 elements with one sample giving much higher concentrations than ours and the other about equal to ours. As compared with the 1979 IEPA report on 63 Illinois lakes, the Charleston Reservoir rates favorably "normal" to "low" in the concentrations of the 10 elements studied by IEPA. Anoxic conditions encountered at the bottom of the reservoir can result in certain elements (such as Iron) going to a reduced state (ferrous) which aids its solution into the water (IEPA 1979). We recommend that further sampling and analysis be performed with particular attention paid to the six metals (arsenic, calcium, copper, magnesium, manganese, and sodium) that appeared to be more abundant in the reservoir than in the river.

Specific comments on aluminum, cadmium, copper, iron, and zinc follow:

Aluminum. Excessive accumulation of aluminum was expected to be occurring at Site 4 due to occasional unintentional lime-alum sludge run-off from the water treatment plant. From these data, Site 4 had the second lowest aluminum concentrations of all sites. Thus, no significant elevation of aluminum appears to have occurred at this site. It also appears that aluminum in the river sediment was slightly higher than the reservoir at this time. Aluminum in the river sediment averaged 5426 mg/kg, while the reservoir (excluding Site 3) averaged 3770 mg/kg.

Cadmium. Cadmium is a potentially toxic metal, and has an additive interaction in fish when combined with zinc. The sediment concentrations for the river and the reservoir appear to be about the same. The average for each is 1.1 mg/kg indicating no significant accumulation.

Copper. The application of copper sulfate to control algae is suspected to be the primary source of copper in the reservoir. It has been applied six times in the past three years, twice in 1987, three times in 1988, and once in 1989. Each application includes 2000 pounds of copper sulfate and 1000 pounds of citric acid as a chelator. It is probable that most of the copper precipitates in the alkaline water and settles in the sediment. It appears that copper concentrations were significantly higher in the reservoir sediment than in the river with the exception of Site 3. Reservoir sediment concentrations averaged 7.7 mg/kg. This significant difference reflects accumulation in the reservoir sediments.

Iron. Overall, iron concentrations were considerably higher than other metals except calcium. Elevated concentrations in the reservoir sediments were possibly due to anoxic hypolimnion conditions under which oxidation and precipitation of primarily ferrous sulfide occurs (IEPA 1979). Note that the replicates showing the highest iron levels were taken from greater depths than the other replicates taken at those sites. However, the mean sediment concentrations of the reservoir (excluding Site 3) and the river were about the same. The river averaged 8721 mg/kg and reservoir averaged 8774 mg/kg suggesting no significant accumulation at this time.

Lead. Lead levels in the reservoir sediment do not appear to be significantly different than the river sediments in this study. The reservoir averaged 8.1 mg/kg (excluding Site 3), and the river averaged 7.9 mg/kg. The alarmingly high lead concentration reported by Daily Lab in 1988 at

Site 3 (120 mg/kg) was not evident from this study. Their sample may have contained some lead shot or a lead sinker which would give higher concentrations.

Zinc. Zinc concentrations in the sediment of the reservoir were slightly higher than copper; however, the river had a slightly higher average concentration of zinc than the reservoir. The river sediment averaged 30.9 mg/kg while the reservoir sediment averaged 27.7 mg/kg (excluding Site 3). Therefore, accumulation of zinc is not apparent in the reservoir at this time.

Table 36. Organics Found in Sediments at Sites 1 and 3 on June 14, 1989.

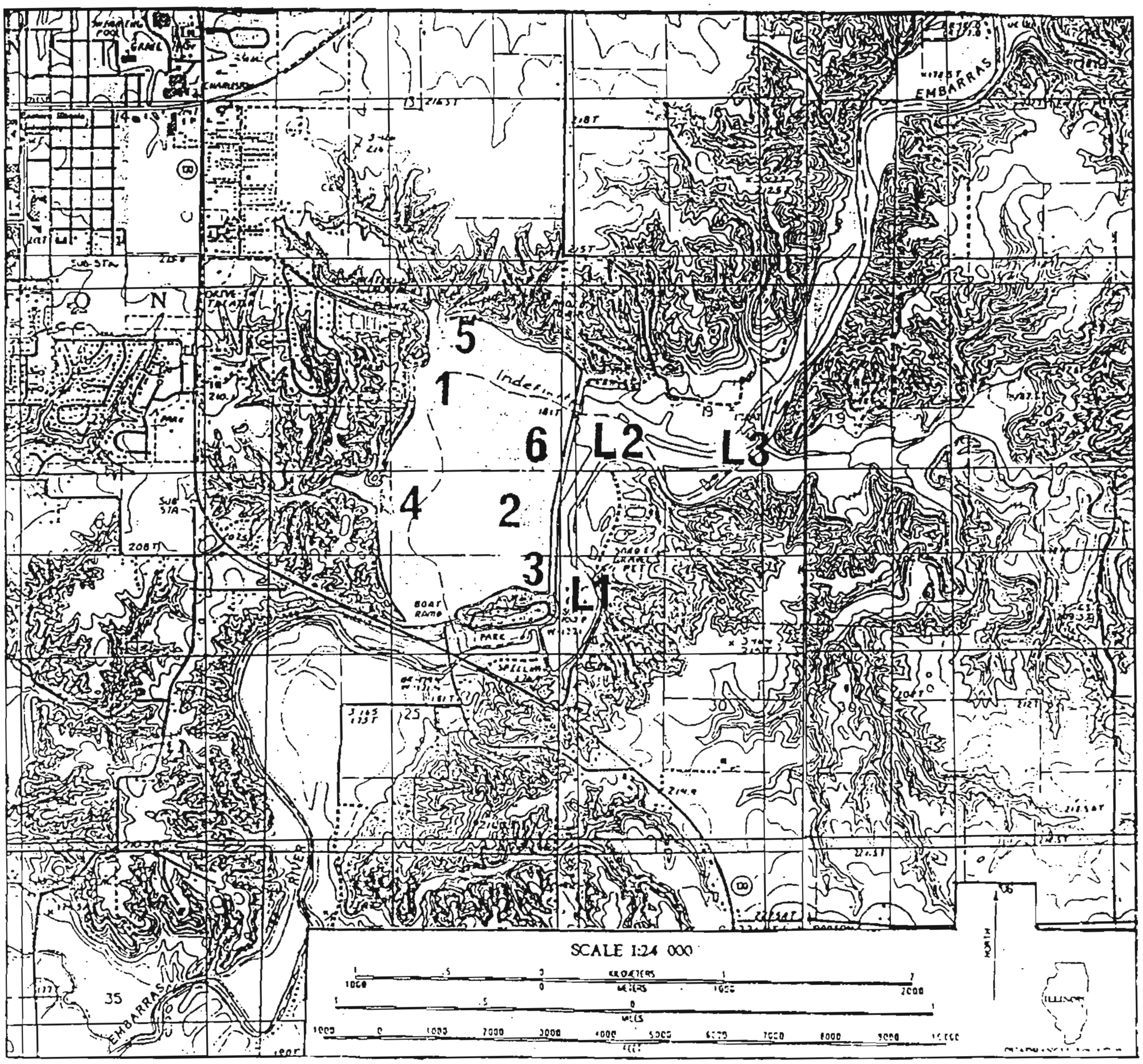
	Site 1	Site 3
Sample depth (feet)	14	5
Parameter	Amount detected* (ug/Kg)	Amount detected* (ug/Kg)
PCB's	10.0	10.0
Aldrin	1.0	1.0
Dieldrin	1.0	1.0
DDT (all analogs)	10.0	10.0
O'P'-DDE	1.0	1.0
P'P'-DDE	1.0	1.0
O'P'-DDD	1.0	1.0
P'P'-DDD	1.0	1.0
O'P'-DDT	1.0	1.0
P'P-DDT	1.0	1.0
Chlordane (Tech. and Met.)	5.0	5.0
Chlordane (C Isomer)	2.0	2.0
Chlordane (T Isomer)	2.0	2.0
Endrin	1.0	1.0
Methoxychlor	5.0	5.0
alpha-BHC	1.0	1.0
gamma-BHC	1.0	1.0
HCB	1.0	1.0
Heptachlor	1	1
Heptachlor epoxide	1.0	1.0

* All of the values indicated above represent the level of detection for that parameter. The true value would be equal to or less than the above values.

Table 37. Charleston Side-Channel Reservoir Sediment Analyses of Samples Collected on 10/31/89.

Metal (mg/kg)	Site 1	Site 2	Site 3	Site 4	Site 5
Al	7800	6900	3500	5300	3800
Cu	11	13	8.3	12	9.7
Fe	7700	6500	5400	5400	4700
Mg	2600	3700	1800	2700	3500
Pb	5.8	5.4	10	4.9	4.4
P	160	36	39	82	110
N	1300	810	550	950	940

Data from analyses performed by Daily Analytical Laboratories.



Side-Channel Reservoir Sampling Sites 1 - 6

Lake Charleston/Embarras River Sampling Sites L1 - L3

Figure 31. Sediment Sampling Sites

Table 38. **Comparison of Various Studies on Sediment Concentrations of 21 Elements in Charleston Reservoir Embarras River, and Other Illinois Lakes mg/kg (ppm)**

	Aluminum	Arsenic	Barium	Beryllium	Cadmium	Calcium
Reservoir Samples, Daily Anal. Lab, (Sites 3, 4, and 5) Oct. 11, 1988						
Site 3	1800	-	-	-	-	-
Site 4	2500	-	-	-	-	-
Site 5	4200	-	-	-	-	-
Reservoir Samples, IEPA (two sites, exact location uncertain) Apr. 29, 1989						
Sample 1	-	3	53.6	-	0.1	-
Sample 2	-	6	-	-	0.1	-
Reservoir Samples, Our Results by ICP (omit Site 3) Jun. 28 and Sept. 21, '89						
Lowest Value	2307	0.20	1.00	0.16	0.75	8779
Highest Value	6218	2.40	27.20	0.30	1.60	29048
Mean	3770	1.40	17.40	0.23	1.15	21341
Standard Dev.	1093	0.74	8.09	0.05	0.25	6237
River Samples, Our Results by ICP, Jun. 28 and Sept. 21, 1989						
Lowest Value	4366	0.69	27.50	0.18	0.89	13004
Highest Value	7113	1.10	39.90	0.42	1.30	15336
Mean	5426	0.84	32.23	0.23	1.13	13875
Standard Dev.	1477	0.23	6.70	0.64	0.21	1273
63 Illinois Lakes, IEPA (1979)						
Lowest Value	-	0.50	-	-	<0.50	-
Highest Value	-	110.00	-	-	8.00	-
Mean	-	12.00	-	-	<1.04	-
Standard Dev.	-	14.60	-	-	-	-
Classification of Charleston Reservoir by Element According to IEPA						
	-	Below Normal	-	-	Normal	-

Table 38. Comparison of Various Studies on Sediment Concentrations of 21 Elements in Charleston Reservoir Embarras River, and Other Illinois Lakes mg/kg (ppm)

	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury
Reservoir Samples, Daily Anal. Lab, (Sites 3, 4, and 5) Oct. 11, 1988							
Site 3	-	4.6	2900	2.3	1000	-	-
Site 4	-	8.7	3900	5.3	3200	-	-
Site 5	-	8.8	5500	120(?)	4200	-	-
Reservoir Samples, IEPA (two sites, exact location uncertain) Apr. 29, 1989							
Sample 1	8.0	22.1	11600	4.4	-	-	0.0005
Sample 2	20.8	52.3	30600	7.3	-	-	0.1050
Reservoir Samples, Our Results by ICP (omit Site 3) Jun. 28 and Sept. 21, '89							
Lowest Value	3.0	11.8	6015	6.3	2856	288	<0.2
Highest Value	6.8	25.2	12647	10.4	11465	592	Background
Mean	4.5	19.5	8774	8.1	5224	381	Equivalent
Standard Dev.	1.1	3.6	1938	1.2	2856	288	Concentration
River Samples, Our Results by ICP, Jun. 28 and Sept. 21, 1989							
Lowest Value	4.8	6.8	7359	6.8	3748	314	<0.2
Highest Value	7.0	9.2	10462	9.4	4590	547	Background
Mean	5.8	7.7	8710	7.9	2913	242	Equivalent
Standard Dev.	1.1	1.3	1590	1.4	2214	164	Concentration
63 Illinois Lakes, IEPA (1979)							
Lowest Value	1.0	3.0	40	3.0	-	500	0.0
Highest Value	75.0	560	55000	250	-	2500	2.4
Mean	21.6	42.0	27100	57.0	-	1300	0.1
Standard Dev.	8.0	56.0	8900	43.0	-	1500	0.2
Classification of Charleston Reservoir by Element According to IEPA							
	Normal	Normal	Below Normal	Below Normal	-	Below Normal	Normal

Table 38. Comparison of Various Studies on Sediment Concentrations of 21 Elements in Charleston Reservoir Embarras River, and Other Illinois Lakes mg/kg (ppm)

	Nickel	Phosphorus	Potassium	Selenium	Silver	Sodium
Reservoir Samples, Daily Anal. Lab, (Sites 3, 4, and 5) Oct. 11, 1988						
Site 3	-	110	-	-	-	-
Site 4	-	170	-	-	-	-
Site 5	-	150	-	-	-	-
Reservoir Samples, IEPA (two sites, exact location uncertain) Apr. 29, 1989						
Sample 1	8.2	240	409	-	1.0	-
Sample 2	21.2	633	1673	-	0.1	-
Reservoir Samples, Our Results by ICP (omit Site 3) Jun. 28 and Sept. 21, '89						
Lowest Value	4.7	222	172	4.4	0.05	30.2
Highest Value	9.1	460	565	10.6	0.14	67.2
Mean	6.8	311	303	5.9	0.08	45.6
Standard Dev.	1.3	66	112	1.7	0.02	11.9
River Samples, Our Results by ICP, Jun. 28 and Sept. 21, 1989						
Lowest Value	6.5	279	334	5.0	0.06	27.7
Highest Value	8.6	421	533	10.9	0.10	44.3
Mean	7.5	330	422	7.8	0.07	36.7
Standard Dev.	1.1	79	101	3.0	0.02	8.3
63 Illinois Lakes, IEPA (1979)						
Lowest Value	-	160	-	-	-	-
Highest Value	-	4930	-	-	-	-
Mean	-	703	-	-	-	-
Standard Dev.	-	476	-	-	-	-
Classification of Charleston Reservoir by Element According to IEPA						
	-	Below Normal	-	-	-	-

Table 38. Comparison of Various Studies on Sediment Concentrations of 21 Elements in Charleston Reservoir Embarras River, and Other Illinois Lakes mg/kg (ppm)

	Strontium	Vanadium	Zinc
Reservoir Samples, Daily Anal. Lab, (Sites 3, 4, and 5) Oct. 11, 1988			
Site 3	-	-	-
Site 4	-	-	-
Site 5	-	-	-
Reservoir Samples, IEPA (two sites, exact location uncertain) Apr. 29, 1989			
Sample 1	-	-	31.3
Sample 2	-	-	73.5
Reservoir Samples, Our Results by ICP (omit Site 3) Jun. 28 and Sept. 21, '89			
Lowest Value	6.1	5.4	19.1
Highest Value	19.9	9.6	38.1
Mean	15.3	7.2	27.7
Standard Dev.	4.2	1.3	6.0
River Samples, Our Results by ICP, Jun. 28 and Sept. 21, 1989			
Lowest Value	11.5	5.4	25.9
Highest Value	15.8	7.2	39.3
Mean	13.8	6.3	30.9
Standard Dev.	2.2	0.9	7.3
63 Illinois Lakes, IEPA (1979)			
Lowest Value	-	-	11.0
Highest Value	-	-	750.0
Mean	-	-	113.0
Standard Dev.	-	-	66.0
Classification of Charleston Reservoir by Element According to IEPA			
	-	-	Below
	-	-	Normal

Elutriation Test

In the event that restoration activities would include dredging, an elutriate sample was collected. The elutriate test is performed in order to address possible concerns over potential release of harmful material to the water column or leaching from spoils at dredging disposal sites. On March 19, 1991 a core sample was collected from a location between site 1 and the raw water intake. Sections of PVC pipe totaling 30 feet were used as a core sampler. Two cores were collected both being between 3 and 4 feet in length. The cores were composited to make a single sample. The sediment material was shipped to Daily Analytical Laboratories of Peoria, Illinois.

A comparison of the water sample and elutriate test results (Table 39) to the GUS (Table 22) indicates that all of the parameters analyzed comply with the GUS. There is a possible exception; the detection limit for silver was 0.01 mg/L, but the GUS has a 0.005 limit. The results of the sediment portion of the elutriation test (Table 39) compare favorably with the IEPA study of 63 Illinois lakes (Table 38) (IEPA 1979). It should be noted that of the 8 metals analyzed in the elutriation test only arsenic, cadmium, chromium, lead, and mercury were also part of the 1979 IEPA study. All of these five metals were equal to or below the mean values reported in the 1979 IEPA study. The CSCR core sediment lead level was more than one standard deviation below the mean but above the lowest level recorded for the 1979 IEPA study.

Table 39. Water, Sediment and Elutriate Analyses for Site 1 Samples Collected 3/21/91.

METAL	WATER (mg/L)	SEDIMENT (mg/kg)	ELUTRIATE (mg/L)
Arsenic	<0.01	12.0	<0.01
Barium	0.05	83.0	0.10
Cadmium	<0.005	0.17	<0.005
Chromium	<0.01	15.0	<0.01
Lead	<0.01	6.4	<0.01
Mercury	<0.0002	0.024	0.0002
Selenium	<0.005	<1.4	<0.005
Silver	<0.01	<0.14	<0.01

Hydrologic Budget

The generalized equation for the water budget of a lake is

$$\text{input} = \text{output} \pm \Delta \text{ storage.}$$ (Cook et. al. 1986)

For the CSCR, input is the sum of stream and groundwater flow, direct precipitation on the reservoir surface, non-channelized overland flow and pumping from LC. Output is the sum of groundwater outflow, overflow releases, evaporation and pumping to the Charleston water treatment plant. The net change in storage has to be factored into this budget.

For this report, the components of the hydrologic budget were monitored from May 1989 to April 1990. The monthly operational records were used to determine the amount of water pumped into and out of the CSCR. A Venturi tube measures the amount of water pumped into the plant. The amount of water pumped into the CSCR is determined by use of hour meters on each pump and by pump curves. Direct precipitation was determined by use of a precipitation gauge at the water treatment plant. Evaporation data for May to September 1989 was based on pan evaporation data from the ISWS Urbana station. Evaporation amounts from October 1989 to April 1990 were estimated because the Urbana station does not monitor evaporation during this part of the year. Storage or surface level elevation was determined by use of a staff gauge on the intake structure in the northwest corner of the CSCR. Water discharge from the reservoir overflow pipes was calculated based on storage elevation and discharge formulas for the overflow pipes. Water that is inadvertently released from the water treatment plant ("plant discharge") is included as part of the in-flow water and has been previously described on page 24.

Due to budgetary constraints, the groundwater input and output and the non-channelized overland flow were not monitored and are treated as part of the residual term of the hydrologic equation. Field observations, made when the Riverview Dam repairs were not complete, showed that there was seepage along the west dike. This may have been due in part to the abnormally large difference between the water levels on either side of the dike.

Measurement of stream flow into the CSCR presented investigators with many problems. Due to the steep transition from the upper watershed to the reservoir level, good stream monitoring locations were difficult to find. Due to the low or nonexistent base flow of these streams, a one foot "V" notch weir was used for flow measurement. While monitoring these weirs, several large storm events caused an overflow of the weirs. It would have been desirable to use continuous flow monitoring equipment in this study, however, the close proximity of a subdivision and numerous signs of vandalism deterred investigators from using such equipment. Manual reading of these weirs provided good baseflow data but were inadequate for storm events. Thus the storm water contribution to the hydrologic budget is considered as part of the residual term.

The key difference in this hydrologic budget as compared to a natural system is the partial ability to offset weather conditions through pumping. An example of this would be raising the level of the CSCR through pumping during a period when the reservoir level would otherwise be falling. The hydrologic budget depicted in Table 40 shows that, of the contributions that can be accounted for, 51.3% of the input and 66.7% of the output is from pumping. The second largest input contribution was from precipitation and makes up 41.2% of the total. Only 6% of the input came from stream baseflow. The overflow portion is only 2.1% of the total outflow, while evaporation accounts for 31.2%.

Comparisons of the budget to long term averages

The average annual precipitation for this portion of central Illinois is over 38 inches. Table 40 reports 38.23 inches of rain for the study year. Roberts and Stall (1967) reported that the mean annual lake evaporation at Urbana, Illinois was 30.5 inches and that 50% of the time the annual lake evaporation would be at least 31.2 inches. The evaporation for the hydrologic budget study year was 31.3 inches. The average annual pumping of water from LC to the CSCR is 427.861 MG. The annual pumping of water out of the CSCR to the water plant is 600.131 MG. The study year placed the input pumping at 424.032 MG. and the pumping output at 597.253 MG. There is less than a 4 million gallon difference between the budget year pumping totals and their respective long term averages.

Table 40. Hydrologic Budget

	1989								1990					
	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	YEAR	%
PUMP IN (MG)	0	25.464	86.016	10.824	0	0	22.008	172.392	42.312	1.008	21.336	42.672	424.032	51.3
RAIN INCHES	2.51	3.16	5.35	3.76	8.26	0.97	1.19	1.01	1.57	5.3	1.68	3.47	38.23	
RAIN (MG)	22.4	28.1	47.7	33.5	73.6	8.6	10.6	9.0	14.0	47.2	15.0	30.9	340.5	41.2
BASEFLOW (MG)	10.5	2.1							1.7	8.4	12.6	16.8	52.1	6.3
PLANT DISCHARGE	0.770	0.434	0.901	0.718	1.023	0.977	0.829	1.049	0.719	0.946	0.619	0.684	9.669	1.2
TOTAL (MG)	33.6	56.1	134.6	45.0	74.6	9.6	33.4	182.4	58.7	57.6	49.5	91.1	826.3	100.0
PUMP OUT (MG)	48.994	48.308	49.556	53.272	58.096	54.999	50.649	47.18	48.853	44.082	45.732	47.532	597.253	66.7
OVERFLOW (MG)	18.530	0.130	0	0	0	0	0	0	0	0	0	0.156	18.816	2.1
EVAPORATION INCHES	4.9	6.3	6.2	5.2	2.7	2.0	1.0				1.0	2.0	31.3	
EVAPORATION (MG)	43.645	56.115	55.225	46.317	24.049	17.814	8.907	0	0	0	8.907	17.814	278.795	31.2
TOTAL (MG)	111.2	104.6	104.8	99.6	82.1	72.8	59.6	47.2	48.9	44.1	54.6	65.5	894.9	100.0
IN - OUT (MG)	-77.5	-48.4	29.8	-54.6	-7.5	-63.2	-26.1	135.3	9.9	13.5	-5.1	25.6	-68.5	
RESERVOIR LEVEL CHANGE (MG)	0	-70	20	-30	9	-40	-70	-9	100	0	-9	40	-62	

WATER LEVEL CHANGE (INCHES)	-7	LEVEL CHANGE - (INPUT-OUTPUT) = NET GROUND WATER + STORM WATER FLOW
WATER LEVEL CHANGE (MG)	-62	-62 - -68.5 = 6.5
NET GROUND WATER + STORM FLOW (MG)	6.5	

Sources: Pumping, rainfall and water level data from City of Charleston Water Treatment Plant Records
Evaporation data calculated from Illinois State Water Survey data
Overflow based on reservoir level and discharge formula for overflow pipe
Plant discharge based on Plant records and estimates of flow rate

Nutrient Budget

The two nutrients most commonly studied in lake or reservoir nutrient budgets are phosphorus and nitrogen. Nitrogen and phosphorus have become widely accepted as the two main nutrients involved in lake eutrophication. There are other nutrients that have acted as a secondary limiting nutrient in specific bodies of water (Collins 1988). As previously stated on page 31, there has been a reduction in the silica concentration after closure of the CSCR. When investigations began, silica was not considered of significance and was not included as a parameter for study.

This study focused on the concentration of phosphorus and nitrogen. Due to problems associated with the determination of nitrogen in contributions from shoreline erosion, internal loading, and nitrogen-fixing blue-green algae, the phosphorus portion of the budget contains the most complete set of data.

Nutrient loads from LC pumping, tributary baseflow, raw water pumping to the treatment plant, and CSCR overflows are calculated based on the water volumes used in the water budget. The monthly water volumes were multiplied by the average nutrient value for that month. The hydraulic budget described the problems accosted with monitoring watershed flow contributions. This problem also affected (under estimated) watershed nutrient loading data. To augment the watershed data some SCS data was incorporated into the budget (Table 42). The yearly totals and their percentage of total load can be located in Table 42.

Mr. Van C. Bowersox, Director of the Office of Precipitation Quality of the Illinois State Water Survey, provided nutrient values for wet deposition flux. This was based on data from the National Atmospheric Deposition Program (NADP). Multi-year (5-7 year) averages from three NADP sites were used to produce values for the CSCR. Three NADP parameters were applicable to the CSCR nutrient budget: Ammonium-N, Nitrate-N, and Phosphate-P. Since the NADP did not measure total or total dissolved phosphorus, the value was listed under both headings. Orthophosphate would be a fraction of both.

An estimation of the loading from shoreline erosion was developed with data supplied by Dr. Vince Gutowski and Dr. Ted Peck. The volume of material that has eroded into the CSCR to date and an annual shoreline erosion rate were estimated by Dr. Gutowski. The range of the annual volume of eroded material was between 33,330 cubic feet and 55,556 cubic feet per year. Dr. Peck of the Department of Agronomy at the University of Illinois indicated that the average density of the eroded material would be between 1.35 to 1.40 and the total phosphorus content would be between 1 to 2 pounds per short ton (2000 lbs.). For utilization in the nutrient budget, the most conservative values were used. This produced an annual shoreline total phosphorus load of 636.62 Kg.

Quantifying the internal nutrient loading of the CSCR presented several problems. Reviewing the original or qualifying conditions of internal loading models served to point out the complicating factors in managing the CSCR. In looking at loading models, the manager must ask whether or not the model is for bodies of water that thermally stratify. If they do stratify, do they remain stratified from about May to September? Does the water body become anoxic or not, and is it phosphorus limited? Other factors that must be considered are tropic state, wind, temperature, and pH. The CSCR is a hypereutrophic body that will stratify, but only weakly. Stratification is not uniform across the CSCR and may not last from one sampling period to the next. Anoxia, when present, is found mainly in the deeper areas of the CSCR and is not always associated with stratification. This is due in part to the large amount of organic activity and the large fetches found at the CSCR.

For the determination of the internal phosphorus load, four loading rates were employed (Table 41). The first is the minimum aerobic values of 0.5 $g/m^2/yr$ and the second is the maximum aerobic value of 5.0 $g/m^2/yr$, suggested by the USEPA's "Clean Lakes Program Guidance Manual". The third is the maximum rate reported by Jacoby (1981) of 5.6 $mg/m^{-2}/day^{-1}$ for a non-stratified, aerobic, shallow, and eutrophic lake affected by high pH. The fourth loading rate is derived from calculations of the biweekly nutrient loads. This was patterned after a formula from Jones (1990), though the CSCR cannot be considered a dendritic lake. This fourth rate proved to be the lowest and is probably an underestimation of the true value.

The first three estimates of internal phosphorus loading show that internal loading is the largest contributing source. The fourth estimation would place the internal phosphorus load second only to shoreline erosion. Even if loading from shoreline erosion was estimated with less conservative numbers, it would not alter the overall perception that internal loading and shoreline erosion are the two largest contributors of phosphorus. The USEPA suggested rate of 0.5 $g/m^2/yr$ was used in the annual nutrient budget (Table 42). The third largest contributor would be from water pumped in from LC.

Table 41. Internal Nutrient Loading Estimations

Method	Annual Load	Percent of Total
USEPA low	663.7 Kg/year	45.64%
USEPA high	6637.1 Kg/year	89.36%
Jacoby	2713.2 Kg/year	77.44%
biweekly	442.0 Kg/year	35.87%

Three other phosphorus sources were investigated during this study: oiler discharge from lake pumps, waterfowl, and septic system discharge. The pumps used to pump water from LC to the CSCR are lubricated by an oil drip system. The type of oil used in this system contains an additive of zinc dithiophosphate. If all the oil used in the pumps made its way into the water and if all the phosphate was available, neither of which is true, the dosage would be 0.033 parts per billion as phosphorus. Although this is an insignificant contribution, it would be highly desirable to convert the lubrication system from oil to water.

The resident population of waterfowl at the CSCR has not been quantified. Observations show that the CSCR has a small resident waterfowl population. In Gremillion's study (1986) of two hypereutrophic lakes, the duck and goose population accounted for 7 to 8% of the annual phosphorus loading. The number of waterfowl reported per hectare on these two lakes would be equal to 2229 to 2919 total waterfowl on the CSCR. According to Ron Bradley, long time bird watcher at the CSCR, the peak migratory population normally numbers between 500 and 1000 and remain for approximately one week. Based on this set of information, the waterfowl phosphorus loading is insignificant.

The septic systems for the homes on the north side of the area called the "Lake Island Tract" have been a source of concern since the CSCR was completed. Attempts were made in 1988 to develop sample site locations that would aid in quantifying phosphorus and bacterial discharges from these septic systems. The results of this work were inconclusive for the Lake Island Tract. From the literature, values of 0.88 Kg/person/year with 80% soil retention and 0.93 Kg/person/year with 0% soil retention were found (Jacoby 1982; Mitchell 1984). These homes have a total resident population of 10. The loading values mentioned above give a range of 8.8 to 9.3 Kg/year. This is less than 1% of the total phosphorus load and only 6.6 percent of the phosphorus load from pumping.

In addition to the three potential sources listed above, Christ (1990) suggested that the abundant gizzard shad population of the CSCR may be affecting internal nutrient loading. As gizzard shad mature they change from a planktivore to a benthophagous fish. The gizzard shad along with other benthophagous fish can significantly increase soluble phosphorus, presumably due to detritus digestion (Brabrand 1990). The effect of benthophagous fish on nutrient loading in the CSCR is yet to be quantified but it is highly likely that Mr. Christ's assertion is valid.

Nitrate and ammonia inputs exceed the output (Table 42). In both the input and output of ammonia, the values are somewhat low and were calculated from data containing many values for limits of detection. The nitrate values recorded from samples collected in the CSCR were also low or below the limits of detection. The values for nitrate from 23 LC samples averaged 6.68 mg/L-N. This accounts for the large difference between nitrate input and output. From this, one can infer that the CSCR is acting as a nitrate sink. The high phytoplankton population and low N/P ratios (see pages 60 and 121) would suggest that the nitrate becomes tied up in the algae biomass.

The two largest sources of Total Solids (TS) loading came from the watershed and shoreline erosion (47.2 and 32.1% of total, respectively). The third largest source of TS load came from Lake pumping (35.15% of total). Lake pumping TS was greater than the total output of TS from the CSCR. It would appear that the CSCR acts as a net solids trap. For each type of solid analyzed, over 95% of the outflow contribution was from raw water pumping. The total net loading of Suspended Solids (SS) and Volatile Suspended Solids (VSS) in Table 42 are negative values. Organic matter is a component of both SS and VSS (APHA 1980). The reservoir's algae blooms may be the prime reason SS and VSS have a net negative load.

Table 42. Nutrient Budget

For the Charleston Side-Channel Reservoir

PARAMETER					Phosphorus			
LOCATION	NITRATE Kg/year	%	AMMONIA Kg/year	%	TOTAL Kg/year	DISS. %	TOTAL Kg/year	%
TO PLANT	942.87	97.77	396.53	97.60	73.646	97.72	302.932	97.68
OVERFLOW	21.51	2.23	9.73	2.40	1.715	2.28	7.2	2.32
TOTAL OUT	964.38		406.26		75.361		310.132	
FROM LC	8606.39	90.88	251.08	40.04	74.192	88.78	141.764	9.45
H2O-SHED#	464.5	4.90	97.12	15.49	4.163	4.98	52.18	3.48
BACKWASH	17.7	0.19	6.2	0.99	0.690	0.83	1.39	0.09
PRECIP.	381.71	4.03	272.65	43.48	4.522	5.41	4.522	0.30
SHORELINE							636.62	42.44
INTERNAL *							663.7	44.24
TOTAL IN	9470.3		627.05		83.567		1500.176	
IN - OUT	8505.92		220.79		8.205		1190.044	

LOCATION	SUSPEND SOLIDS Kg/year	%	TOTAL SOLIDS Kg/year	%	VOLATILE SOLIDS Kg/year	%	VOLSUS SOLIDS Kg/year	%
TO PLANT	94039.2	98.56	672160	96.34	213450	95.62	23031.7	97.48
OVERFLOW	1370.9	1.44	25551	3.66	9782	4.38	594.8	2.52
TOTAL OUT	95410.1		697711		223232		23626.5	
FROM LC	46479.6	50.67	769435	19.41	260590	88.29	9127	71.08
H2O-SHED#	951.3	1.04	1872461	47.24	25819	8.75	315.6	2.46
BACKWASH	44299	48.29	48528	1.22	8735	2.96	3397	26.46
SHORELINE			1273242	32.12				
TOTAL IN	91729.9		3963666		295144		12839.6	
IN - OUT	-3680.2		3265955		71912		-10786.9	

* Phosphorus is based on low aerobic value from USEPA 1980 "Clean Lakes Program Guidance Manual"

\# = Values for NO3, NH3, TP and TS are SCS estimates

All other values for H20-shed are based on City baseflow data

Trophic State

Carlson's Trophic State Index (TSI) is best suited for lakes with few macrophytes and little non-algal turbidity (Carlson 1977). The CSCR has few macrophytes and a major portion of its turbidity is from the algae biomass. Carlson's TSI uses a scale of 0 to 110 and is indexed to the algae biomass. How well the CSCR fits Carlson's index is pointed out by the mean (74) and the standard deviation (2.1) of the TSI values. Table 43 lists the average TSI per year by method and investigator. All of the averages place the CSCR in the hypereutrophic range. When looking at the individual samples from 1988 to 1990, the corresponding TSI values ranged form eutrophic to hypereutrophic.

Table 43. Carlson Trophic State Indices for the SCR (1988-1990)

		Charleston WTP		IEPA		CWTP and IEPA	
		AVG	TSI	AVG	TSI	AVG	TSI
1988							
	Secchi Disk (m)	0.36	75			0.36	75
	Total P (mg m-3)	176	78.7	111	72.1	144	75.4
	Chl-A (mg m-3)			67.86	72	67.86	72
	Average TSI		77		72.1		74
1989							
	Secchi Disk (m)	0.38	74	0.38	74	0.38	74
	Total P (mg m-3)	131	74.5	100	70.6	116	72.6
	Chl-A (mg m-3)	76.1	73.1	69.71	72.2	72.9	72.7
	Average TSI		74		72		73
1990							
	Secchi Disk (m)	0.36	75			0.36	75
	Total P (mg m-3)	130	74.3	154	76.8	142	75.6
	Chl-A (mg m-3)	63.4	71.3			63.4	71.3
	Average TSI		74		76.8		74

Average TSI (1988-1990) = 74
Standard Deviation = 2

Limiting Algal Nutrient Analysis

In 1988 an algal assay was planned in order to address the limiting nutrient portion of this study. Due to problems that developed with an incubation room and the difficulty in enumeration, this method was abandoned. Reliance was then placed on the use of nitrogen and phosphorus ratios.

The ratios between total nitrogen and total phosphorus are considered to have a midpoint of 15. The farther away from that midpoint the greater the certainty of the limiting nutrient. The USEPA "Clean Lakes Program Guidance Manual" suggests using ratios of ten or below to indicate nitrogen limited waters. The use of 13 or lower was suggested by Cooke (1986) for nitrogen limitation in his overview of monitoring data evaluation. Both Cooke and the USEPA guidance manual suggested the use of 20 or above to indicate phosphorus limited waters.

The May to October monthly average N/P ratios for 1989 and 1990 reveal that there are frequently periods when the ratio is between 13 and 20 (Table 44). It also shows definite periods when ratios were below 10. Only one monthly average at one site produced a ratio of 20 or above. There appears to be a tendency for the fall to be nitrogen limited with the other months being a mix of conditions. Pumping and internal phosphorus releases may have a major effect on this ratio.

Table 44. Total Nitrogen / Total Phosphorus Ratios for the Side-Channel Reservoir (1989 - 1990) Monthly values taken from I.E.P.A. data

1989

SITE	May	June	July	Aug.	Sept.	Oct.	AVG
1	19.3	17.5	18.0	15.0	7.3	6.7	14.0
2		13.5	19.8	16.5		7.6	14.4
3	18.6	16.4	15.5	9.8	8.9	6.0	12.5
SCR Mean	13.6						

1990

SITE	May	June	July	Aug.	Sept.	Oct.	AVG
1	1.1	18.4	16.2	15.2	9.6	21.8	13.7
2	1.2	18.2	15.3	15.5	1.1	13.4	10.8
3	1.2	16.4	17.1	18.3	0.6	9.1	10.5
SCR Mean	11.7						

Section (a) (11) Biological Resources and Ecological Relationships

In the previous section (a) (10) several components of the CSCR's biological resources were discussed. This was done because those components are an integral part of the limnology of the CSCR. They are also components that are widely used as indicators of the current health of a body of water. The biological components listed in this section (a) (11) are no less important but are either not directly related to the CSCR's limnology or are not a widely used indicator of a lake's health.

Birds

Ron Bradley has been an avid bird watcher for many years. Over the years Mr. Bradley has kept a log of the various sitings he has made. From 1983 to present, that log has included his observations at the CSCR. Table 45 is a list of the birds that are common or fairly common at the CSCR. A more detailed list of common to rare birds can be found in Appendix G. Mr. Bradley has included information regarding which birds are migrant or resident, high counts and dates of rare sightings.

Herpetological species

From the larger more visible Red-Eared Turtles basking on floating logs to the small but vocal calls of the Spring Peeper, the amphibians and reptiles of the CSCR can be an aestheticly pleasing group of animals to observe. Dr. Edward Moll, Professor at Eastern Illinois University and an internationally recognized expert in his field, provided us with information on the amphibians and reptiles found at the CSCR. The species list in Table 46 contains information on abundance, habitat and diet. This list contains one specie, Clonophis kirtlandi, that is on the Watch List for Federal Endangered Species.

Mammals

Since the beginning of the application process for this grant (Fall 1987), there has been an almost daily increase of urbanization pressure on wildlife habitat within the CSCR watershed. The City Council and Board of Zoning have taken no action to curb the rate of development or to impose reasonable guidelines by which to govern developments or construction activities. With continued development of this land we can expect that the mammals listed as uncommon (Table 47) will become rare, and the rare mammals will simply fail to be seen again in this area.

Dr. Richard D. Andrews, a Professor with the Department of Zoology at Eastern Illinois University and long time resident of Coles County, provided the list in Table 47. The information is based on Dr. Andrews' experience and on the most recent reference to Illinois mammals (Hoffmeister 1989).

Table 45. Birds of the Side-Channel Reservoir
Information by Ron Bradley

Species of Common Birds:

Common Loon	Red-breasted Merganser	Tree Swallow
Pied-bill Grebe	Turkey Vulture	Barn Swallow
Great Blue Heron	Osprey	Blue Jay
Canada Goose	American Coot	American Crow
Mallard	Killdeer	Carolina Chickadee
Gadwall	Ring-billed Gull	Tufted Titmouse
American Wigeon	Mourning Dove	House Wren
Northern Shoveler	Belted Kingfisher	Carolina Wren
Wood Duck	Northern Flicker	Gray Catbird
Lesser Scaup	Red-bellied Woodpecker	Brown Thrasher
Common Goldeneye	Red-headed Woodpecker	American Robin
Ruddy Duck	Downy Woodpecker	Wood Thrush
Veery	White-breasted Nuthatch	Swainson's Thrush
European Starling	Red-eyed Vireo	Tennessee Warbler
American Redstart	House Sparrow	Common Grackle
Northern Cardinal	Red-winged Blackbird	Indigo Bunting
House Finch	Rose-breasted Grosbeak	Dark-eyed Junco

Species of Fairly Common Birds:

Horned Grebe	Ring-necked Duck	Hooded Merganser
Bufflehead	Double-crested Cormorant	Common Merganser
American Black Duck	Red-tailed Hawk	Northern Bobwhite
Gadwall	Ring-necked Pheasant	Lesser Yellowlegs
Northern Pintail	Spotted Sandpiper	Herring Gull
Green-winged Teal	Pectoral Sandpiper	Bonaparte's Gull
Blue-winged Teal	Least Sandpiper	Chimney Swift
Redhead	Semipalmated Sandpiper	Eastern Kingbird
Acadian Flycatcher	Yellow-bellied Sapsucker	Bank Swallow
Eastern Wood Pewee	Great-crested Flycatcher	White-eyed Vireo
Rough-winged Swallow	Northern Mockingbird	Warbling Vireo
Gray-cheeked Thrush	Blue-gray Gnatcatcher	Nashville Warbler
Ruby-crowned Kinglet	Yellow-throated Vireo	Yellow Warbler
Prothonotary Warbler	Black-and-White Warbler	Magnolia Warbler
Blackburnian Warbler	Golden-winged Warbler	Blackpoll Warbler
Chestnut-sided Warbler	Black-throat Green Warbler	Palm Warbler
		Ovenbird
Northern Waterthrush	Common Yellowthroat	Wilson's Warbler
Canada Warbler	Eastern Meadowlark	Orchard Oriole
Northern Oriole	Brown-headed Cowbird	Scarlet Tanager
Purple Finch	Rufous-sided Towhee	American Goldfinch
Swamp Sparrow	American Tree Sparrow	Chipping Sparrow
Field Sparrow	White-crowned Sparrow	
Song Sparrow	White-throated Sparrow	

Table 46. Herpetological Species of the Charleston Side-Channel Reservoir

Species:	Relative Abund.*	Habitat:	Diet:
		Amphibians	
Ambystoma texanum	3	Fields, flood plains, temporary ponds	Worms, snails, arthropods
Ambystoma tigrinum	2	Prairie and Woodland ponds	Worms, snails, arthropods
Necturus maculosus	2	Aquatic (lakes and rivers)	Fishes, worms annelids, snails
		Aquatic (backwaters)	Worms, mollusks arthropods
Siren intermedia	1	Aquatic (backwaters)	Worms, mollusks arthropods
Bufo americanus	4	Terrestrial, prairie	Arthropods worms
Bufo woodhousei	4	Prairie, woodland	Arthropods
Acris crepitans	4	Ponds, lakes rivers	Arthropods
Pseudacris triseriata	4	Temporary ponds	Arthropods
Hyla crucifera	4	Temporary ponds woodlands	Arthropods
Hyla chrysoscelis	3	Temporary ponds floodplains	Arthropods
Rana areolata	1	Prairies	Crayfish insects
Rana catesbeiana	4	Permanent water	Arthropods, small vertabrata
Rana blairi	3	Prairies	Arthropods
Rana sphenocephala	3	Floodplains	Arthropods

(Table 46 continued)

Species:	Relative Abund.*	Habitat:	Diet:
Rana sylvatica	2	Floodplains	Arthropods
		Reptilia	
Chelydra serpentina	3	Aquatic	Fish, arthropods mollusks, plants
Sternotherus odoratus	2	Aquatic	Mollusks, fish Arthropods, worms
Terrapene carolina	3	Terrestrial	Worms, arthropods plants
Chrysemys picta	4	Lakes, ponds rivers	Aquatic plants arthropods, mollusks
Pseudemys scripta	2	Lakes, rivers	Aquatic plants, fish, mollusks arthropods
Graptemys oachitensis	1	Rivers, lakes	Aquatic plants mollusks arthropods
Graptemys geographica	1	Rivers, lakes	Mollusks, insects
Trionyx muticus	2	Rivers	Arthropods, fish mollusks
Trionyx spiniferus	3	Rivers, lakes	Arthropods, fish mollusks, verts.
Eumeces fasciatus	2	Arboreal/ terrestrial	Arthropods
Diadophis punctatus	2	Woodlands	Worms, arthropods salamanders,
Heterodon platyrhinos	3	Prairie, woodlands	Toads/frogs
Opheodrys aestivus	2	Woodlands	Arthropods
Coluber constrictor	3	Prairie, forest edge	Vertebrates, arthropods
Elaphe obsoleta	2	Woodland	Mammals, birds

(Table 46 continued)

Lampropeltis calligaster	4	Prairie	Vertebrates
Lampropeltis triangulum	1	Woodland	Vertebrates
Thamnophis radix	2	Prairie	Worms, amphibians
Thamnophis sirtalis	4	Prairie, woodland often near water	Annelids, amphib. arthropods
Storeria dekayi	3	Woodland, prairie	Annelids
Storeria occipitomaculata	2	Woodland	Worms, slugs
Clonophis kirtlandi**	2	Prairie, woodland near small streams	Worms
Nerodia sipedon	3	Lakes, rivers	Fish, amphibians

* Relative abundance: 4 - very common; 3 - common; 2 - uncommon; 1 - rare.

** Watch list for Federal Endangered Species.

Information provided by:

Dr. Edward Moll, Eastern Illinois University

Table 47. Mammals of the Charleston Side-Channel Reservoir Watershed

Common Name	Scientific Name	Relative Abundance
Order Marsupialia		
Family Didelphidae		
Opossum	Didelphis marsupialis	Common
Order Insectivora		
Family Talpidae		
Eastern Mole	Scalopus aquaticus	Common
Family Soricidae		
Least Shrew	Cryptotis parva	Uncommon
Northern Short-tailed shrew	Blarina brevicauda	Common
Southeastern shrew	Sorex longirostris	Uncommon
Order Chiroptera		
Family Vespertilionidae		
Little Brown bat	Myotis lucifugus	Common
Indian Bat	Myotis sodalis	Rare *,+
Keen's myotis	Myotis keenii	Rare
Silver-haired bat	Lasionycteris notivagans	Uncommon
Eastern pipistrelle	Pipistrellus subflavus	Common
Big brown bat	Eptesicus fuscus	Common
Red bat	Lasiurus borealis	Common
Hoary bat	Lasiurus cinereus	Rare
Evening bat	Nycticeius humeralis	Rare
Order Carnivora		
Family Procyonidae		
Raccoon	Procyon lotor	Common
Family Mustelidae		
Long-tailed weasel	Mustela frenata	Uncommon
Mink	Mustela vison	Uncommon
Striped skunk	Mephitis mephitis	Uncommon
Badger	Taxidae taxus	Rare
Family Canidae		
Red fox	Vulpes fulva	Uncommon
Gray fox	Urocyon cinereoargenteus	Uncommon
Coyote	Canis latrans	Common
Family Felidae		
Bobcat	Lynx rufus	Rare **

(Table 47 Continued)

Order Rodentia		
Family Sciuridae		
Woodchuck	Marmota monax	Common
Thirteen-lined ground squirrel	Spermophilus tridecemlineatus	Uncommon
Franklin's ground squirrel	Spermophilus franklinii	Uncommon
Eastern Chipmunk	Tamias striatus	Common
Eastern gray squirrel	Sciurus carolinensis	Common
Eastern fox squirrel	Sciurus niger	Common
Southern flying squirrel	Glaucomys volans	Uncommon
Family Castoridae		
Beaver	Castor Canadensis	Uncommon
Family Muridae		
Deer mouse	Peromyscus maniculatus	Uncommon
White-footed mouse	Peromyscus leucopus	Common
Southern bog lemming	Synaptomys cooperi	Uncommon
Prairie vole	Microtus ochrogaster	Common
Woodland or Pine vole	Pitymys pinetorum	Rare
Muskrat	Ondatra zibethicus	Common
Barn rat	Rattus norvegicus	Common
House mouse	Mus musculus	Common
Family Zapodidae		
Meadow jumping mouse	Zapus hudsonius	Rare
Order Lagomorpha		
Family Leporidae		
Eastern Cottontail	Sylvilagus floridanus	Common
Order Artiodactyla		
Family Cervidae		
White-tailed deer	Odocoileus virginianus	Common

Source: Dr. Richard D. Andrews

* On both the Illinois and Federal Endangered Species lists.
** On the Illinois Threatened Species list.
+ It has never been reported form Coles County but due to its status and summer habitat preference for woodlands along waterways, it was included.

PART 2

FEASIBILITY STUDY

OF THE

CHARLESTON SIDE-CHANNEL RESERVOIR

COLES COUNTY, ILLINOIS

Identification of Existing CSCR Problems

The following is a summarization of the major use impairments and related problems that were identified in the Diagnostic Study.

1. Internal Nutrient Loading

The release of phosphorus from sediments and cycling of phosphorus by aquatic organisms is the catalyst for most of the eutrophication related problems within the CSCR. The nutrient budget indicated that internal releases were the single largest source of phosphorus. The mean reservoir concentration was 0.144 mg/l TP. At times, the nitrogen level drops while phosphorus release increases, producing a condition that is favorable for the growth of blue-green algae. Their prolific growth combined with their subsequent decomposition contributes to the following problems: scum and odor which detract from aesthetic enjoyment, high turbidity levels which block the penetration of light through the water-column and suppress the growth of submerged aquatic plants, low dissolved oxygen levels which degrade fish habitat, and taste, odor and trihalomethane problems with Charleston's water supply.

2. External Nutrient Loading

The CSCR has five main sources of external phosphorus loading. From largest to smallest contributor, these sources are (in kg/yr): shoreline erosion (636.6), pumping from LC (141.8), the watershed (52.2), precipitation (4.5), and discharge from the water treatment plant (1.4). The problems associated with these sources are the same as for internal loading.

3. Sedimentation

The sediment load primarily comes from the same sources as the external nutrient loading (in kg/yr): ravine storm flow (1,872,461), shoreline erosion (1,273,242), pumping from LC (769,435), and discharge from the water treatment plant (48,528). Sedimentation, primarily from shoreline erosion, has filled in the deep water areas. The maximum depth has gone from 20 feet in 1982 to 16 feet in 1988. There has been a corresponding reduction in reservoir volume by 22%. The shallower the CSCR becomes, the more pronounced the eutrophication problems will be. To remove all of the sediments that have accumulated inside the CSCR since the completion of the Riverview Dam would require the removal and disposal of 1.3 million yd^3 of spoil.

Storm event sediment loading from the watershed was not adequately quantified by direct monitoring. SCS loading estimates indicate that storm event sediment loading should be addressed as part of a complete watershed management plan.

4. Shoreline Erosion

As pointed out in item 3, shoreline erosion is the second largest source of sedimentation. It is also a major source of nutrient loading. Shoreline erosion results in defoliated areas which are less aesthetically pleasing than vegetated shorelines. The erosion has become so severe that it is threatening real estate, its sediments have buried some of the intake ports to the water treatment plant, and it has eroded past City property lines into neighboring properties. Action is needed to prevent further encroachment upon and destruction of property.

5. Nuisance Algal Blooms

An algal population is considered to be in a bloom when the number of cells/mL exceeds 600 (Water Resources Center 1981). Phytoplankton analysis showed that all samples greatly exceeded this value. Some counts were greater than 20,000 cells/mL. This same data set showed that there were periods when the dominant algae type was blue-green algae. The blue-green algae type has been associated with taste and odor causing compounds (ISWS 1989). Chlorophyll a analysis is also used to help define the algae population. Chlorophyll a values for the CSCR ranged from 21.4 to 155.5 ppb with a mean of 69 ppb. This mean falls into the hypereutrophic range (NALMS 1988). All of the chlorophyll a data fell into the eutrophic (10-25 ppb) to hypereutrophic range (>25 ppb).

The ill effects of an algae bloom can be manifested in several forms. Effects that are aesthetically displeasing include scums on the water surface and odors coming from the water. Reservoir water quality problems occur and also include reduction of transparency which limits macrophytic growth and decomposition of algae which depletes the dissolved oxygen in bottom waters. Both of these problems reduce the available fish habitat. In addition, public water supply problems include: taste and odor, whether from the algae or their decomposition, and trihalomethane production. Trihalomethanes are produced when disinfection compounds react with organic materials (like algae) in the water.

The City is currently using routine phytoplankton analysis to determine when to treat the reservoir with copper sulfate. The use of copper sulfate is more of a maintenance measure than a restorative treatment. Reduction of the nutrient loading is needed to effectively control the algae population.

6. Low Dissolved Oxygen Levels

The above item, "Nuisance Algal Blooms", states that the decomposition of algae depletes the dissolved oxygen in bottom waters. This is the result of bacterial decomposition of algal cells that have died and settled to the bottom along with other organic matter. The aerobic decomposition will continue until the oxygen level of the water is depleted. After oxygen is depleted, decomposition continues by anaerobic decomposers. This change can be used as a signal for the potential release of iron, phosphorus, and sulfates.

Data from the diagnostic portion of this study reported that 53% of the profiles at site 1 and 36% at site 3 had some portion of the water column with a dissolved oxygen level of less than 5.0 mg/L. The "General Use Standard" states that the dissolved oxygen level shall not be less than 5.0 mg/L at any time. The City's present aeration system has been helpful in preventing the development of anoxic conditions around the City's raw water intake. This system's effect is limited to a small area around the intake and does not prevent oxygen levels from falling below 5.0 mg/L throughout the entire reservoir. The low dissolved oxygen condition can cause a reduction in useful fish habitat and an increased risk of fish kills. The release of hydrogen sulfide, an anaerobic decomposition product that is associated with some taste and odor problems in potable water supplies, does not appears to be a problem in the CSCR.

7. Taste, Odor and Trihalomethanes

The Charleston Water Treatment Plant produces a good quality water which complies with all current USEPA drinking water standards. In order to maintain compliance with the changing USEPA standards, numerous changes in chemical and treatment operations have been made. Controlling the production of trihalomethanes (THM's) has been a costly and time consuming process. The group of compounds known as trihalomethanes contain compounds that are known carcinogens. All of the changes for controlling THM's thus far have been made at the treatment plant. If algal blooms can be averted by reservoir restoration, then the production of THM's and treatment cost could be reduced.

The average potable water consumer only has three methods for evaluating the quality of water. These all involve the use of our senses. The average consumer can ask: does the water taste, smell or look good? Potable water can comply with USEPA standards and still have an "off" taste or odor. To confuse the situation further, the public can purchase bottled water that has no taste or odor problems but is of an inferior quality. This is because bottled water is not forced to adhere to the stricter water quality standards that are imposed on tap water. This can seem ironic since bottled water is primarily sold for drinking and cooking, while a major portion of tap water literally goes down the drain. However, the consumer is entitled to tap water that is aesthetically pleasing. Most of the City's efforts in controlling taste and odor problems have been within the treatment plant. Copper sulfate has been used in the CSCR to disrupt algal blooms. As with controlling THM's, if restoration of the CSCR can avert algal blooms, then taste and odor problems and in-plant treatment costs could be reduced.

8. Aquatic Macrophytes

In 1989, a macrophyte survey was conducted by Dr. John Ebinger. The survey revealed that the CSCR was devoid of submersed aquatic macrophytes. The emergent aquatic macrophytes were mainly found along the north shore. An adequate population of aquatic macrophytes is important to the overall health of a reservoir. Aquatic macrophytes are important for the following reasons:

1. They provide a habitat for young fish and invertebrates.
2. They provide a substrate for the growth of periphyton and bacteria, which are an important food source to some fish.
3. They disrupt the momentum of waves which could reduce shoreline erosion and the resuspension of sediments.
4. Aquatic macrophytes compete with algae for nutrients which could reduce the impact and duration of algae blooms.

If restoration methods are successful in improving the transparencies of the CSCR, then we could expect the macrophyte population to increase.

9. Fisheries

The IDOC biennial fish surveys of the CSCR have registered an overabundance of gizzard shad and white crappie. In the past, the natural shad die-offs have left the shoreline littered with dead shad. This is not conducive to maintaining a shoreline with a pleasing appearance. Don Dufford, IDOC fisheries biologist, has recommended the stocking of predatory fish species to reduce the numbers of shad and to thin the white crappie population. It is the City's intention to continue current stocking programs. The fisheries of the CSCR could reap substantial benefits from the reduction of nutrient and sediment loading.

10. Water Treatment Plant Discharge

On March 6, 1990, an investigation of the sludge pumping station indicated that it worked properly under normal treatment conditions. However, backwashing of filters and cleaning of clarifiers overloaded the pumping station. A one foot, 90 degree V-notch weir was placed in the receiving ravine, and a single filter was backwashed. The rate of flow in the ravine exceeded the capacity of the weir. Calculations for flows exceeding weir capacity were based on a greater than 1 foot flow value (3.10 $ft.^3/sec.$, 2.00 M.G./day). The water passing through the weir was more than 66.3% of the water used in the backwash process. Sample analysis of the discharge and extrapolation into the nutrient budget shows that this source contributes little to the nutrient budget but is high in suspended solids (44,299 Kg/yr.). The City has taken elementary steps to reduce the release from the sludge pumping station. The City is planning additional work on this system in 1992 to rectify this situation.

11. Degradation of Recreational Facilities

The two main parks bordering the CSCR are Lakeview and Riverview Parks. The facilities at both are old and in need of repair. Time and vandalism have taken a heavy toll on the facilities at Lakeview. Riverview Park is the only area around the CSCR that has working restrooms when it is not closed for repairs or for the winter. Major changes are needed in these areas including the possibility of administrative reorganization and funding changes. Improvement in these support facilities would increase both the use and enjoyment of these areas.

Objectives of the Lake Water Quality Management Plan

The CSCR is currently a hypereutrophic water body. It may be impractical to expect to reverse this condition to a point where the CSCR would be classified as mesotrophic. It is more realistic to expect to return the reservoir to a moderately eutrophic state. The CSCR's technical advisory committee believes that no single restoration technique will provide adequate water quality improvement. A successful management plan will need to have a multi-faceted approach. The ultimate goal of each facet of the management plan will be to improve the water quality and the support facilities of the CSCR. This will provide for an enhanced recreational experience and a safe water supply.

Reservoir Quality Objectives

1. Alleviate internal nutrient loading.
2. Intercept or inactivate sources of external nutrient loading.
3. Establish and maintain shoreline erosion control practices.
4. Reduce the duration and magnitude of algae blooms.
5. Improve fishery resources through continued stocking and alleviating problems with low dissolved oxygen and a lack of good habitat.
6. Improve the transparency of the CSCR water.
7. Provide the treatment plant with a higher quality raw water through improved reservoir water quality.
8. Reclaim reservoir volume that has been lost to sedimentation.

Recreational Opportunities Objectives

Any recreational opportunity at the CSCR will be affected by the degree of success that restoration efforts have in achieving the "Reservoir Quality Objectives". In order for any waterbody to be utilized to its fullest potential, it must have adequate support facilities. Specific recreational objectives are listed below.

1. Preserve existing recreational lake uses: fishing, boating, wildlife observation, picnicing, sunbathing, hiking and general aesthetics.

2. Improve fishing opportunities by stocking, habitat improvement and providing easier access.

3. Restore and/or replace deteriorated support facilities.

4. Promote public awareness of the uniqueness of the CSCR area and provide for a nature interpretation program.

5. Expand the scope of recreational activities at the reservoir.

6. Improve the public image of Lakeview Park.

Section (b) (1) Pollution Control and Reservoir Restoration Alternatives

The two preceding segments summarized the existing problems and management objectives of the CSCR. This segment will outline restoration alternatives for the problems that have been identified. Each alternative will address the reservoir management objectives.

1. Internal Nutrient Loading

The nutrient budget in the Diagnostic Study states that the largest source of phosphorus was from internal sediment release. Internal loading accounts for nearly 664 kg of phosphorus per year. This is over 44% of the total phosphorus loading. A successful restorational alternative for internal nutrient loading must be one that can significantly reduce loading at a reasonable cost and without any major objectionable side effects.

The USEPA "Clean Lakes Program Guidance Manual" (1980) states that in-lake restoration techniques such as dredging, aeration, and nutrient inactivation are important lake restoration tools in two situations:

1. When sufficient pollutant reduction is being accomplished in the watershed to allow desired lake quality to be maintained, but recovery from the degraded condition will be slow or will not occur simply as a result of watershed management.

2. When material accumulated in the lake constitutes a significant source of pollutants which is independent of controllable activities in the watershed.

Aeration was attempted but failed to arrest or reverse eutrophication. Other techniques that should be considered are dredging and nutrient inactivation. There are some inherent difficulties in attempting to compare these two methods. Both have been proven effective in alleviating internal nutrient recycling. However there is some question about the longevity of nutrient inactivation projects in shallow, well mixed lakes. Dredging has a higher initial treatment cost, but can have sustained water quality improvement and the additional benefit of deepening a lake.

A. Aeration/Destratification. After experiencing severe taste and odor problems in 1987 City officials contacted Dr. Raman K. Raman of the Illinois State Water Survey. Dr. Raman discussed with the city a number of possible solutions pertaining to the correction of taste and odor problems. One of these was the use of aeration-destratification systems. With the CSCR being a shallow reservoir that only weakly stratifies, mechanical destratification was ruled out. Other aeration and/or destratification methods were considered. The principle behind hypolimnetic aeration is to increase the oxygen concentration in the water column without destratifying it. With a history of stratification being disrupted in the CSCR in midsummer by wind events, hypolimnetic aeration was ruled out. The City considered the use of defused aeration to be the best candidate for achieving an increase in dissolved oxygen concentrations and for shifting the algae population away from blue-green dominance.

The capital expenditure required to obtain a system capable of destratifying the entire reservoir was deemed too costly. The City elected to place a defused aeration system around the Water Treatment Plant's raw water intake structure. In 1988 a "Reef Aeration-Mixing System" from Environmental Dynamics Inc. was installed. This system was comprised of 12 (19" X 25") aeration blocks, one blower unit and installation hardware. The uninstalled price of the system was $10,990.

The method for deploying this system has evolved with time. Initially the aeration blocks were to be placed on the reservoir bottom. This would have caused the aeration blocks to sink into the soft sediments and the bubbling action would have re-suspended particulate matter from the bottom. The aeration blocks were first deployed by suspending them under anchored floats. A major storm in November of 1988 pushed the system toward the west shore and broke several air lines. The system was repositioned with heavier anchors. In the summer of 1989 the water level in the reservoir dropped by more than 2 feet. This allowed the aeration blocks to settle into the sediments and the bubbling action caused the re-suspension of sediments. To alleviate the problem of fluctuating water levels, a series of tripods were installed in 1990. The aerators were then attached to the tripods. The aeration blocks were lowered to a depth of 12 feet. The tripods have improved operational conditions.

The area in which this system was installed has an uneven bottom. In order to keep all of the aeration units working they must be at a uniform depth. If the units are placed at varying depths it may result in some units failing to work. It has been difficult to maintain a uniform depth and prevent one or more of the units from being either too deep or too shallow. Too deep of a placement will result in the re-suspension of sediments and too shallow will lead to the development of an anoxic area below the aeration block. Anoxic conditions below the aeration units have been observed.

To deploy and maintain an aeration system that would treat the entire reservoir would be costly and require closing the reservoir to boat traffic. The current system only affects an area of approximately 4 acres. If the system was expanded to affect that part of the reservoir which is eight feet deep or deeper, it would cover 225 acres. If operational efficiencies remained the same, the system would have to be 54 times larger. The initial capital expenditure for this size increase would be $781,000 and require an annual operational cost of $185,279. To prevent the accidental entanglement of boats and boaters with air lines and platforms, boating would be prohibited.

B. Dredging. There are four main reasons for using dredging as a reservoir restoration method: removal of nuisance macrophytes, removal of toxic substances in sediments, deepening the reservoir, and limitation of nutrient recycling. The latter two are applicable in the CSCR. This fact warrants the consideration of dredging as a restoration method for the CSCR. The need for deepening is the result of watershed sediment loading (47% of total solids load) and shoreline erosion (32% of total solids load). Shoreline erosion is also the second largest source of external phosphorus loading (>42% of total P). It would not be prudent, however, to undertake a dredging operation until shoreline erosion control methods are implemented.

Determining the appropriate depth of dredging when the intent is purely for deepening is a simple matter. Determining this depth when dredging is for limiting nutrient recycling is more complex. An appropriate method for making this determination is the use of vertical and horizontal mapping of nutrients in the sediments. Mapping of this type will begin at the CSCR in 1992. Mapping is used to determine how deep dredging must go in order to expose sediments of relatively low nutrient value. When the CSCR was constructed, all of the sediments that had accumulated on the bottom of Lake Charleston were left in place. The CSCR contains 225 acres that were originally part of LC bottom surface. If the accumulated sediments from 1947 to 1974, 1,418.5 acre-feet (Yang 1974), is divided by the surface acres 404.0, then an average depth of accumulated sediments would be 3.51 feet. It is conceivable that all of these presumably nutrient rich sediments would have to be removed. The overall effectiveness of this restoration method will hinge on the phosphorus concentration in the exposed sediments and whether the CSCR continues to be a highly mixed body after deepening.

If an average of 3.5 feet of sediments were removed from the 225 acres (91 hectares) mentioned above, it would equal 789 acre-feet or 1,272,920 yd^3. In Cooke's review of dredging cost (Cooke etal. 1986), he provided a cost range from $2,137 to $100,605/ha. The final cost of the Lake Springfield dredging project has been estimated at $2.54 per yd^3 of material removed. The cost of just dredging was estimated at $1.39 per yd^3. The $2.54 value includes engineering, land acquisition and spoils site preparation (personal correspondence Michael J. Luepke). Mr. Peter Berrini of Cochran & Wilken, Inc. is currently involved with a number of dredging projects. Mr. Berrini feels that it is highly unlikely that a new dredging project could duplicate the Springfield numbers. Mr. Berrini indicated that $2.50/yd.^{3} is a more realistic cost for the dredging operation. Spoils site preparation and construction is not included in the $2.50/yd.^{3} cost. Mr. Berrini provided an estimation of spoils site preparation and construction cost for the CSCR project ($992,000).

Using the $2.50/yd.^{3} value with the cubic yard of material to be removed from the CSCR would produce a dredging cost of $3,182,300. The total cost of dredging and spoils site preparation and operation would be $4,174,300 (Table 48). The total estimated cost for the CSCR divided by its total number of hectares (135/ha) would yield $30,921/ha. This is higher than the mean value reported by Cooke ($12,691/ha). If restoration was 100% effective and benefits were based solely on reduction of total phosphorus loading, then dollars per kg of load reduction would be an acceptable means of treatment comparison. Dredging the CSCR would cost $6,289/kg TP (based on one year loading values). It would not be unreasonable to expect the benefits of dredging to last for ten years or longer.

Disposal of dredging spoils creates a number of special problems for the CSCR. Approximately 3/4 of the shoreline is bordered by steep slopes. The remaining 1/4 is made up by the Side-Channel dike and Dam "A". Sheet piling and similar operations are not allowed near the dike for fear that it could jeopardize the integrity of the dike. This rules out internal storage of the spoils over the submerged peninsula in the CSCR.

Slightly less than one-half of the shoreline is closely bordered by the Embarras River-LC. It would not be advisable to string discharge pipeline across these water bodies as flooding could cause major problems. It could also restrict the movement of recreational water craft. Even if crossing the river were not a problem, most of the potential disposal sites along the river are within the 100 year flood plain (100 YFP). Siting a disposal site within a 100 YFP requires additional engineering cost and an increased permitting process. The dredging applicant would need to show that the site would not adversely impact properties in the flood plain during flood events.

Ruling out the sites mentioned above leaves upland storage as a possibility. There are several sites that are suitable for use as a spoils storage area. The water that exits the spoils storage site could be returned to the reservoir. This would minimize the possibility of reservoir drawdown from the extra pumping. The main problem with upland storage is that a barge mounted booster pump would be required to pump the dredged material uphill. The elevation difference between the reservoir surface and an average upland site is 121 feet (37 meters). This elevation difference represents a considerable head pressure that the pumps would have to overcome. Friction head loss is the resistance a liquid encounters from pipe walls when being pumped. The longer the total pipe length the greater the total friction head loss. The greatest distance material would be pumped from the CSCR to a spoils site would be between 7000 and 8000 feet (2134 to 2438 km). The greater the total head pressure, the larger the dredge and booster pump needed and the greater the operational cost.

The size of the spoils holding area is determined by total material to be dredged, the timeframe for completing the project, and the rate at which the spoils settle. This later component would need to be determined by conducting a series of settling tests. It would be possible to construct an upland disposal area that would have minimal impact on residents and wildlife in the surrounding area. It would require the use of some farm ground. Tests have shown that the sediments contain no detrimental concentrations of pesticides or metals. It is conceivable that the dried sediments could be sold for fill or lawn dressing. This could help lower the overall cost of the project. When the disposal area was emptied, the area could again be returned to farming.

During the dredging operation, there would be some disruption of boating accessibility. Some areas would need to be closed off so that boaters do not interfere with the operation. The dredging operation could last a year or more depending on the size of the dredge and spoils holding area. Lake users would have to contend with higher noise levels. There would be some disturbance of aquatic habitat, but this area should recover within a year or two.

C. **Phosphorus Inactivation.** The inactivation of phosphorus is a restoration alternative that can be executed on reservoir waters and sediments. It can also be used as a pre-treatment of source water to a reservoir. Several chemicals and application methods exist for this restoration alternative. In this segment we only considered in-reservoir treatment of waters to control nutrient cycling from sediments. The two main types of chemicals that are commonly employed are aluminum and iron salts. For use in the CSCR, a floc that will sorb phosphorus without being affected by shifts in redox potential is needed. An aluminum hydroxide floc would meet this requirement. A suitable application method would be to use a truck tanker to pump alum to a barge. The barge would mix the alum with reservoir water and pump the solution through a submerged manifold.

To obtain current information on cost associated with this treatment method, Mr. Thomas Eberhardt was contacted. Mr. Eberhardt is a committee member of the North American Lake Management Society and a representative of Sweetwater Technology Corporation. One of the treatment activities that Sweetwater engages in is the barge application of alum. Mr. Eberhardt recommended that the areas of the lake that are 6 feet deep or deeper should be targeted for treatment. Shallower depths are less likely to be subject to anoxia induced phosphorus releases and more prone to floc displacement from wind mixing. The treatment rate would be approximately 500 gal. of alum per acre. Dosage rate of aluminum would be 0.5 to 26 grams/meter^3. A ballpark in-place cost for alum treatment is $1.00 per gallon. With 297 acres at a depth of 6 feet or greater (Figure 9), the CSCR treatment cost would be $148,500. Breaking the price down further puts chemical and equipment cost at $500 per hectare, $60,000 total for the CSCR. Labor would run 1 to 2 man days per hectare or 133 to 266 total man days. If this operation proved to be 100% effective in eliminating the internal phosphorus loading, the treatment cost would equal $224/kg TP (Table 48). The benefits from alum treatment could be expected to last from one to five years.

Alum treatments have some similarities with using copper sulfate. Both use a material that is potentially toxic to the aquatic environment, and the effectiveness of both treatments are dependent upon pH. When treating a reservoir with alum, the reservoir waters should be maintained between pH 8 to pH 6. This range will maximize the production of an aluminum hydroxide floc. If the pH falls much below this range, toxic aluminum (III) will be formed. A 1% solution of alum has a pH of 3.5. When a body of water is treated with the alum the pH will be lowered. How much it is lowered is dependent upon the dosage rate and the buffering capacity of the water. Most of the adverse side effects of this treatment have been associated with low pH and the formation of aluminum (III). Dosage is targeted at producing as much aluminum hydroxide floc while maintaining a minimum pH of 6 and without exceeding 50 ug Al L^{-1}. The 50 ug standard is based on toxicological work by Freeman and Everhart (1971).

The aeration system would have to be shut down and removed in order to provide access for treatment. When aeration is resumed after treatment, care should be taken to not disrupt the floc blanket. Some treatments have failed or have been short lived due to underestimating the proper amount of floc needed to blanket the sediments. Other treatment failures have been related to wind and wave action disrupting the floc blanket (Cooke etal. 1986). This latter problem is a prime concern for using this treatment at the CSCR. Wind and wave action have played a major role in the reservoir's shoreline erosion problems.

During the time of application (1 to 3 months), there would be some disruption of boating accessibility. Some areas would need to be closed off for short periods of time so that boaters do not interfere with the operation. Lake users would have to contend with higher noise levels. There could be some degradation of benthic macroinvertebrate habitat. A recent investigation into macroinvertebrate populations indicated that macroinvertebrates may be in limited numbers within the planned treatment area. This is a condition that is not uncommon in Central Illinois lakes.

Table 48. Internal Loading, Largest Loading Source - Restoration Alternatives and Costs.

(Note: All costs listed in italics are based on 100% effectiveness of treatment which may be unattainable)

A)	Aeration/Destratification		
	Initial Capital Expenditure		\$ 781,000
	Annual Operational Cost		\$ 185,279
	first year operation		\$ 966,279
	Cost per Kg. of phosphorus loading		*\$ 1,456*
A)	Sediment Removal		\$4,174,300
	Cost per Kg. of phosphorus loading		*\$ 6,289*
	Cost per yard³ sediment removed		*\$ 3.28*
B)	Phosphorus Precipitation and Inactivation		
	Information from Tom Eberhardt		
	Dosage rate:	500 gal of alum/acre	
	Treatment area:	Bottom area at a depth of $\geq$5'	
		297 acres total	
	In-place cost:	\$1.00 per Gal.	
		For 297 acres	\$ 148,500
	Cost per Kg. of phosphorus loading		*\$ 224*

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2. External Nutrient Loading

The CSCR has five main sources of external phosphorus loading. From largest to smallest contributor, these sources are: shoreline erosion (637 Kg/yr), pumping from the LC (142 Kg/yr), watershed (52 Kg/yr), precipitation (5 Kg/yr), and discharge from the water treatment plant (1 Kg/yr). In the segment entitled "Identification of Existing CSCR Problems", internal and external nutrient loading was listed first and second. Most of the remaining items are directly or indirectly attributed to the effects of internal and external loading. As stated previously, nutrient loading can produce a condition that is favorable for the growth of blue-green algae. The prolific growth of blue-greens and other algae forms combined with their subsequent decomposition contributes to the following problems: scum and odor which detract from aesthetic enjoyment, high turbidity levels which block the penetration of light through the water-column and suppress the growth of submerged aquatic plants, low dissolved oxygen levels which degrade fish habitat, and taste, odor and trihalomethanes problems with Charleston's water supply.

The loading problems from each of the five sources will have to be addressed and corrected separately. Loading from precipitation is one component that is beyond our control. Loading from the discharge at the water treatment plant has already been reduced. It is the intent of the Water Treatment staff to completely eliminate the water plant discharge. Any expenditure for this portion of CSCR restoration will be completely funded by the City. The remaining loading sources will be discussed separately and in greater detail.

A. Shoreline Erosion. The process of shoreline erosion in the CSCR is primarily wave activity undercutting poorly consolidated materials. As the cliff retreats, the higher slopes lose their basal support and the upper 2 to 4 feet of soil undergoes mass movement into the CSCR. The south shore is composed of easily eroded glacial till, allowing strong north and northwest winds to create wave action which undermines the slopes. Here we find many cliffs with heights over 20 feet and some reaching 50 feet in height (Figures 24-28). Another method of shoreline erosion occurs when large trees on the edge of the cliffs fall into the CSCR. This causes large masses of soil to be carried into the water and creates a large scar on the shore which contributes significant sediment to the CSCR. Twice since the completion of the CSCR the boat ramp on the south shore has been dug out. This was necessary due to the accumulation of sediments from shoreline erosion that obstructed the boat ramp.

Approximately 33,330 cubic feet of shoreline is eroded into the reservoir each year. This is equal to a phosphorus loading of 636.62 Kg/year. Every foot of shoreline that was part of a steep slope and was not protected by riprap or a concrete apron has eroded. Within the CSCR there is over 9000 feet of shoreline that is in need of protection (Table 34). There are many ways to control erosion, and each way is appropriate in a given range of circumstances. The range of cost for erosion control is quite wide. For comparing costs, all treatments are evaluated as being 100% effective, although this degree of effectiveness may be unattainable. The exact amount of loading contributed by a specific section of shoreline is unknown. Thus, loading is assumed to be evenly distributed along that portion of the shore that is experiencing erosion problems (9199 feet). Erosion control methods can be divided into two catagories, structural and non-structural methods. The following is a comparison of some of these methods.

Non-Structural Methods

1. Willow Planting. The use of planting willows as protection against shoreline erosion is a type of biotechnical control. Willow species are preferred due to their ability to root readily and without the use of growth hormones. Once established, fibrous root systems help to hold the soil together, and the rest of the tree protects the bank by slowing wave action. Over time, the stability of the soil brought about by the vegetated willows helps other plant species to become established. There are various methods of utilizing willows such as willow staking, post driving, willow cuttings, live facsines, live booms, or combinations of more than one method (Tetreault 1991).
The method which seems most appropriate, economically and feasibly, for the CSCR is a willow cutting method. For this method, sandbar willows (*Salix interior*), one-half to one inch in diameter and two to three feet in length, are cut from a nearby stand, kept moist, and transported to the area of treatment. Holes are made along the shoreline deep enough so at least about 40% of the sprig is buried. The cuttings are staked about one-and-a-half feet apart in a row. Rows are planted one foot apart up the bank and staggered for better coverage. The cuttings must be deep enough to receive enough moisture and to withstand wave action. Each cutting should include at least one terminal bud scar near the top and a few lateral buds to be certain enough growth hormones present in these areas cause root formation. The key to any willow method, however, is that the material be planted in a period of dormancy, usually from late Fall to early Spring.

It was the decision of the Technical Advisory Committee to demonstrate the technique on a few experimental plots around the reservoir. The above mentioned willow cutting method was used on 160 feet of eroded shoreline in February of 1992. Half of the willow treated shoreline was also first laid with an erosion control blanket consisting of straw and coconut fibers. The matting was used to test whether a temporary stabilizing material increases the willow survivorship. Control and matting sections without willow treatment were also established to compare erosion rates among sites with willows, sites with willows and matting, sites with matting alone, and sites with no treatment whatsoever.

It is hoped that willow planting on the reservoir proves effective because it provides many benefits at low equipment and material costs. Besides controlling erosion, it is a natural way of stabilizing a bank, possibly creating new fish and macrophytic habitat, and is generally more aesthetically pleasing than artificial erosion controls. One possible detraction from the propagation of willows is the decrease in availability of shoreline fishing spots previously used in certain areas.

Potentially 61% of erodible shoreline is targeted for willow treatment. The banks in these areas consist of a Miami loam soil type and have slopes ranging from 30 to 60 percent. Where shoreline erosion has cut into these banks the slope is nearly vertical. If 100% effective, 390 kg/yr of total phosphorus and 779,000 kg/yr of total solids will be prevented from eroding into the CSCR. The estimated cost of planting willows along the 5,630 feet treatment area (Figure 32) is $19,707, based on SCS estimates of $3.50/ln ft. This estimate, however, is derived from the willow post method and is considerably higher than the cutting method. Sufficient matting for this area would cost $5780. Labor costs range from $10,150 to $31,700. Total cost for willows and matting is $46,412. If totally effective, the cost/kg of phosphorus loading equals $120 (Table 49). Provided the willows establish themselves just as well without the erosion blanket, costs of material and labor will be driven down considerably further.

2. <u>Tree Cutting.</u> This method is narrowly focused on those trees that are on the verge of falling and, if left to a natural course of events, will contribute substantial although localized sediment loading. If the trees on the edge of the cliffs were removed, these large scale inputs of sediment to the CSCR could be slowed. The trees that this operation is concerned with are trees that are equal to or are greater than 6" diameter at a height of 4 feet and are within 15 feet of the shoreline or an erosion edge. These trees should be tagged for cutting if they meet any of the following criteria:

1) The crown diameter or its root-ball has been undercut by 30% or more.

2) The tree's main trunk has an angle of 30 degrees or more from 90 degrees of level.

3) The tree, due to damage or disease, is in danger of falling within the next 6 months.

The shoreline area should be surveyed each April and October for trees that meet the above criteria. The cutting of the tagged trees should be carried out within the following two months. This should be executed on all CSCR shoreline property owned by the City. The cut trees should be dropped and allowed to lie in place. For shoreline areas that do not belong to the City or the property line is in doubt, the following should be done:

1) An effort should be made to determine the property line and mark it for future reference.

2) An agreement should be made with the property owner that will allow for the maintenance of the shoreline in a manner that is advantageous for both the City and the property owner.

The CSCR is not used for nesting habitat by any endangered species of predatory birds, although the large trees near the shoreline are used as a perch by non-resident eagles, hawks and ospreys. In order to limit any potential destruction of riparian habitat, state wildlife officials will be notified before cutting.

The amount of sediment that is dislodged by these trees has not been quantified. Therefore it is not possible to assess a cost/benefit relationship for this method. Start-up and one year operation of this method would be less than $1,500 (Table 49). Due to the low cost, it would seem prudent to enact this operation on a two year trial basis, in which time the method could be evaluated for continued use.

3. Reduced Water Levels. Normal water level at the CSCR is 588.0 feet above sea level. From the time the reservoir was filled to the present, the level has ranged from a high of 588.8' to 585.6'. One of the main reason for the construction of the CSCR was to provide adequate water storage. Until 1991, the normal operational procedure for water levels in the CSCR was to provide enough pumping to the reservoir to maintain the level at 588.0'. During dry periods, the flow of water over the Riverview Dam sometimes stops. When this condition occurs pumping must be curtailed.

At a location between 9 to 12 inches below normal pool, a natural bench or ledge can be found. This bench is made up of gravel, rock and shale. This material is less erodible than the poorly consolidated materials located above it. It also has a lower nutrient value than the humus and top soil that is eroded when water levels are higher. When the reservoir level is within this 9 to 12 inch range, the waves will break on this ledge and lose most of their energy. This reduces the undercutting that leads to shoreline erosion. If the reservoir was targeted for this lower depth it would reduce erosion, but it could place the public water supply reservoir in a precarious position in times of drought. For this reason, it is advisable to target the lower levels during periods of minimal evaporation and plentiful river flow rates.

In order to develop a useable pumping guideline, City data on precipitation and pumping from the reservoir along with average evaportion rates from ISWS data (Roberts and Stall 1966) were utilized. Plotting the average monthly Reservoir pumping from 1982 to 1990 revealed that only four months (July, August, September, and October) had average pumping rates higher than the mean for all months. An average monthly evaporation value for the CSCR was calculated based on averaging the reported values for the ISWS Urbana station and the Springfield station. The CSCR evaporation value was subtracted from the average precipitation. If the resulting number was positive, then there is a net gain of water for that month. If the number was negative, then there was a net loss of water that month. Only four months showed a net loss of water (May, June, July and Aug.). Pumping rates and net water loss were given heavy consideration in the development of a pumping guideline.

To balance the need for water reserves and shoreline protection, the following operational guideline for the reservoir is recommended.

1) From October 1 to March 15, the target CSCR water level will be -12 inches from normal pool.

2) From March 15 to April 15, the target CSCR water level will be -9 inches from normal pool.

3) From April 15 to May 15, the target CSCR water level will be -6 inches below normal pool.

4) From May 15 to September 1, the target CSCR water level will be -3 inches below normal pool.

5) From September 1 to October 1, the target CSCR water level will be -6 inches below normal pool.

Pumping in dry periods shall be conducted in such a manner as to prevent the draw down of the water in LC to a point below the cap of the spillway on the Riverview Dam. If water stops flowing over the spillway, then pumping should be curtailed.

This method could be used with no additional cost to the City. There would be virtually no adverse effects, and any noticeable effects would be offset by the benefits of reduced erosion. How long this technique will work before the bench is eroded away is unknown The City is now using this operational guideline on a trial basis.

4. Purchase of Land and Property. When the engineering plans for the CSCR were first developed, purchase of 52.9 acres of right-of-way, construction, and flood easement was recommended. By the time the CSCR was constructed, only 20.5 acres of right-of-way, 9 acres of construction and maintenance easement and 4 acres of flood easement were obtained. The 20.5 acres for right-of-way were for the east shore of the side-channel and is not part of the CSCR shoreline. The flood easement was set at a level of 588 feet above sea level. The level at which water starts to leave the reservoir via the overflow is 588' 2". In some areas, this puts non-City property under water. Most of the erosion has been on City owned or controlled property. In one area the erosion has cut back through City owned land and is now eroding neighboring land.

The purchase of additional land and or easements would not in and of its self cause any reduction in erosion and its subsequent loading. It would, however, provide the City with unfettered access to these shores and the opportunity to establish whatever control methods the City deems necessary. The cost would be $10,000 and up.

Table 49. Shoreline Erosion Control Costs of Non-Structural Methods.

(Costs listed in italics are based on 100% effectiveness of treatment which may be unattainable)

1)	Willow Planting		
	Treatment area: 5,630 ln/ft.		
	Treatment cost:	$	19,707
	Erosion matting (optional)	$	5,780
	Additional Labor ($10,150 to $31,700)	$	20,925
	Total Cost, Willows and matting	$	46,412
	Cost per Kg. of phosphorus loading	*$*	*120*
	Cost per Kg. of sediment loading	*$*	*0.06*
2)	Tree Cutting		
	Chain Saw	$	375
	Fuel, oil, can and safety equipment	$	65
	Maintenance	$	30
	Labor	$	1,000
	Total	$	1,470
3)	Reduced Water Levels	$	NAC
4)	Purchase of land and property and or easements for maintenance and shoreline erosion control	$	10,000 (and up)

NAC = no additional cost

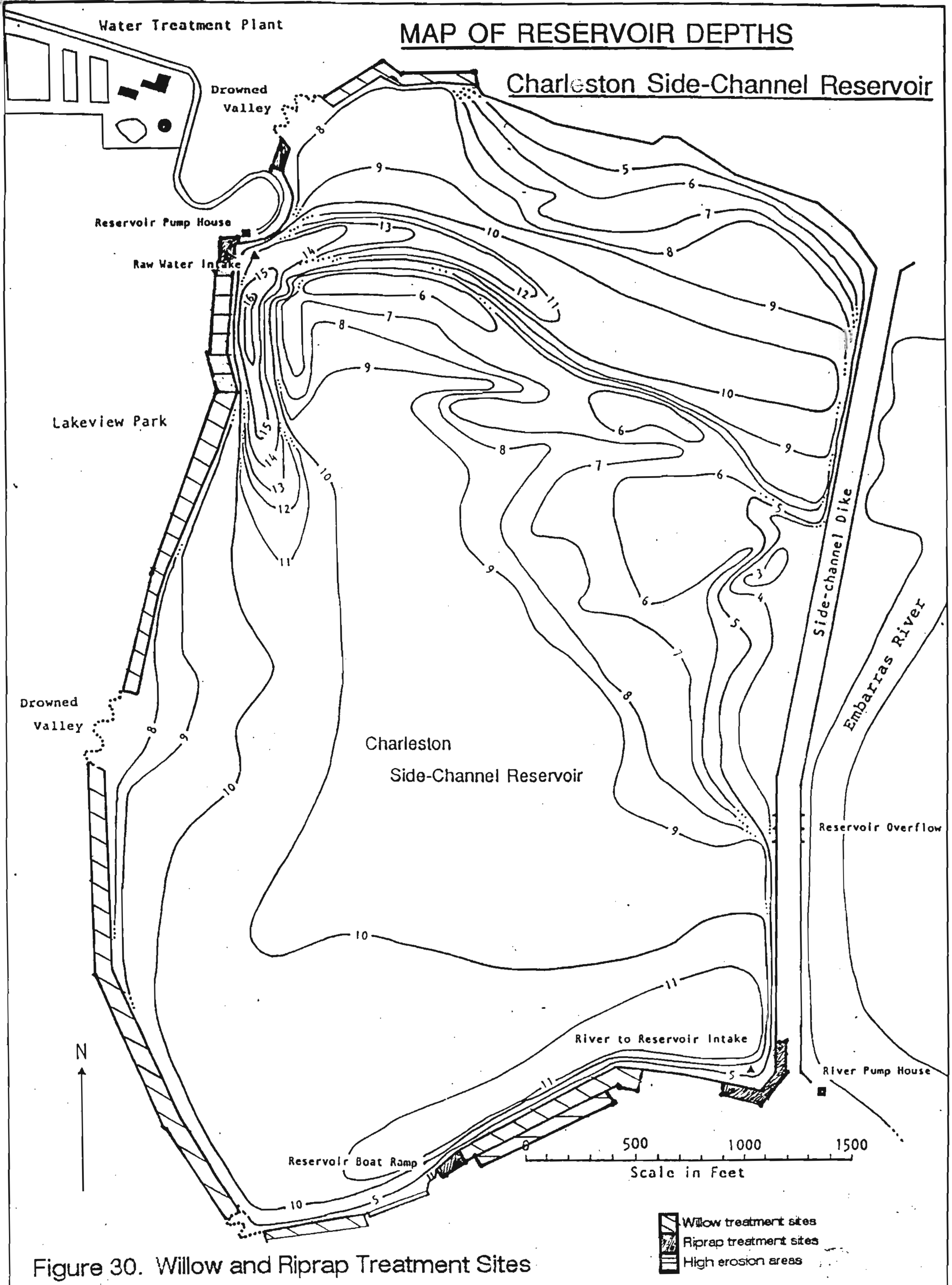

Figure 30. Willow and Riprap Treatment Sites

5. <u>Riprap and Gabions.</u> Riprap is the placement of rock along a shoreline to prevent the erosion of a bank. The use of gabions is similar; the main difference being that the rock is placed in large wire baskets. The wire baskets are an advantage over riprap alone, when the accidental dislodging of rock represents a potential safety hazard. Riprap can be placed over a natural or artificially graded slope. Artificially grading a slope would be limited at the CSCR. The use of land-based, earth moving equipment would be impractical on the steep forested slopes of the CSCR shoreline. Moving this equipment into place could be more damaging than the benefits of re-sloping, although there are some small areas that are accessible and less subject to damage by earth moving equipment. In order to reach some area for treatment, a barge would have to be used to transport the riprap and put it in place along the shoreline by hand. Riprap and gabions are best suited in areas where pedestrian traffic is heavy and would limit the success of non-structural methods. They are also appropriate where the combination of slope and wave action would undermine attempts to establish non-structural methods.

The following design information is adapted from the Proceedings of the Fifth Annual Conference and International Symposium on Lake & Watershed Management; North American Lake Management Society.

1) Riprap should be placed into the water 1.5 times the wave height below the still water surface.
2) Riprap should extend onto shore the runup distance plus 0.5 foot above the still water level.
3) The minimum thickness of the riprap should be 2.5 times the median size.
4) A layer of bedding material to act as a filter should be at least 6 inches thick, or filter fabric should be used.
5) On slopes of 6:1 or steeper, the riprap at the lowest elevation (the toe) should be anchored.

Most of the banks considered for riprapping consists of Miami loam type soil and have 30 to 60% slopes. The cost per linear foot of shoreline treated by riprap would be $18.76, and 425 ft (4.62%) of affected shoreline would be treated (Figure 32). The cost for gabion treatment would be $36.24 per linear foot. If totally effective, 29.4 kg/yr of total phosphorus and 58,800 kg/yr of total solids will be prevented from eroding into the CSCR. The cost per Kg. of phosphorus loading reduction if the methods were 100% effective would be $249 for riprap and $481 for gabions. The cost per Kg. of sediment loading reduction if the methods were 100% effective would be $0.13 for riprap and $0.24 for gabions. All of the areas that would be selected for this type of treatment have been adversely impacted by shoreline erosion and thus would not realize any adverse impacts from treatment. Riprap is not the most aesthetically pleasing shore to look at; it is, however, more pleasing than a defoliated shore.

6. Sea Wall. Sea walls are used in areas where steep slopes and other site characteristics make non-structural and riprap or similar methods inappropriate. Sea walls are rigid structures whereas riprap is considered to be a flexible revetment. The rigid revetment forms a barrier between the land and the water. After sheet piling is driven into the soil the area beside the piling is backfilled. The material for backfill can be mechanically dredged from the reservoir. This backfilled area can be seeded and made into a recreational area. The sea wall and backfilled area will stop wave action and provide a bench to help stabilize the remaining portion of the slope.

The following design information is from the Proceedings of the Fifth Annual Conference and International Symposium on Lake & Watershed Management; North American Lake Management Society.

1) Steel sheet piles can be driven into hard soil and soft rock. Aluminum and timber sheet piles can be driven into softer soil.
2) For a cantilever seawall, the sheet piling should be driven deep enough to resist overturning, which usually requires penetration to a depth two to three times the freestanding height, depending on the foundation characteristics at the site.
3) For an anchored seawall, sheet piling should be embedded to a depth 1.5 to 2 times the freestanding height. Again, the foundation characteristics may indicate shallower or deeper penetration.
4) The top of the seawall should be 1 foot plus runup above the stillwater elevation (use 1.5:1 curves for a smooth surface to determine runup).
5) Drain holes should be placed at regular intervals to facilitate movement of water from behind the structure. The drain holes should be backed with filter cloth or crushed stone filters.
6) Wing walls should be used to prevent flanking (erosion at the ends of the seawall). If the ends are not protected, erosion could produce a retreating shoreline at each end of the seawall.

For the CSCR, the expected height of a sea wall is three feet above the average water level. Due to the high cost of building a seawall, this method should be limited to those areas with severe problems. The 1050 feet of shore on the south and 770 feet on the west shore, which together constitutes 19.8% of the total erodible shoreline, were considered for this treatment (Figure 32). These areas consist of Miami loam type soil and have 30 to 60% slopes. In order to develop an estimation of cost related to seawall construction, Mr. Jack Poff of AFS Shorewall & Dock was consulted. Mr. Poff indicated that there was a good degree of probability that a sheet piling seawall would be successful along the south shore. Mr. Poff felt that the west shore would require sediment coring and an engineering study before any work could be done. Mr. Poff provided an estimate of $478,800 for the 1050 foot south shore treatment or $456/foot. This is based on using pilings that have an effective life of 50 years. The west shore cost was developed by multiplying the 770 foot shore by $456 and increasing the sum by 15% to cover engineering and coring cost. The west shore treatment cost is $351,120 or $502/foot. If 100% effective, 126 kg/yr. of total phosphorus and 252,000 kg/yr. of total solids will be prevented from eroding into the CSCR. The cost per Kg. of phosphorus loading reduced is $6,811. The cost per Kg. of sediment loading reduced is $3.40.

During the construction phase, recreational activity would be prohibited near the job site. CSCR visitors and residents would have to contend with increased noise and traffic levels during construction. The largest potential drawback to this method is that the vibrations caused by driving the piling could jeopardize the integrity of the side-channel dike.

7. <u>Raft Wave Barrier.</u> In this method, logs are connected together to form rafts. The rafts are connected in series and and are anchored off shore. The intent of the treatment is to allow the log rafts to absorb a portion of the wave energy before it reaches shore. This is not a widely used method for shore protection. Thus, evaluating its performance for adverse effects or benefits is not possible at this time. It is, however, deserving of a trial period in which its merits could be evaluated.

To develop a cost estimate, a four log raft design was used. Each log would be an American National Standards Institute (ANSI) class 9, non-treated, Douglas Fir, 30' length pole. Douglas Fir is selected over Southern Pine for its reputation as a better float log. The poles used will be non-treated in order to avoid any potential toxic side effect. Poles of ANSI class 9, 30 feet length are selected because the length reduces the number of rafts needed over a given distance when compared to 20 or 25 foot poles. Class 9 is preferred due to its light overall weight. The average weight of a class 9 - 30' pole is 400 lbs., whereas a class 1 - 30' pole has an average weight of 1390 lbs. A two man crew with a backhoe could easily handle a 30' class 9 pole. The higher the weight and longer the pole the more difficult the job would become. Each pole would be connected on its side, at either end, by an 18 inch chain and eye bolt to form the raft. The end of each log in a raft wound be connected by the same method to the next raft. Between each raft and at the ends of a series of rafts, a concrete filled tire will be used to anchor the barrier in place. The total cost for materials, construction and deployment of a 1050' barrier (Figure 33), which would protect 11.4% of the erodible shoreline, would be $14,996. The banks which would be protected consists of Miami loam soil type and have 30 to 60% slopes. If 100% effective, 72.6 kg/yr of total phosphorus and 145,000 kg/yr of total solids will be prevented from entering the CSCR. This would represent a cost per Kg. of loading reduction equal to $214 and $0.11 for phosphorus and sediment respectively.

To provide for a proper evaluation of this method, a 300 foot demonstration plot is being developed on the south shore of the CSCR. It is expected that this may provide good cover for some species of fish. Due to the location it would not be highly visible. It would also be practically inaccessible from land. Boaters would most likely be the only group to encounter the structure. For safety, warning buoys would be placed around the barrier.

Table 50. Shoreline Erosion Control Costs of Structural Methods.

(Note all costs listed in italics are based on 100% effectiveness of treatment which may be unattainable)

5a)	Riprap		
	Treatment area 425 ln/ft		
	Riprap	$	2,034
	Filter stone	$	1,313
	(From the Charleston Stone Co.)		
	Filter fabric	$	744
	(From Spunbond Business Group)		
	Labor	$	3,881
	Total	$	7,972
	Cost per Kg. of phosphorus loading	*$*	*249*
	Cost per Kg. of sediment loading	*$*	*0.13*
5b)	Gabions		
	Treatment area 425 ln/ft		
	Riprap	$	2,341
	(From Charleston Stone Co.)		
	118 Gabions	$	6,042
	(From Maccaferri Gabions, Inc.)		
	Labor	$	7,011
	Total	$	15,404
	Cost per Kg. of phosphorus loading	*$*	*481*
	Cost per Kg. of sediment loading	*$*	*0.24*
6)	Sea wall using sheet piling		
	Treatment area; south shore 1050 ln/ft	$	478,800
	Treatment area; west shore 770 ln/ft	$	351,120
	Core and Engineering study	$	35,120
	Total	$	865,040
	Cost per Kg. of phosphorus loading	*$*	*6,811*
	Cost per Kg. of sediment loading	*$*	*3.40*
7)	Raft Wave Barrier		
	Treatment area 1050 ln/ft		
	Material	$	13,268
	Labor	$	1,728
	Total	$	14,996
	Cost per Kg. of phosphorus loading	*$*	*214*
	Cost per Kg. of sediment loading	*$*	*0.11*

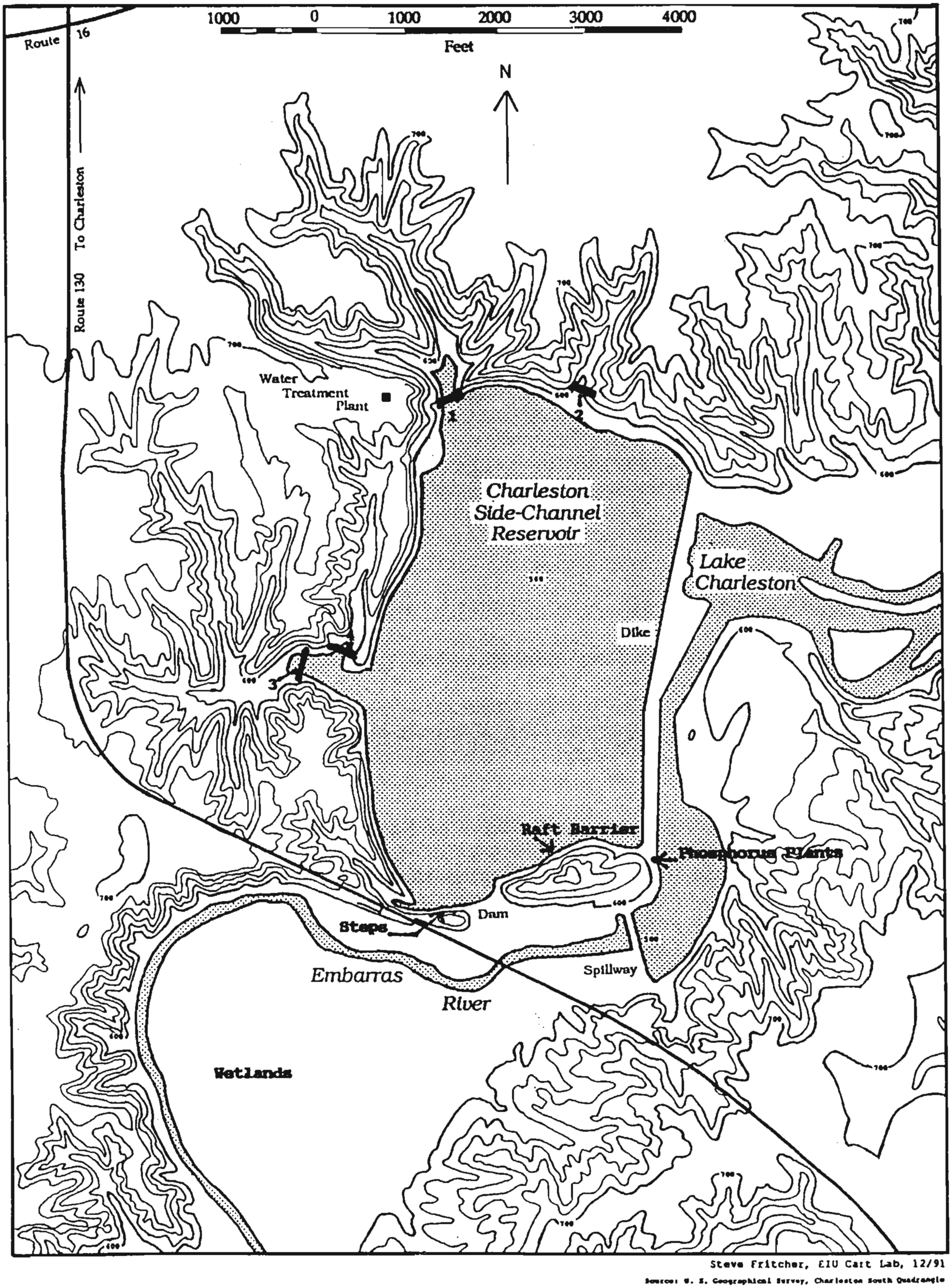

Figure 33. Locations of Some Restoration Activities
(1-4 refers to Sediment Control Structures)

B. Pumping from Lake Charleston to the Side-Channel Reservoir. In the hydrologic budget section of this report, pumping from LC represented 51.3% of the total water input to the reservoir. The subsequent nutrient and solids loading from this pumped water was as follows: 91.0% of the total nitrate loading, 9.5% of the total phosphorus loading, and 19.4% of the total solids. This is the third largest source of total phosphorus and total solids loading.

Any consideration of restoration alternatives for this loading source should be proportional to its extent of loading when compared to other sources. It would not be prudent to spend an exsorbant amount of money on a phosporus reduction alternative that was unproven and only addressed a small portion of the total loading. Four alternatives were considered for treatment of this loading source. One method is simply the addition of a metal salt into the water that is pumped to the reservoir. The other three methods are pretreatments of pumping waters. Two of the pretreatment methods are accomplished with water treatment plants and one method uses wetlands to reduce loading. The range of total cost for the four restoration options is $3,072 to $2,200,000.

1. <u>Alum addition to Lake Charleston pump water.</u> The two main chemicals that were considered for inactivation of phosphorus were aluminum and iron salts. As previously stated, for use in the CSCR, a floc that will sorb phosphorus without being affected by shifts in redox potential is needed. For this reson aluminum salts are preferred. This method would inject alum via a metered feeder pump into the discharge pipe of the pumps. The water and alum would mix as it moved through the discharge line, manifold and discharge gate. Dosage rate could be controlled by pH and "Jar Test" results. The alum would produce an aluminum hydroxide floc that would sorb phosphorus and precipitate solids. The floc and whatever attached to it would settle to the bottom. This would provide a source water that was lower in dissolved and particulate phosporus and, after the floc had settled, lower turbidity. This option does not prevent the introduction of the phosphorus and solids but it does remove them from the water column. Over time this settling could constitute a major layer of aluminum rich sediments. The long term toxilogical effect of such a layer is unclear.

To install this setup into the existing pump house would cost $3,072. The cost per Kg. of phosphorus loading reduced is $21.67. A value for sediment reduction is not provided as it would not prevent the accumulation of material on the reservoir bottom. Installation would be quick and would not interfere with any other activities. It is likely that the general population would not notice the change in operation.

2. Phosphorus Removal Plants. Two types of treatment plants were investigated for this report. The first is a "Turn-Key" treatment plant and the second is a solids contact clarifier coupled with a decelerating flow filter. Most phosphorus removal plants are designed for waste water or sewage treatment. In these plants, the influent waters contain phosphorus concentrations substantially higher than what would normally be found in LC waters. The design goal of these plants is to achieve or maintain compliance with USEPA or state regulations regarding phosphorus discharge limits. The goal for most plants is an effluent total phosphorus concentration of 1.0 mg/l. These plants have a proven ability to reduce high levels of total phosphorus (>20.0 mg/l) to values of less than 1.0 mg/l. In some instances values of 0.01 mg/l were recorded (Schleife 1990). However, the range of post filtration total phosphorus values contains concentrations well above 0.1 mg/l.

The average total phosphorus concentration for the water pumped from LC was 0.092 ppm. In order to provide for an adequate reduction in total phosphorus, effluent concentrations would have to be maintained well below 0.1 mg/l. Normally the standards used for calibrating laboratory equipment for the analysis of phosphorus in waste water samples is substantially higher than that used for limnological samples. The use of these higher calibration curves to analyze low levels in lake phosphorus could generate erroneous data (Bland 1991). Therefore, it is difficult to evaluate these treatment plants based purely on the data available in the literature. A more appropriate method would be the use of a pilot plant study with analysis performed by a reliable third party laboratory. Some manufacturers provide a pilot plant service for a fee of $1000/week.

These plants would be effective in reducing the amount of particulate matter that entered the CSCR. Aluminum or iron salts and/or an anionic polymer could be used for coagulation and flocculation. This system would have the advantage of not adding a floc layer or potentially toxic substance to the reservoir. The City would then have to dispose of the sludge and sediment that it strips from the treated water. Dealing with this problem could substantially add to the annual operational costs. The total cost of a 4000 gal/min package plant is $395,500. The cost for sediment and phosphorus reduction is $0.51 and $2,790 per kg. respectively. The total cost of the solids contact clarifier plant is $910,000. The cost for sediment and phosphorus reduction is $1.18 and $6,419 per kg. respectively. Yearly operational costs for the treatment plants have not been calculated.

The construction or placement of these plants would result in an increase in noise levels, a limitation of access to some areas and a degradation of aesthetics. The long term affects of these plants would be similar. The noise of motors and pumps, the sight of the large treatment structures and the reduced access to some areas would detract from the overall enjoyment of the CSCR and LC (Figure 33).

3. Wetlands Treatment of Source Water. This treatment method was originally presented to the City as part of three restoration alternatives for the CSCR from the Soil Conservation Service. The ensuing description of the project is provided by the SCS. This alternative consists of a gravity open channel from the existing Lake Charleston to a 68 acre parcel of cropland below the Lake. This 68 acre field would be converted to a wetland area by land grading and installing dikes to control water flow (Figure 33). A tile collection system with a sump, a pumping station, and a return flow pipeline would be installed.

The water from Lake Charleston would flow through the open channel to the wetland. From the wetland the water would flow into a subsurface tile system to a sump and would then be pumped into the Charleston Side-Channel Reservoir. This system would replace the existing system that pumps water from Lake Charleston and the Embarras River into the Charleston Side-Channel Reservoir. The wetland and the soil acting as a filter system would remove approximately 95 percent of the sediment and phosphorous and 80 percent of the nitrogen. The wetland would maintain a water level of 6 inches to 18 inches and would be planted in cattails.

To be effective in removing nitrogen, the wetlands must be harvested. To harvest, the diversion of water would be stopped and the water table in the wetland area would be lowered to allow the use of large farm equipment. The wetland would be sized for a 5 cubic foot per second flow and have approximately a 6 day flow through time. The total cost estimate for this method would be $443,500. Cost per Kg. of loading reduced for phosphorus and sediment is $3,128 and $0.58 (Table 51).

Wetlands systems have been used to reduce a wide range of contaminants. Some of the contaminants that could be reduced by this method are: biochemical oxygen demand, suspended solids, nitrogen, phosphorus, trace metals, trace organics, and pathogens. Reduction of these pollutants is achieved through: sedimentation, filtration, chemical precipitation and adsorption, microbial interactions, and uptake by vegetation (Hammer 1989). Constructed wetlands with subsurface flows are used in European countries to treat screened raw sewage and primary effluent. In recent years, the City council has been considering the future of the area known as the "Lake Island Track". A portion of the discussion has centered around how to properly deal with the waste from the homes on this piece of land. If a wetland treatment area was developed, the effluent from existing septic systems could be routed to the wetland. This would eliminate the need for the forced main system that has been purposed for these homes at a cost of $261,000.

The proposed site of this wetland is in the 100 year flood plain of the Embarras River. All of the regulations and disadvantages of construction in a floodplain that were outlined under the section on dredging also apply for the wetland. The USEPA publication titled "The Lake and Reservoir Restoration Guidance Manual" made the following statement about wetlands: *Natural areas such as wetlands around a lake have occasionally been used for advanced waste water treatment because they can function as a biological filter to remove silt, organic matter, and nutrients from an inflowing stream to the lake and improve lake quality. Wetlands, however, can also contribute organic matter and nutrients to lakes under some conditions. Nutrients released from wetlands can fertilize algal growth and contribute to lake problems. Whether a wetland serves as a source or filter for nutrients and organic matter is an area that needs better understanding and study.*

Table 51. Pumping Load, Third Largest Loading Source - Pre-treatment Alternatives and Costs

(Note all costs listed in italics are based on 100% effectiveness of treatment which may be unattainable)

1)	Alum addition to Lake pump-house		
	1 Metering Pump W&T 44-213	$	1310
	Plumbing	$	400
	1 Meter	$	27
	3 Solenoid valves	$	375
	Electrical wiring	$	500
	1 Drum Cradle	$	220
	Labor	$	140
	Misc.	$	100
	Total	$	3072
	Cost per Kg. of phosphorus loading	*$*	*22*
2a)	Package Phosphorus Removal Plant		
	Keystone Engineering & Treatment	$	395,500
	Cost per Kg. of phosphorus loading	*$*	*2,790*
	Cost per Kg. of sediment loading	*$*	*0.51*
2b)	Claricone and Decelerating-flo Filter		
	1 For a 4000 gal/min pumping rate	$	910,000
	Cost per Kg. of phosphorus loading	*$*	*6,419*
	Cost per Kg. of sediment loading	*$*	*1.18*
	2 For a 8000 gal/min pumping rate	$	2,200,000
	Cost per Kg. of phosphorus loading	*$*	*15,519*
	Cost per Kg. of sediment loading	*$*	*2.86*
3)	USDA Soil Conservation Service Wetland plain		
	Acquisition and Construction of Wetland	$	310,000
	Tile System	$	25,000
	Pump and Pipe	$	40,000
	Gravity Channel	$	8,500
	Misc. Costs	$	60,000
	Total	$	443,500
	Cost per Kg. of phosphorus loading	*$*	*3,128*
	Cost per Kg. of sediment loading	*$*	*0.58*

C. Watershed Loading. Of the five main sources of external phosphorus loading, watershed tributary flow is the third largest (52.18 Kg/yr). The watershed is the largest source of sediment loading (47%, 2,064 tons). Shoreline erosion is the second largest source (32%, 1,404 tons). The total sediment load adds 4.4 acre-feet of material to the CSCR each year. Measurement of stream flow into the CSCR presented investigators with many problems. Some of the problems were as follows: 1) topography, stream monitoring locations were difficult to find; 2) at times, low to nonexistent baseflows occurred; 3) large storm events overflowed monitoring weirs; 4) numerous signs of vandalism deterred investigators from using continuous flow monitoring equipment. Manual reading of these weirs provided good baseflow data but were inadequate for storm events. The watershed baseflow phosphorus loading contribution (6 kg/yr.) underestimates the total watershed loading. For this reason the CSCR nutrient budget was constructed using SCS estimations of watershed loading.

For this loading source, three alternatives have been considered. The first, sedimentation basins, is an alternative that was originally proposed by the SCS. The second alternative is the adoption of a watershed zoning ordinance that Superintendent Dick Sherman proposed to the City Council in 1989. The third alternative is to purchase tracts of land within the watershed that are highly susceptible to erosion. This would serve as a buffer zone from residential development. The ensuing segments will expand upon the preceding options.

<u>1. Sedimentation Basins.</u> The SCS proposed the construction of four sediment control structures which would control run-off from 81 percent of the watershed. The SCS estimated that the total sediment from sheet, rill, ephemeral, channel and gully erosion is 2064 tons. The structures will reduce these sources of sediment by 77.5 percent or 1599 tons per year. The structures will be designed to control the 10 year, 24-hour storm plus hold the sediment for 10 years. Two of the structures will be located in the ravine system up from the west shore. The remaining two structures would be up from the north shore (Figure 33). The release rate for a 48 hour detention time for the four structures ranges from 1.5 to 9.6 $foot^3/sec$ (Table 53).

The cost estimate for constructing the four basins is $41,100. This cost estimate reflects costs for easements and acquisition, clearing, earth-fill, pipes and appurtenances, riprap, seeding, mulching, mobilization and miscellaneous costs. After the basins are filled with sediment the City would then remove the accumulated material. The cost per Kg. of phosphorus loading reduced is $790. The cost per Kg. of sediment loading reduction is $0.03 (Table 52).

The location of the individual basins would not be in high visibility areas. This would limit the impact that construction would have on aesthetics. Some vegetation would have to be disturbed in the construction area and to provide access to the site. None of the normal reservoir and park uses would have to be curtailed during or after the construction of the basin. Noise levels would be higher during construction. After completion only a small percentage of the recreational users would encounter the structures. The structures could be incorporated into a bridge for hiking trials to provide improved access to the more remote portions of the watershed. The structures could be designed to house flow monitoring and water sampling equipment.

2. Zoning and Education. In 1989, a sanitary survey of the watershed was executed. This survey was carried out in the form of a walking tour by a two man team. The tour took place over a three day period. Some of the items found or confirmed by this tour were: 1) A 19th Century abandoned cemetery; 2) The remains of a junkyard; 3) An improperly supported, 12" diameter, suspended sewer main; 4) Storm-flow control devices that were in need of maintenance; 5) Severe erosion that has undercut portions of one roadway; and 6) Kitchen middens and household junk piles. In addition to these finds, one landowner had his timber logged and the City approved a new housing development in the watershed. In order to establish a reasonable set of guidelines for the watershed, Mr. Dick Sherman (Water Treatment Plant Superintendent) conducted a review of watershed zoning rules and regulations in Illinois. Based on this review, Mr. Sherman constructed a proposal for a Charleston Side-Channel Reservoir Watershed zoning ordinance (Appendix H).

This option should not be viewed as a panacea but as a tool for ensuring that certain reasonable standards are met and/or maintained. As stated above, sedimentation basins would reduce watershed sediment loading by 77.5%. The zoning ordinance would be aimed at reducing, by planning and proper management, the erosion at its source. This set of rules would also provide a means of governing the use of herbicides, pesticides and fertilizers within the watershed. The cost of implementing this ordinance is minimal. The main cost that the City would incur would be for inspection. Inspection could be carried out by current City staff while conducting their normal duties. The cost of inspection could be deferred through filing fees and penalties. It is true that inspection costs incurred by a developer would most likely be passed on to the buyer. However, this cost would be so small that it is highly unlikely that the fee itself would prevent any project from being undertaken.

The ordinance would have no detrimental effects on recreation or aesthetics. Nor would the ordinance interfere with any of the current reservoir uses. It would, however, provide a tool for helping maintain the aesthetics of the reservoir and its watershed.

3. Purchase of Lands Susceptible to Erosion. Portions of the land within the watershed are comprised of soils that are highly susceptible to erosion. The steep slopes and soil type make this area unsuited for numerous activities. A prime example of this is the soil type listed as 27g Miami loam (Table 2, Figure 4). Soil 27g is found on steep slopes (30 to 60%). The SCS made the following comments about this area: *Most areas are used for woodland. It generally is unsuited to cultivated crops, hay and to use as a site for dwellings and septic tank absorption fields because of the slope and the severe erosion hazard.* Frequently the 27g is found bordering soils on lesser slopes that are only moderately suited for dwellings or cultivation.

There are three subdivisions within the watershed which have or are bordered by 27g. The SCS has recommended the installation of sedimentation basin or detention ponds for these subdivisions. The oldest of these subdivisions was constructed with a storm water detention pond. But in the last ten years, very little has been done to offset the affects of increased impervious surfaces and channelization of storm water. The most recent developments have channeled run-off and delivered it to the tops of steep grades. The storm water then descends unchecked into the surrounding ravines. There are literally thousands of acres around Charleston which are suitable for residential or industrial development. In contrast, the land area of the direct CSCR watershed is only 804 acres. Any additional development of this area should be carefully thought out.

If susceptible lands can be purchased at a reasonable cost, then the acquired properties could be used as a buffer zone to prevent over development which would, in turn, prevent future loading of the CSCR. This alternative would have no detrimental effects on recreation or aesthetics. Nor would this option interfere with any of the current reservoir or watershed uses. No estimation of loading reductions has been developed for this alternative.

Table 52. Watershed Loading Alternatives and Costs.

1)	Sedimentation Basins (USDA SCS)	
	Four sediment control structures	$ 41,100
	Cost per Kg. of phosphorus loading	*$ 790*
	Cost per Kg. of sediment loading	*$ 0.03*
2)	Zoning and Education	NAC
	Adoption of Proposed Zoning Ordinance	
3)	Purchase of highly erodible Lands	
	This would provide a buffer zone from over development in portions of the watershed.	$ 38,000 (and up)

NAC = No Additional Cost

Table 53. Sediment Control Structures Storage Requirements

	Charleston Side-Channel Reservoir Watershed				
	Basin 1	Basin 2	Basin 3	Basin 4	Total
Drainage area (acres)	292	257	52	56	657
Percent of Watershed	36.3	31.9	6.5	7.0	81.6
1 Year Sediment Delivery (tons)	711	626	126	136	1599
10 Year Sediment Delivery (tons)	7110	6260	1260	1360	15990
10 Year Sediment Delivery (Acre-feet)	7.1	6.3	1.3	1.4	16.0
Storage Required 10 Year Storm (Acre-feet)	30.6	26.9	5.4	4.0	66.9
Storage Required 10 Year Storm Plus 10 Year Sediment (Acre-feet)	37.7	33.2	6.7	5.4	82.9
Required Release Rate In CFS for a 48 Hour Detention Time	9.6	8.5	1.7	1.5	-

Source: USDA Soil Conservation Service

D. Point Source Discharge from the Water Treatment Plant. Prior to 1978, the Charleston Water Treatment Plant operated under an NPDES permit to discharge, via a ravine, lime and alum sludge into what was then Lake Charleston. In February of 1990, observations of new erosion in this ravine prompted an investigation of the sludge pumping station. The investigation indicated that the pumping station worked properly under normal treatment conditions. However, backwashing of filters and cleaning of clarifiers overloaded the pumping station. On March 6, 1990 the receiving ravine was monitored for flow and water quality. The flow in the ravine was greater than 66.3% of the volume of water used in a backwashing process. An estimation was made of the annual loading rate based on the March 6th data (Table 8). The nutrient loading from this source was minimal (Table 8), but the solids loading was estimated at 48,528 Kg/year.

It should be noted that this condition is unintentional and it is the intent of the staff of the Charleston Water Treatment Plant to rectify this situation. Since this problem is considered a point source discharge, any corrective work would be considered ineligible as matching funds for CSCR restoration projects. Thus cost estimates were not prepared for this loading source.

Intial corrective actions included repair of check valves and pumps. On January 23, 1992, sandbags were added to the top of the baffle plate. The sand bagging restricts the flow to the overflow pipe and increases the storage volume in the receiving pond. In March 1992, repair work was started on the filter influent valves. Faulty influent values were unnecessarily adding water to the backwash wasteflow. In some instances this flow would have been as high as 200 gallons/min. (0.45 $ft.^3$/sec.). The combined effect of these steps has substantially reduced the amount of water that is discharged from the overflow. Plans have been made to cut down the opening in the face of the sludge intake structure and remove accumulations of sludge in the receiving pond. This would have the effect of adding storage volume to the receiving pond and reduce the volume of water that discharges from the overflow. In 1991 and 1992, funding was requested for the purchase of a belt press and modifications of the sludge handling system ($600,000). Budget constraints eliminated this item from the Water Treatment Plant budget. If this item was adopted, then the discharge problem with the sludge pumping station could be eliminated.

3. Biomass Control for Algae

Management techniques that are employed to control biomass may have no effect on nutrient levels. A biomass control technique uses some other means (light, predation, etc.) to limit the growth of algae or aquatic plants. Three biomass control methods (copper sulfate treatment, aeration/artificial circulation, and predator fish stocking) have been used in the CSCR with limited or temporary success. None of the methods in this section are new to the CSCR. A description of past experience and future viablity of these methods is provided below.

A. **Copper Sulfate.** In 1981, the City first started using copper sulfate to control algae blooms. In 1981 and 1982, each treatment involved the use of 1000 lbs. of copper sulfate. Beginning in 1983, the dosage rate went to 2000 lbs. per treatment. Citric acid was added as a chelating agent in the operation in 1988. The number of treatments per year grew from one in 1981 to three in 1988. Phycological examination and enumeration was first used at the CSCR in 1989. The analysis was used to determine when to treat the reservoir with copper sulfate. Prior to this time the need for treatment was determined by the "Gee it looks pretty green to me" method. This latter method is used far too frequently in water supply reservoirs. Algae enumeration has resulted in a reduction in the number of treatments per year. Only one treatment was used in 1989 and 1990. This reduced copper sulfate use by 66% and treatment costs by more than 33%.

As noted previously in this report, application of copper sulfate as an algicide was effective at reducing algal numbers, but treatment is costly and the benefits are temporary. Algal biomass increased again after application. It has been suggested that rebound of algal populations after copper sulfate treatment, as seen in this study, may be due to toxic effects of copper on zooplankton (Cooke et al. 1986). The projected cost of phycological examination and copper sulfate treatment of the CSCR is $4,255 per year (Table 54).

Modifications of taste and order control treatment at the Charleston water plant provided the opportunity to forgo use of copper sulfate in 1991. Taste and odor control will be managed by in-plant methods at the water treatment plant. If it is deemed that control is unlikely due to the abundance of algae or a failure in taste and odor control operations, then copper sulfate treatments will be used.

B. **Aeration and Artificial Circulation.** Algal biomass is probably limited by light at site 1. Circulation of water from the hypolimnion may disperse algal cells throughout the water column. One way in which aeration can decrease phytoplankton densities depends on higher zooplankton grazing rates attainable when algal community dominance shifts from blue-green algae to green algae. The City's aeration system has provided some water quality benefits, but the results have been less than were anticipated. If the system was greatly expanded, perhaps the anticipated benefits could be realized. To do so would be very expensive and would necessitate the closure of the reservoir to boating. For these reasons, the aeration system will be maintained for future use but will not be expanded. For additional information refer to section on Aeration under Internal Nutrient loading (page 137). The projected annual maintenance cost for the aeration system is $600 (Table 54).

C. **Predator Fish Stocking.** In January of 1988, IDOC fisheries biologist Donald Dufford provided the City with a copy of his "Lake Periodic Report" of the CSCR. The report recommended the stocking of hybrid striped bass (when available) to control the abundant gizzard shad population. Subsequent conversation with Mr. Dufford revealed that it would be several years before the state could provide the CSCR with hybrid striped bass.

Natural die-offs of gizzard shad in 1987 and 1988 had littered the shore with decaying fish and had imparted an odor to the water. It was hoped that if the hybrid striped bass could reduce the shad population it might also improve water quality. Since the CSCR is a water supply reservoir, rotenone or other toxins could not be used to restructure the fish population. Water level draw-down, to manipulate fish populations, in the CSCR is impractical. Hence, addition of piscivorous fish, in addition to aeration - artificial circulation, appeared best suited for a biomanipulation program (Shapiro etal. 1983).

Due to the efforts of the City, FishAmerica and IDOC, 8,920 hybrid striped bass and 5000 largemouth bass were stocked in the CSCR from 1988 to December of 1991. Mr. Dufford's "Lake Periodic Report" of the CSCR for 1990 - 1992 shows some improvement in the piscivorous population, but gizzard shad are still abundant. The City and IDOC both have planned to continue stocking of piscivorous fish. The cost of one full stocking of hybrid striped bass is $2,595 (Table 54). This should eventually provide improved sport fishing and improved water quality.

Table 54. Biomass Control for Algae.

A)	Copper Sulfate Treatment		
	Phytoplankton Seasonal Analysis	$	1,400
	Single Treatment Copper Sulfate	$	1,300
	Single Treatment Citric Acid	$	950
	Gas and Oil	$	25
	Labor	$	580
	Total	$	4,255/yr
B)	Aeration and Artificial Circulation		
	Maintain existing system	$	600/yr
	Electiric power consumption	$	3,431/yr
C)	Biological Controls		
	Continue stocking Hybrid Striped Bass	$	2,595/yr
TOTAL		**$**	**10,281/yr**

4. Taste and Odor

Taste and odor control will be managed by the water treatment plant using in-plant methods. If it is deemed that control is unlikely due to the abundance of algae, copper sulfate treatments in the reservoir may be used.

5. Improvement of Recreational Opportunities

As stated previously, according to "The Illinois Outdoor Recreation Plan (IORP): 1988 - 1993", Coles county is rated as having a "high need" for water area open to the Public. The IORP report expressed concern for this area in the following statement: "In rural Illinois, especially Central Illinois, special resource areas are often few and far between, requiring a long trip to reach." The IORP shows that the Illinois Department of Conservation (IDOC) Region 3 has the lowest number of acres of water area open to the Public, the fewest boat launching ramps and the least feet of swimming beaches. Eleven of the thirteen lakes listed in Table 7 are part of IDOC Region 3. It is clear that there is a real need for maintaining and improving water related recreation to this part of Illinois.

The City keeps no records of the attendance or utilization of the parks or support facilities near the CSCR. Without this type of information it is difficult to determine the extent of use or to forecast increased usage resulting from water quality or recreational restoration. The improvement of recreational opportunities can be divided into two segments. The first segment pertains to the improvement of the fishing experience at the CSCR. The second involves the upgrading of the support facilities of the CSCR and surrounding recreational areas.

A. Fishing Opportunities. Above, under "Biomass Control for Algae" and "Predator Fish Stocking", the stocking of hybrid striped bass and largemouth bass was mentioned. The IDOC is also responsible for the stocking of channel catfish in the CSCR. From 1983 to December of 1991 the IDOC stocked 74,522 channel catfish into the CSCR. It is the intention of the IDOC to maintain the channel catfish population by annual stocking. The main purpose of this stocking is to improve channel catfish fishing opportunities in this part of the state. The hybrid striped bass stocking has the dual purpose of a predator control on gizzard shad and to provide a trophy species for fisherpersons. The cost of stocking channel catfish, hybrid striped and largemouth bass is $5035 (Table 55).

If the proposed erosion control methods reduce the amount of suspended sediments and the nutrient loading methods reduce the concentration of nutrients in the water column, then aquatic vascular plant growth would increase. This would improve fish habitat and may cause an overall improvement in the fish population. The increased aquatic plants would provide forage and spawning areas for some fish.

Table 55. Improvement of Fishing Opportunities

1)	Continuation of the IDOC fish stocking program	$	865
2)	Continue stocking Hybrid Striped Bass	$	2,595
3)	Additional stocking of Largemouth Bass	$	1,575

Source: IDOC and Fountain Bluff Fish Farm.

B. Recreational Facilities. The two main parks bordering the CSCR are Lakeview and Riverview Parks (Figure 5). The facilities at both are old and in need of repair. Time and vandalism have taken a heavy toll on the facilities at Lakeview. Riverview Park is the only area around the CSCR that has working restrooms when it is not closed for repairs or for the winter. Major changes are needed in these areas including the possibility of administrative reorganization and funding changes. Improvement in these support facilities would increase both the use and enjoyment of these areas.

After discussions with City officials and members of the general public, six areas were targeted for recreational improvement. These areas are: Lakeview Park, Riverview Park, the Side-Channel Dike (Figures 3 and 9), the CSCR boat ramp (Figure 5), the Old Water Plant (concrete apron Figure 5) and an area simply referred to as "The Steps" (Figure 33). The ensuing information will detail the recreational options for the aforementioned areas. Cost of the options, benefits and potential detriments if any will be provided. No cost analysis, per projected increased usership, have been made since no records of existing or past use are available for establishment of a baseline. In order to properly evaluate improved post-restoration usership, pre and post restoration user and traffic surveys will be conducted.

1. Lakeview Park. This park has greatly deteriorated over the years. It is in need of a substantial face lift. This park has lost its drinking fountains, restrooms, wooden overlook and lighting to vandalism. Not only has the facilities of this park degraded, its reputation has too. It is sometimes used as an

area of drug and alcohol consumption. It is reputedly a meeting spot of some individuals for the purpose of obtaining sexual favors. This is not the kind of reputation that a park with such scenic beauty deserves. This should be a park where family can feel comfortable picnicking and enjoying nature.

In order to combat the problems in this park, four options have been prepared. As with any set of alternatives the option of doing nothing or, in this case, closing the park is always a possibility. It should be noted that most of Lakeview Park's problems did not develop until the State of Illinois closed the Blue Star Memorial Park on Illinois highway 16. This park had problems with vandalism and had also developed a reputation as a meeting spot. It is possible that if Lakeview was closed it would only cause the problems to be shifted to some other location. The four options are geared at improving usership. With increased general usership, the effect of any undesirable elements would be diminished.

Option 1. Rebuild picnic tables and replace damaged grills. Reconnect electrical power and add two street lights that are less susceptible to vandalism. The main trail to the three hiking trails should be covered with wood chip. **$2440.00**

Option 2. This option is inclusive of Option 1. Construct a 24' by 30' pavilion which will house drinking fountains and a Poly-John trailer. The Poly-John trailer would normally be anchored to the pavilion site and attached to water and power lines. The unit has an 800 gallon waste tank which could be serviced by the City's suction truck. The use of this unit would mean that sewer lines, lift stations, septic tanks and leach fields would not be needed. The City could temporarily relocate the unit for special events (parades and festivals). If the area was being subjected to unacceptable levels of vandalism, the City would have the option of moving the unit out. This is something that could not be done with a conventional restroom. **$20840.00**

Option 3. This option would be in addition to option 1 and 2. The park is currently used as a turnaround point by joggers and walkers. This is an activity that the city would like to see increased in the park. To facilitate this, an exercise course complex could be installed along the main park trail. The complex would include: horizontal ladder, parallel bars, vault beam and other stations. **$25740.00**

Option 4. This option is best used with option 2. Establish a nature interpretive program for children. This program could be set up using students from EIU as instructors and managed through the Recreation department. This could help educate the public about the environment and the CSCR watershed. **$1900.00**

2. Riverview Park. Riverview Park has been subjected to less vandalism and enjoys a far better reputation than Lakeview. Three options have been prepared for this area. These options are intended to replace those items that have worn out and to increase usership through addition of new facilities.

Option 1. This option calls for the addition of 6 low maintenance, single pedestal, wheelchair accessible picnic tables. Three grill and three trash cans would be added. **$2970.00**

Option 2. This would call for the closing of the existing restrooms and installing a Poly-John trailer (as described in option 2 of Lakeview). A drinking fountain would be added near this site. **$14,500.00**

Option 3. A standard type swing-set and a climber play-structure would enhance the enjoyment of younger users. **$10,000.00**

3. Side-Channel Dike. The dike is frequently used as a path for walkers, runners, bicyclers and as a route for access to fishing. After heavy rains the top of the dike can become very muddy and thus limits its use. The placement of a layer of road pack and rock would make this a year round path and improve access by emergency vehicles. **$6,932.00**

4. CSCR Boat Ramp. The boat docks that are located on either side of the CSCR boat ramp are susceptible to wracking and twisting due to wave and ice movement. The access ramps have been rebuilt several times and the docks are removed almost annually for repair. When the docks are removed for repair, it imposes an inconvenience on boaters. The key problem with the docks is their anchoring system which is not flexible enough to respond to icing and high wave conditions. The replacement of the anchoring system would alleviate this problem. **$630.00**

5. Old Water Plant. The concrete apron located in the northwest corner of the CSCR is about all that remains of one of Charleston's former water treatment facilities. The old water treatment plant was raised in 1963. The area has been used off and on over the years as a construction spoils (dirt, rock, brick concrete, etc.) dumping site. Once again it became a spoils site in 1990. The recreational restoration options for this area in-

volved the continued filling of depressions to achieve a near level grade. When this is accomplished the area will be covered with clean fill and seeded. This area has the potential of being developed into a beneficial recreation area. Three options for further development of the site are listed below.

Option 1. The area would be leveled and seeded. This option calls for the addition of 3 low maintenance, single pedestal, picnic tables. Three grill and three trash cans would be added. **$3,050.00**

Option 2. This would include all of option 1 and adds a 6'3" by 24' fishing dock and a 4' by 20' connecting bridge with handrails. **$9,753.00**

Option 3. This would include all of option 1 and 2 with the addition of a boat ramp and parking area. Presently this area is not open to vehicle traffic due to the one lane access road that is bordered by a steep drop off. Due to the traffic safety issue, we cannot recommend this option at this time. **$44,753.00**

6. The Steps. "The Steps" is a local name for concrete steps that were originally part of a LC boat club. The steps and part of a support pillar is all that is left of the club house. The steps now lead down into the reservoir. This is a favorite fishing spot for many anglers. The steps are located on the south shore west of the parking area for the CSCR boatramp. A 3.5' high concrete barricade separates the roadway and parking lot from the reservoir. City Commissioner John Wennet informed us that numerous older citizens had complained about the difficulty in climbing over the barrier in order to fish at The Steps. The options presented below are intended to improve accessibility to this fishing area.

Option 1 Cut a 4' wide opening in the barricade. **$200.00**

Option 2 Option 1 plus construct an asphalt walkway. **$788.00**

Option 3 In addition to option 2, this area would be made handicap accessible. Handicap parking would be added to the existing parking lot. Near The Steps a wheelchair accessible fishing dock and gangway would be added. **$9,446.00**

Selection of Restoration Alternatives

Before final selection of preferred restoration alternatives was made, a technical advisory committee was formed. This committee reviewed pertinent data on all feasible alternatives. Some alternatives were dismissed due to their questionable longevity or potentially adverse side effects. After selecting those alternatives that were appropriate for the CSCR and its watershed, the cost of implementation was totaled. The present and future fiscal liabilities of the City's Water and Sewer found were reviewed.

It is the desire of City officials to execute restoration in a fascicle, sound manner and to limit the need to increase water and sewer rates. Thus it was decided to break restoration into a two tier approach. Tier 1 includes those options that the City could afford to undertake at this time. Tier 2 includes two items that are expensive and need additional engineering work before they can be enacted. Tier 2 items will be delayed for a few years. This will allow the City to evaluate the effectiveness of the Tier 1 methods and reduce the City's debit exposure. Between the year 2000 and 2007, five water and sewer bonds will be retired. After these bonds are retired, the water and sewer fund will have a greater degree of financial flexibility. However, this is not to be interpreted as meaning that the City will delay Tier 2 restoration until the year 2000. Below is a list of Tier 1 and Tier 2 preferred alternatives.

Internal Nutrient Loading

1.	Dredging	Tier 2

External Nutrient Loading

A. Shoreline Erosion

1.	Willow Planting	Tier 1
2.	Tree Cutting	Tier 1
3.	Reduced Water Levels	Tier 1
4.	Purchase of Land and Property	Tier 1
5.	RipRap (limited area)	Tier 1
6.	Raft Wave Barrier	Tier 1
7.	Sea Wall	Tier 2

B. Pumping from LC to CSCR

No alternatives were selected for this loading source.

C. **Watershed Loading**

1.	Sedimentation Basins	Tier 1
2.	Zoning Ordinance	Tier 1
3.	Purchase of Land	Tier 1

Biomass Control for Algae

Continue Existing Methods

A.	Copper Sulfate	Tier 1
B.	Aeration and Artificial Circulation	Tier 1
C.	Predator Fish Stocking.	Tier 1

Improvement of Recreational Opportunities

A. **Improvement of Fishing Opportunities**

1.	Stocking of Channel Cat	Tier 1
2.	Stocking of Hybrid Striped Bass	Tier 1
3.	Stocking of Largemouth Bass	Tier 1

B. **Recreational Facilities**

1.	Lakeview Park - Option 3 (- wood chipping and pavillion)	Tier 1
2.	Riverview Park - Options 1,2 & 3	Tier 1
3.	Side-Channel Dike Option	Tier 1
4.	CSCR Boat Ramp Option	Tier 1
5.	Old Water Plant - Option 2	Tier 1
6.	The Steps - Option 3	Tier 1

Section (b) (2) Benefits Expected From Restoration

A. Statement of Objectives. For a review of project objectives please refer to "Objectives of the Lake Water Quality Management Plan" page 135.

B. Restoration and Anticipated Water Quality Changes. When evaluating restoration alternatives and projecting anticipated water quality changes, it has become customary to employ a lake response model. With modeling, a lake manager can compare existing conditions to restoration scenarios. This can enable the manager to determine if the selected methods for restoration will have a noticeable effect on water quality.

One model that is useful in predicting lake phosphorus concentrations was developed by Vollenweider (USEPA 1988).

$$[P\ (ppb) = Pi/1+T^{.5}] \quad (2.1)$$

In this model Pi is equal to the average inflow phosphorus concentration (equation 2.2). The hydraulic residence time is represented by T (equation 2.3).

$$Pi = \{TP\ loading\ lbs./yr.\ /\ Mean\ Outflow\ acre\text{-}ft./yr.\}*368 \quad (2.2)$$

$$T = Lake\ volume\ (acre\text{-}ft.)\ /\ Mean\ outflow\ (acre\text{-}ft./yr.) \quad (2.3)$$

Using all the phosphorus loading sources listed in Table 42 and substituting the SCS watershed values for the baseflow values, we have a TP loading of 3307.9 lbs./yr. If this is plugged into equation (2.1) with other CSCR data, it produces a lake phosphorus concentration of 219 ppb. This value is higher than the average CSCR total phosphorus concentration of 144 ppb. This may point out potential problems with using this model with the CSCR or the possibility of overestimation of one or more loading sources.

If we accept the 219 ppb value and combine it with Carlson's Tropic State Index (TSI) formula for total phosphorus (equation 2.4), we obtain a TSI value of 81.9.

$$TSI = 14.42\ \ln\ Total\ Phosphorus\ (mg\ m^{-3}) + 4.15 \quad (2.4)$$

The mean TSI value for the CSCR is 74 (Table 43). Carlson's TSI is designed so that every ten TSI units represents a doubling or halving of algae biomass or transparency. If a restoration option is to produce noticeable improvement, it will have to generate a 10 TSI unit reduction or better. In other words, a restoration plan would have to drop the calculated TSI of the CSCR from 81.9 to 71.9 or lower.

Under the proposed restoration plan, loading from LC and precipitation would remain the same, backwash loading would be eliminated, and watershed loading would be reduced by 77.5%. Loading for the above sources would equal 348.4 lbs./yr. The remaining loading would come from internal cycling and shoreline erosion. By inserting 71.9 as the TSI value we can solve equation (2.4) for total phosphorus. This total phosphorus value can be used as the P value in equation (2.1) and the equation can be solved for Pi. The Pi value can be used in equation (2.2) to find the total phosphorus loading per year needed to produce a TSI of 71.9 in the CSCR (1648 lbs./yr.). If we then subtract the loading from LC, precipitation and the watershed from 1648 lbs./yr., the sum is 1299.4 lbs./yr. This sum is equal to the total loading limit for both internal cycling and shoreline erosion, if a TSI of 71.9 is to be obtained. The current loading for internal cycling and shoreline erosion is 1463.5 and 1403.8 lb./yr. respectively. Reducing the total loading for both of the above sources to 1299.4 lbs./yr. would represent a 54.7% reduction. This is feasible, but only after Tier 2 restoration is fully implemented. If loading from shoreline erosion was reduced by 100% (which is not realistic) and internal recycling was unchanged, the loading reduction would only be 49%.

Let's consider a second 10 TSI unit reduction (61.9 TSI). If all other conditions remained the same, loading from internal cycling and shoreline erosion would have to be reduced by 83% (474.83 lbs./yr.). Due to the complexities of the CSCR's shoreline erosion problems, it is doubtful that this level of restoration could be achieved. It should be remembered that this model imparts an artificially high initial TSI value on the SCSR. Thus, less load reduction may be needed to achieve a TSI of 61.9 or less. From this information it becomes apparent that restoration to achieve a mesotrophic condition (TSI 40 - 50) is an unrealistic goal. Of the 134 lakes that participated in the Illinois Volunteer Lakes Monitoring Program for 1990, only 16 had a TSI of >50 (IEPA 1991). However, considerable benefits could be derived from a reduction in the eutrophic level of the CSCR.

C. Anticipated Benefits of the CSCR Restoration Plan.

Tier 1 Benefits

The Tier 1 portion of the restoration plan is designed to address a wide range of water quality and recreational problems. The implementation of this plan will generate an equally wide range of benefits. This plan will provide the basis for improved water quality and reverse the trend of deteriorating recreational facilities. With the subsequent completion of Tier 2, stabilization of shorelines and substantial deepening of the reservoir will be achieved.

Several of the restoration methods are aimed at reducing nutrient and sediment loading. With reductions in nutrient loading, we could anticipate a reduction in the algae population. Reducing the algae population and the non-algae turbidity from sediment loading will provide an increase in transparency. Increased transparency would provide for improved aesthetics, increased viability of aquatic plants and improved site feeding by fish.

External nutrient loading will be controlled by sedimentation basins and shoreline erosion control methods. Control of phosphorus loading will inhibit the development of algae blooms. It may also serve to shift the limiting nutrient more toward being phosphorus limited. This could affect the phytoplankton population composition by limiting or preventing the dominance of of blue-green algae. The reduction in total population and change of type dominance will aid in the control of trihalomethanes and taste and odors problems. Control of these three problems will be greatly appreciated by consumers of Charleston potable water. Additional benefit will be derived from the elimination of foul smells near the shore due to algae.

The combined effect of all of the restoration items listed under shoreline erosion on page 144 will serve to retard the filling in of the reservoir via sedimentation. They will aid in re-establishing a vegetative cover on and near the shore. The vegetative cover will enhance the overall appearance of the CSCR. The success of the willow plantings will provide a foothold for aquatic plants to establish themselves. This reintroduction of plants will be important in providing cover and spawning areas for fish and other aquatic animals. The plants will also compete with algae for nutrients and hopefully limit algae biomass. Limiting the algae biomass will in turn limit the amount of oxygen required to accomplish the decomposition of senesced plankton. With a lowered oxygen demand the oxygen level within the water column should remain higher. Higher oxygen levels will be less stressful to fish and may reduce water treatment cost.

Most of the sediment loading that is delivered via the watershed will be intercepted by the four sedimentation control structures. Control of this loading will be augmented by by the adoption of the "Watershed Zoning Ordinance". Hopefully the ordinance will serve as both a management and educational tool. Key land purchase will have a mitigating influence on the potential over-development of the watershed. This will benefit the reservoir by limiting the potential of increased run-off, overuse of lawn chemicals and disturbance of highly erodable soils.

The continued stocking of channel catfish will help maintain this species in the CSCR. Channel catfish are perhaps the most common target of anglers within the reservoir. The stocking of largemouth and hybrid striped bass will help rebalance the food chain. Predation by these piscivorous species will reduce the overabundant gizzard shad, which may be contributing to nutrient cycling, and improve the condition of the white perch. Hybrid striped bass grow to be very large and will provide anglers with a trophy species. With an increase in the average size or number of fish caught, there will be an exponential increase in fish stories.

To provide anglers with an adequate setting for relating their tales, the City will be undertaking a renovation project of the CSCR support facilities. The enhancement of fishing opportunities and recreational facilities may usher in a renaissance for Lakeview and Riverview Parks. The Tier 1 plan will call for the re-establishment of two sets of rest rooms. In general, access will be improved and attention will be paid to the needs of our mobility-impaired citizens. A nature program and exercise path will be established at Lakeview Park. Numerous tables, grills and benches will be added. It is believed that this area will once again become a source of City pride.

As stated in Section (a, 5) the City maintains no records for the purpose of tracking fishing or hunting activities in or around the CSCR. Likewise the City has no records on general park and/or reservoir use. Without a base of data to draw from, it is impossible to project recreational usage increases. In order to establish a base for determination of anticipated increased usage a survey is currently being developed. This survey will be executed prior to implementation of any Phase 2 restoration work.

Tier 2 Benefits

The two Tier 2 restoration methods are listed as dredging and sea wall construction. The benefits that are expected from the sea wall construction is the halting of the severe erosion problems. This extreme erosion threatens property on the south shore and the intake structure in the northwest corner of the CSCR. In addition to protecting property it will also augment the beneficial effects that are list under Tier 1 for shoreline erosion, nutrient and sediment loading. Dredging will provide a means for diminishing the release of phosphorus from bottom sediments. The reduction of internal phosphorus loading will bestow the same benefits as were listed for Tier 1 nutrient loading. Dredging will also reclaim lost reservoir depth. The increased depth will provide for improved fish habitat and water storage capacity.

Section (b) (3) Phase 2 Monitoring Program

Tier 1: The phase 2 monitoring program is based on the results of the phase 1 study and the selected restoration methods. Certain items that were part of the phase 1 program have been omitted. Sampling and/or monitoring methods pertinent to the restoration technique were added. The goal of the monitoring program will be to determine the relative response of the reservoir ecosystem to the implemented restoration plan.

In-reservoir monitoring will be conducted at sites 1, 2, and 3. Sampling frequency will be twice a month from May through October; the rest of the year sampling will be monthly. Monitoring will include testing for nutrients, solids and other assorted physical and chemical parameters (Table 56). The main inflow and outflow points of the CSCR will be monitored using grab sampling. Water for the inflow will be collected at the LC pump-house when pumping operations are underway. The outflow will be collected at the City water treatment plant raw water tap. To evaluate the effectiveness of the sedimentation basins, four storm events will be monitored from a proposed basin. To insure that the dredge spoils detention area is being operated correctly, weekly samples will be collected from the return water flow.

In the first year of Phase 2, after implementation of Tier 1 restoration methods, monitoring will start for the development of a hydrologic and nutrient budget. This work will be completed in the second year. Following implementation of Tier 2, a second hydrologic and nutrient budget will be conducted in project year number 4. A comparison will be made between these two budgets and the Phase 1 hydrologic and nutrient budget. This will be done to evaluate restoration performance.

In addition to water quality, other monitoring operations will be conducted during phase 2. The IDOC is planning to maintain its biennial fish survey. Immediately and two years after implementation of erosion control measures, the erosional cliffs will be mapped. This will be compared with previous mapping data to decide if the rate of erosion has slowed. To provide shoreline erosion data, 34 inch long sections of rebar will be driven in flush with the shore surface. One year after implementation of erosion control measures, the amount of exposed rebar will be measured to estimate the rate of shoreline erosion. The willows will be surveyed in spring and fall to measure their survival rate.

Tier 2: Before sea-wall construction is started, a coring study will be conducted to determine if the site geology will permit the use of this restoration method. As pointed out under the section on dredging (page 139), an engineering study will be needed to decide the size of the spoils holding area. A new sedimentation survey will be needed to estimate the volume of material to be removed. A settling test will be performed to determine the time required to settle the spoils properly. Mapping of sediment phosphorus concentration will be used to aid in developing a dredging plan.

Table 56. Phase 2 CSCR Water Quality Monitoring

Parameter	CSCR 1, 2, 3	Plant Intake	LC Pump house	Basin #1	Return Flow
Secchi Disk	M,S				
D.O./Temp Profile	M,S	W, |	W, |	E, |	W, |
Total Phosphorus	M,S	W	W	E	W
Dissolved Phosphorus	M,S	W	W	E	W
Ammonia-Nitrogen	M,S	W	W	E	W
NO2+NO3-Nitrogen	M,S	W	W	E	W
Kjeldahl Nitrogen	M,S	M	M		M
Turbidity	M,S	W	W	E	W
Total Suspended Solids	M,S	W	W	E	W
Volatile Suspended Solids	M,S	W	W	E	W
pH	M,S	W	W	E	W
Alkalinity	M,S	W	W	E	W
Conductivity	M,S	W	W	E	W
BOD					M
COD					M
Chlorophyll a, b, c	M,S				
Phytoplankton	M,S				
Metals					Q

Site	Latitude	Longitude	Sampling Depth	Responsible Agency
CSCR #1	39 28 13	88 08 37	S,B	CITY
CSCR #2	39 28 01	88 08 35	S,B	CITY
CSCR #3	39 27 47	88 08 34	S,B	CITY
Plant Intake	39 28 20	88 08 58	G	CITY
LC Pump House	39 27 39	88 08 25	G	CITY
Basin #1	39 28 28	88 08 53	A	CITY
Return Flow	39 28 ??	88 11 ??	A	CITY

Key:
M = Monthly sampling (12 samples per year)
S = Seasonal added sampling (May to October) sample twice per month
W = Weekly sampling
| = no profile
E = Event sampling, maximam number of events = 4
Q = Quarterly sampling
S = Sample collected one foot below the surface
B = Sample collected one foot above the bottom
G = Grab sample from pump house tap or stilling basin
A = Automatic flow proportional samplers

Section (b) (4) Schedule and Budget

The schedule for the Phase 2 restoration is separated into Tier 1 and Tier 2 projects. The restoration projects, evaluation and funding are spread over a five year time frame. After completion of Tier 1 projects in year 1, an interim evaluation will be conducted. The interim evaluation and engineering study (year 2) will be used to determine the amount of dredging needed. In the last year of the project, a final report of the Phase 2 project will be prepared and distributed.

Tier 1

Year 1 — **Shoreline Erosion**	
1. Willow Planting	$46,412.00
2. Tree Cutting	$1,470.00
3. Reduced Water Levels	-0-
4. Purchase of Land and Property	$65,000.00
5. RipRap (limited area)	$7,972.00
6. Raft Wave Barrier	$14,996.00
Watershed	
1. Sedimentation Basins	$41,100.00
2. Zoning Ordinance	-0-
3. Purchase of Land	$38,000.00
Continue Existing Methods (These are annual costs)	
A. Copper Sulfate	$4,255.00
B. Aeration/Artificial Circulation	$600.00
C. Predator Fish Stocking	$4,170.00
Improvement of Recreational Opportunities	
A. **Improvement of Fishing Opportunities**	
1. Stocking of Channel Cat	$865.00
2. Stocking of Hybrid Striped Bass	(Part of Predator Fish Stocking)
3. Stocking of Largemouth Bass	
B. **Recreational Facilities**	
1. Lakeview Park - Option 3 (- wood chipping and pavilion)	$23,100.00
2. Riverview Park - Options 1, 2 & 3	$27,470.00
3. Side-Channel Dike Option	$6,932.00
4. CSCR Boat Ramp Option	$630.00
5. Old Water Plant - Option 2	$9,753.00
6. The Steps - Option 3	$9,446.00
Monitoring	
1. Water Quality	$13,673.00
2. Erosion	$550.00
General Project Planning, Management & Administration	$12,000.00
Year 1 Total	$328,394.00

Year 2

Tier 1	
1. Water Quality and Erosion Monitoring	$13,673.00
2. Interim Evaluation and Report	$9,100.00
3. Annual Cost of Continuing Methods	$7,625.00
Tier 2	
1. Engineering and Coring study for Sea-wall	$35,120.00
2. Phosphorus concentration mapping	$5,000.00
3. Sedimentation survey	$5,000.00
4. Engineering and Design of Dredging spoils basin	$100,000.00
5. Purchase of property for Dredging spoils basin	$200,000.00
General Project Planning, Management & Administration	$12,000.00
Year 2 Total	$347,130.00

Year 3

Tier 2	
Sea wall	
1. South shore construction	$478,800.00
2. West shore construction	$351,120.00
Dredging	
1. Hydraulic Dredging	$3,182,300.00
2. Sediment Disposal Site Construction	$692,000.00
Monitoring	
1. Water Quality for Tier 1 & 2	$5,748.00
2. Monitoring for Disposal Site Operation	$9,000.00
Miscellaneous	
1. General Planning, Management & Administration	$12,000.00
2. Annual Cost of Continuing Methods	$7,625.00
Year 3 Total	$4,738,593.00

Year 4

Tier 2	
1. Water Quality Monitoring	$27,345.00
2. Erosion Monitoring	$550.00
3. Remapping of reservoir depths	$10,700.00
Miscellaneous	
1. General Planning, Management & Administration	$12,000.00
2. Annual Cost of Continuing Methods	$7,625.00
Year 4 Total	$58,220.00

Year 5

Tier 2	
1. Completion and Distribution of Final Report	$25,000.00
2. General Planning, Management & Administration	$12,000.00
3. Annual Cost of Continuing Methods	$7,625.00
Year 5 Total	$44,625.00
Project Total	$5,516,962.00

Section (b) (5) Sources of Matching Funds

The primary source of non-federal matching funds for the proposed Phase 2 Clean Lakes Program restoration project will be the City of Charleston. To defray portions of the financial liability, the City is seeking support through grants from the Illinois Department of Conservation (IDOC). In-kind services from the IDOC and Eastern Illinois University are part of the City's matching fund.

Section (b) (6) Relationship to Other Pollution Control Programs

To execute the Phase 2 restoration plan the City will need to maintain an integrated approach which coordinates the activities of several agencies, individuals, and programs. The following is a list of participants that the City will be working with.

1. **Illinois Environmental Protection Agency.** The Phase 2 restoration plan will maintain compliance with the IPCB "General Use Water Quality Standards" and "Public and Food Processing Water Supply Standards". During the sighting and operational stages of the dredging operation, the City will maintain close communication with the IEPA Divisions of Water and Land Pollution Control and Public Water Supplies. This will be done in order to ensure compliance with all relevant regulation.

2. **Illinois Department of Conservation.** The CSCR and the LC are managed under a cooperative agreement between the City and the IDOC. IDOC has indicated its intent to continue management of the fish population in the CSCR. The City is seeking funding through the Open Space Land Acquisition and Development fund (OSLAD) for the purchase of property along the north shore of the reservoir. The area will be developed as a park and will provide a buffer from over-development of the watershed.

3. **Illinois Department of Transportation.** Prior to the development of the willow test plots for shoreline stabilization, the IDOT was contacted. The IDOT coordinated efforts through the "Protect Illinois Waters" program to determine if permitting was warranted. During year two of the proposed restoration project, the City will coordinate efforts with the IDOT to secure permits related to the dredging and spoils retention operations.

4. **U. S. Army Corps of Engineers.** Along with the IDOT, the USACE is a participant in the "Protect Illinois Waters" program. The City received written notice that the Willow planting project is not subject to permitting by the USACE. In year two of the restoration plan, the City will provide the USACE with needed information for permitting the dredging operation.

5. **Soil Conservation Service, USDA.** The SCS provided the City with three separate restoration alternatives for the CSCR. One of the alternatives (sedimentation basins) was incorporated in the Phase 2 restoration plan. The City will work closely with the SCS on the implementation of this portion of the plan.

Section (b) (7) Public Participation Summary

The City has conducted several public participation meetings during the execution of the Phase 1 Diagnostic/Feasibility Study. The first was held on December 6th, 1989. This meeting described what activities had taken place up to that date. It also outlined problems with the CSCR and indicated what restoration steps may be needed.

The Coles County League of Women Voters held a public forum entitled "Land Use, Water Quality: Considerations for the Future". The meeting was advertised locally and open to the public. The forum was held on the campus of EIU at 7:00 P.M. on October 16, 1991. In this forum six speakers provided information on the CSCR, its watershed, land uses, septic systems, general lake management and water quality. The list of speakers included two members of the IEPA, two members from the City's CSCR project, a professor from the EIU Geology Department and an officer from the Coles County Health Department. The forum concluded with a question and answer period.

On January 22, 1992 a legal notice appeared in the Charleston "Times-Courier" announcing the March 7, 1992 public participation meeting/hearing. On March 3 information about the meeting/hearing was aired on a morning radio talk show. During a City Council meeting (3/3/92), commissioner Bruce Schism announced information about the meeting/hearing. A report about the upcoming meeting/hearing was aired by WEIU TV on Friday (3/6/92). The Times-Courier published a news item regarding the meeting/hearing in the March 7th morning paper. The meeting/hearing presented the results of the diagnostic study. Restoration alternatives that had been deemed feasible by the "CSCR Technical Advisory Committee" were outlined. Input from the attendants was requested. The meeting concluded with a question and answer session.

On April 7th the Restoration plan was presented to the Charleston City Council during a city council meeting. Subsequently portions of the restoration plan have been presented to the Charleston Board of Zoning and the Playground and Recreation Board.

Prior to the March 7th meeting/hearing, a project summary and fact sheet was prepared and made available to all who requested additional information (Appendix I). This summary/fact-sheet was available to any interested party at the billing desk of the Charleston Water Department. This same information was handed out to the audience of the March 7th meeting/hearing. No letters or other written material were received before or after the meeting/hearing.

The following is a list of questions and answers that were transcribed from the audio tape of the March 7th meeting/hearing. Questions were from the audience which was comprised of members of the general public and the news media. The answers to audience questions were handled by the following people.

City of Charleston Staff; Dick Sherman, Alan Alford and Jeff Bushur

Easter Illinois Universtiy; Dr. Vince Gutowski (Geology /Geography), Dr. Charles Pederson and Dr. Willam Weiler (Life Science)

Q. Do we have news media here?
A. Yes we do.
Q. I would just love for them to give some real emphasis to the vandalism that takes place in the park areas, because I think that the public needs to be much more aware of that. We just don't hear much about it.
A. (Dick Sherman) I would like to speak to that. (Mr. Sherman gave a run-down of the vandalism that has occurred in the CSCR and surrounding area.)

Q. How does vandalism cause a problem with the water?
A. In most cases, it does not have a direct effect unless someone throws a contaminant into the water. It has a greater impact on the overall aesthetics and usability of the support facilities.

Q. What are the other uses of rip-rap?
A. It is used in drainage ditches and waterways where erosion is a problem.

Q. Will the grant be used to replace rip-rap (that was removed due to vandalism)?
A. No. This area near the Dam will be reworked using City funds.

Q. If you don't receive enough grant money, which will you work on first: the water part or just the recreation?
A. We would primarily be addressing the water quality problems. As part of a complete restoration plan, we would want to look at both. In any activity, we would try to make incremental improvements on both water quality and recreation.

Q. Do you think that a local fundraiser could be used for recreational facilities?
A. I think it is a good idea. It is going to take a grass roots effort in order to get something going.

Q. What does this treatment (sea wall) focus on? Erosion?

A. Yes, this would be addressing erosion. You have several avenues there. First, you have a severe erosion problem. That erosion problem is adding material into the reservoir which causes it to fill in. Also this material has nutrients associated with it and is causing some nutrient loading. It is eroding so rapidly and is in an area where it is beginning to threaten property. It has to be addressed, or you will eventually see houses falling off into the reservoir.

Q. What is a sea wall exactly?
A. It is a series of sheet piling that is driven into the sediments and anchored in place. Then material will be built up inside of that wall. (A local example of sheet piling was cited.)

Q. I was curious about whether or not these (restoration methods) will be combined in their use?
A. We do not think that any one particular method will solve the problems in the reservoir. It is going to take a combination of different techniques in order to adequately address the problems of the reservoir. Basically, the restoration plan is going to have to look at all the areas and see what we can do. We will have to see what money is available and what we can afford to do.

Q. About the reduced water levels, how is that going to help? What would it be?
A. Whenever waves start to cut into the bank, it leaves behind a little platform, just below the water level. As long as you have waves cutting along on this wall, this (speaker was using hands to describe action) will keep slumping in. But if we just drop the level so it is not hitting against the bank, then it is going to break along the bench. The bench has a lot of gravel and lag gravel. Then you will reduce the wave energy, and you are not undercutting that steep slope anymore, and it is expending all of the wave energy on the bench. If you drop the level of the reservoir for six months out of the year, it does not cost you anything. You are preventing erosion for a good part of the year just by dropping the water level.

Q. How do you drop the water level (of the CSCR).
A. You just don't pump into the Lake (CSCR). We are usually pumping in from the River (LC) to the Lake (CSCR), and taking out of the Lake (CSCR) to supply the City. So all we do is just not pump into the reservoir for a period of time.

Section (b) (8) Operation and Maintenance Plan

The primary responsibility for the Phase 2 CSCR Operation and Maintenance (O&M) plan will fall with the City. A description of the tasks involved in implementation and the responsible parties are listed below.

Grant Administration and Management. Overall administration of the grant will be performed by the IEPA. Local administration and management will be conducted by the City. Planning will involve the IEPA, City, EIU, IDOC and the Coles County Regional Planning and Development Commission.

Monitoring Phase 2. The Phase 2 water quality will be conducted by the IEPA, the City and EIU. Following the completion of restoration work, a long term water quality monitoring program will be developed and administered by the City.

Tier 1

Shoreline Erosion Control. The city will have sole responsibility for the long term O&M of all the shoreline erosion control methods.

Willow Planting. The selecting, cutting and evaluation of survivorship of willows will be supervised by members of the EIU Life Sciences Department. The establishment of erosion monitoring devices and evaluation of erosion data will be supervised by Members of the EIU Department of Geology/Geography. All of these activities will be coordinated by the City.

Tree Cutting. The City will tag all trees that are to be cut. To limit the potential destruction of riparian habitat, IDOC wildlife officials will be notified before cutting. Trees will be downed by City personnel.

Reduced Water Levels. Water levels will be monitored, and pumping rates will be adjusted by the City.

Purchase of Land and Property. Purchase of erodable lands will be carried out through an Open Space Land Acquisition and Development Fund (OSLAD) grant and is subject to the operational guidelines of said grant. The IDOC administers all OSLAD grants.

Riprap. The City will install, monitor and replace riprap as needed.

Raft Wave Barrier. The construction and installation of the raft wave barriers will be executed by the City. The performance and erosion control effectiveness will be determined by the City and EIU.

Sedimentation Basins. The City will select a contractor for the construction of the control basins. The contractor will adhere to the design and construction guidelines set forth by the SCS. The City is responsible for the long-term operation and maintenance of the basins. Financial support for sustained basin operation will be provided by the City.

Zoning Ordinance. The City will adopt an appropriate version of the watershed zoning ordinance. The ordinance will be administered and enforced by the City.

Copper Sulfate. Application of copper sulfate will be performed by the City. Treatments will be administered as needed, based on the phycological examination of the CSCR. The City will maintain its algicide permit and comply with all IEPA rules regarding its use.

Aeration/Artificial Circulation. The operation and maintenance of the City's aeration system will be at the discretion of the City.

Fisheries Management. Biennial fish surveys will be conducted by the IDOC. The survey will be used to determine species to stock and their densities. The fish for stocking will be supplied by the IDOC. Supplementary fish stockings will be made by the City with the approval of the IDOC.

Recreational Facilities. The construction and/or installation of additional facilities will performed by the City or its contractors. Rehabilitation or maintenance of facilities will be carried out by the City. The City is responsible for the long-term operation and maintenance of the support facilities. Financial support for continued care of the facilities will be provided by the City.

Tier 2

Seawall. The construction of the seawall will be executed by the contractor in accordance with the specifications set forth by the project engineer. After successful completion of the seawall, the City will assume long term responsibility for the structure.

Dredging. The City will select an engineering firm for this operation. The engineering firm will determine the amount of material to be removed from the CSCR. The firm will also design a spoils detention basin and delivery system. The firm will be responsible for overseeing the construction and operation of the spoils detention basin. All applicable permits will be obtained by the firm. The City will also select a dredging contractor to perform the dredging operation. With the development of watershed and shoreline erosion control measures, additional dredging will not be needed for many years. The current sedimentation rate is one inch every 6 years. Long term rehabilitation of the spoils detention basin will be managed by the City.

Section (b) (9) Copies of Permits or Pending Applications

In the fall of 1991, the CSCR technical advisory committee decided to establish a series of willow test plots. The plots were needed to evaluated the performance of this restoration method in controlling shoreline erosion. To insure compliance with any unforeseen regulations, the City contacted representatives of the IEPA, IDOT and IDOC. The individual representatives of these agencies concluded that no permit was needed for reservoir shoreline willow planting. A permit application was filled out and mailed to the USACE. In January of 1992, the City received written correspondence indicating that the willow planting project was exempt from permitting.

Permits will be required for hydraulic dredging, construction of spoils detention basin, storage of spoils, and return of spoils discharge water. Permits will be obtained from the IEPA, IDOT, and the USACE. Application for permits will be made in the first year of the Phase 2 project. Dredging related operations will not start until the third year of the project. This will provide adequate lead time for application review.

PART 3

ENVIRONMENTAL EVALUATION

OF THE

CHARLESTON SIDE-CHANNEL RESERVOIR

RESTORATION PROJECT

COLES COUNTY, ILLINOIS

Section (c) (1,3,7, & 12) The environmental evaluation section contains 14 parts. Each part asks questions in regarding potential environmental impacts. These could result from the implementation of the proposed restoration project. The CSCR restoration project will have no impact on the 4 items listed above.

The CSCR restoration project will not result in the displacement of people (c 1). There will be no reduction in the amount of open spaces and no change in land use patterns (c 3). There will be no long-range increase in energy demand (c 7). There will be no adverse effects to wetlands and related resources (c 12).

Section (c) (2) Defacement of Residential Areas The area surrounding the CSCR contains less than a dozen residences that are within sight or hearing distance of the reservoir. There should be minimal short-term and no long-term adverse visual or auditory impacts from dredging. The area designated for the construction of the spoils detention basin is in an area surrounded by agricultural fields and should have no adverse impact on its nearest neighbors. The occupants of the residences near the CSCR and any visitors should be positively impacted by the restoration project. The general public should derive both short-term and long-term positive benefits from shoreline erosion control and recreational facility improvements.

Section (c) (4) Impacts on Prime Agricultural Land Only one portion of the restoration plan will result in the loss of any type of agricultural land. The construction of the dredge spoils detention basin will result in the loss of 36.4 to 40.5 hectares (90 to 100 acres) of prime agriculture land. The spoils area will be reclaimed after all of the material has been sold as fill or lawn dressing (less than 5 years). After the area is reclaimed, it could be returned to agricultural production.

Section (c) (5) Impacts on Parkland, Other Public Land, Scenic Resources The City-owned parks that border the CSCR will be positively impacted by the proposed restoration project. Restoration will have a long-term effect on the parks. There should be no adverse impacts on the parks. For detailed information on the proposed changes refer to "Improvements of Recreational Opportunities" page 170.

Section (c) (6) Impacts on Historic, Architectural, Archaeological, or Cultural Resources No structures are located on any of the areas where land-disturbing activities are planned. The City submitted a request for site review to the Historic Preservation Agency of the State of Illinois (HPA). The HPA determined that there are no known sites of historic, architectural, or archaeological importance in the proposed areas. Due to the close proximity of some known sites the HPA has indicated that a survey of the area is warranted. This could be conducted within a two-day time frame.

Section (c) (8) Changes in Ambient Air Quality or Noise levels There should be no long-term (beyond the life of the project) changes in ambient air quality or noise levels. Some short-term increase in daytime noise levels related to the dredging operation and seawall construction will occur. It is a possibility that the short-term ambient air quality could be effected by the emissions from construction equipment. Also a possibility exists that decomposition gases may be released during dredging.

Section (c) (9) Adverse Effects of Chemical Treatment A chemical treatment was not selected as a restoration alternative. The City does reserve the option to continue the use of copper sulfate treatment for algae control, on an as-needed basis. Starting in 1989, phycological examination was used as the basis for treatment. This resulted in a reduction of the average number of treatments per year. In 1991 no copper sulfate treatments were used in the CSCR. There should be no adverse effects due to chemical treatment.

Section (c) (10) Compliance with Executive Order 11988 on Floodplain Management. In studying this requirement the City referred to a Federal Emergency Management Agency (FEMA) flood insurance rate map. The map was panel 125 of 200 for Coles County, Illinois. The City concluded that this map is grossly inaccurate. The panel has an effective date of August 5, 1985. This is three and a half years after the CSCR had been completed and filled, yet the map still shows pre-CSCR Lake Charleston. We can only assume that the effects of the side-channel and dike have not been factored into the FEMA data.

All of the restoration activities are located either up-land or behind the side-channel dike. It is the City's contention that the dike removes the CSCR from the Embarras River's 100 year flood plain. Thus none of the restoration work would have any impact on Flood Plain Management. The City is investigating whether a hydrologic study of the effects of constructing the CSCR has ever been done. The City will apprise the IEPA if any information leads us to revise our position with regard to this matter.

Section (c) (11) Dredging and Other Channel, Bed, or Shoreline Modifications The elutriate test procedure and other tests on CSCR sediments have thus far revealed no hazardous materials. The area to be dredged does not represent an ecologically important habitat. None of the dredged material is to be discharged to the waterway. Dredge spoils will be contained in an upland disposal site. The City will adhere to all USACE, IEPA and IDOT guidelines for dredging operations.

Section (c) (13) Feasible Alternatives to Proposed Project. In this section we must ask the question "Does the project need to be done"? The reservoir is hypereutrophic with problems of oxygen depletion during summer, severe algal blooms, periodic fish kills, trihalomethanes, and objectionable taste and odors. These problems greatly detract from the beneficial use of the CSCR for recreational use as well as a potable water supply. Without action to reverse the continued degradation of this resource, citizens would be compelled to travel considerable distances to compensate for the loss of this important local recreational site. The additional fuel consumption that would be a direct result of such an increase in travel would greatly affect levels of atmospheric pollutants as well as wasting energy.

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APPENDIX A

Methodology

APPENDIX A

Methodology

Table A-1. Methods Used by the Charleston Water Treatment Plant and Eastern Illinois University for Water Quality Analysis of the CSCR.

Parameter	Method
Secchi depth/ Total depth	Secchi disc measurement
Temperature/ Dissolved Oxygen	Membrane electrode method - 4500G (1)
pH	Electrometric method - $4500\text{-}H^{+}B$ (1)
Alkalinity	Alkalinity titration method - 2320B (1)
Hardness	EDTA titrimetric method - 2340C (1)
Turbidity	Nephelometric method - 2130B (1)
Conductivity	2510B (1)
Nitrate nitrogen	Nitrate electrode method - $4500\text{-}NO_3D$ (1)
Ammonia nitrogen	Ammonia-selective electrode method - $4500\text{-}NH_3F$ (1)
Chlorophyll	Acetone extraction, spectrophotometric (2)
Solids	
Total Solids	Dried at 103-105°C - 2540B (1)
Total Suspended	Glass fiber filtration, dried at 103-105°C - 2540D (1)
Total Fixed	Ignited at 550°C - 2540E (1)
Total Volatile	Ignited at 550°C - 2540E (1)
Volatile Susp.	Glass fiber filtration, ignited at 550°C - 2540E (1)
Total phosphorus	Persulfate digestion, ascorbic acid method - 4500-P-E (1)
Total dissolved phosphorus	Filtration with 0.45um filter, ascorbic acid method - 4500-P-E (1)

(1) Standard Methods for the Examination of Water and Wastewater. 17th Edition. 1989. APHA, AWWA, WPCF.
(2) "Chlorophyll Content in Surface Water". IEPA paper.

Table A-2. Methods Used by the IEPA for Water Quality Analysis of the CSCR.

Parameter	Method
Temperature/ Dissolved oxygen	In situ determination using Hydrolab 4041 Yellow Springs instruments (YSI) Model 57 Dissolved Oxygen Meter
Transparency	Secchi disc
Total Susp. solids	Filtration on glass fiber filter, determination of increase in weight upon drying at 103-105°C
Vol. Susp. solids	Loss in weight of TSS filter upon ignition at 550°C
Turbidity	Nephelometrically using Hach Model 2100 Turbidimeter
Conductivity	YSI Model 33 S-C-T Conductivity Meter or Electrolytic Conductivity Measuring Set, Model MC-1
Alkalinity	Titration of 10 ml sample 0.02 N H_2SO_4 to phenolphthalein and brom cresol green-methyl red end points
pH	Sargent-Welch Model PBL pH Meter, calibrated in field or Hydrolab 4041 or 8000
Nitrate - nitrite - N	Cadmium reduction method on Technicon Auto-Analyzer
Ammonia - N	Phenate method on Technicon Auto-Analyzer
Total Kjeldahl - N	Digestion at 370°C followed by determination of ammonia as above
Total phosphorus	Digestion to convert all phosphorus forms to orthophosphate followed by determination using ascorbic acid reduction method using Techinicon Auto-Analyzer
Total Diss. Phosphorus	Field filtration followed by TP analysis as above
Chemical oxygen demand	Titrimetric, low level method sample refluxed with a sulfuric acid, potassium dichromatic, mercuric sulfate, and silver sulfate solution. Treated with standard ferrous ammonium.
Chlorophyll	Concentration by filtration, extraction with acetone, determination of optical density and calculation of concentration by standard formulae

Phytoplankton.

The following information provides the methods used by Kaye Surratt in her phytoplankton analysis (1990). Grab samples were collected from the upper meter of water. Reservoir water samples were preserved for phycological examination by the addition of 3 ml of Lugol's solution to 100 ml portions. Phytoplankton samples were filtered, and enumeration followed the methods of McNabb (1960). A phase contrast microscope was used for identification. Phytoplankton diversity was calculated using the Shannon-Weaver Index (Shannon and Weaver 1963):

$$H' = -\text{sum}\ p_i \log_{10} p_i$$

where p_i = number of individuals of species i divided by the total number of individuals

Evenness (J') was calculated as a ratio of observed diversity to maximum diversity for a given number of taxa (Pielou 1969), using the formula:

$$J' = H'/H'max$$

where H'max = log s

s = number of taxa present in a given sample

The Illinois State Water Survey used different methods for phytoplankton analysis. Water samples of 390 ml portions were preserved with 10 ml of formalin. A 1-ml aliquot was pipetted into a Sedgewick Rafter Cell. A differential interference contrast microscope was used for identifying and counting purposes. Five short strips were counted. The algae were identified as to species and were classified into five main groups: blue-greens, greens, diatoms, flagellates, and others. Green algae were counted by individual cells except for *Actinastrum*, *Coelastrum*, and *Pediastrum*, which were recorded by each colony observed. *Scenedesmus* was counted by each cell packet. Diatoms were counted as one organism regardless of their grouping connections. For flagellates, a colony of *Dinobryon* or a single cell of *Ceratium* was recorded as a unit.

Sediments - Chemical Contents. All analyses provided by Daily Analytical Laboratories, IEPA certified, were performed by methodology acceptable to the U.S. EPA and IEPA.

Sediments - Metal and Metalloid Analysis. A complete description of the methods used for metal and metalloid analysis by Allison and Marquart is given in Appendix F.

Trophic State Index. Carlson's (1979) Trophic State Index (TSI) is a quantitative way to classify lakes to the degree of eutrophication through the calculation of an index number. A high index number indicates a high eutrofication level. The index numbers for the CSCR were calculated from the three methods of computing TSI's: by using Secchi disc transparencies, total phosphorus concentrations, and chlorophyll *a* values.

$$TSI = 60 - 14.41 \ln \text{Secchi Disc (meters)}$$
$$TSI = 14.42 \ln \text{Total Phosphorus } (mg\ m^{-3}) + 4.15$$
$$TSI = 9.81 \ln \text{Chlorophyll } a\ (mg\ m^{-3}) + 30.6$$

Oligotrophic lakes (relatively unproductive) have TSI values of less than 40. Mesotrophic lakes (moderately productive) have values between 40 and 50. Eutrophic lakes (highly productive) have values greater than 50. Hypereutrophy, an extreme of eutrophy, corresponds to TSI values at least greater than 65.

<u>Biological Resources and Ecological Relationships</u>. All tables concerning biological resources (birds, amphibians and reptiles, and mammals) were compiled by their respective authors (Bradley, Moll, and Andrews) based on personal experience with the area's fauna.

APPENDIX B

General Use Water Quality Standards

TITLE 35:
ENVIRONMENTAL PROTECTION

SUBTITLE C:
WATER POLLUTION

Chapter I:
POLLUTION CONTROL BOARD

State of Illinois

Rules and Regulations

This printing of Title 35: Environmental Protection,
Subtitle C: Water Pollution, Chapter I: Pollution Control Board
includes amendments through July 9, 1990

SUBPART B: GENERAL USE WATER QUALITY STANDARDS

Section 302.201 Scope and Applicability

Subpart B contains general use water quality standards which must be met in waters of the State for which there is no specific designation (Section 303.201).

Section 302.202 Purpose

The general use standards will protect the State's water for aquatic life, 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.

(Source: Amended at 12 Ill. Reg. 12082, effective July 11, 1988)

Section 302.203 Offensive Conditions

Waters of the State shall be free from sludge or bottom deposits, floating debris, visible oil, odor, plant or algal growth, color or turbidity of other than natural origin. The allowed mixing provisions of Section 302.102 shall not be used to comply with the provisions of this Section.

(Source: Amended at 14 Ill. Reg. 2899, effective February 13, 1990)

Section 302.204 pH

pH (STORET number 00400) shall be within the range of 6.5 to 9.0 except for natural causes.

Section 302.205 Phosphorus

Phosphorus (STORET number 00665): After December 31, 1983, Phosphorus as P shall not exceed 0.05 mg/l in any reservoir or lake with a 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. For the purposes of this Section, the term "reservoir or lake" shall not include low level pools constructed in free flowing streams or any body of water which is an integral part of an operation which includes the application of sludge on land. Point source discharges which comply with Section 304.123 shall be in compliance with this Section for purposes of application of Section 304.105.

(Source: Amended at 3 Ill. Reg. 95, effective May 17, 1979)

Section 302.206 Dissolved Oxygen

Dissolved oxygen (STORET number 00300) shall not be less than 6.0 mg/l during at least 16 hours of any 24 hour period, nor less than 5.0 mg/l at any time.

Section 302.207 Radioactivity

a) Gross beta (STORET number 03501) concentration shall not exceed 100 picocuries per liter (pCi/1).

b) Concentrations of radium 226 (STORET number 09501) and strontium 90 (STORET number 13501) shall not exceed 1 and 2 picocuries per liter respectively.

Section 302.208 Numeric Standards for Chemical Constituents

a) The acute standard (AS) for the chemical constituents listed in subsection (d) shall not be exceeded at any time except as provided in subsection (c).

b) The chronic standard (CS) for the chemical constituents listed in subsection (d) shall not be exceeded by the arithmetic average of at least four consecutive samples collected over any period of at least four days, except as provided in subsection (c). The samples used to demonstrate compliance or lack of compliance with a CS must be collected in a manner which assures an average representative of the sampling period.

c) In waters where mixing is allowed pursuant to Section 302.102, the following apply:

1) The AS shall not be exceeded in any waters except for those waters for which the Agency has approved a ZID pursuant to Section 302.102;

2) The CS shall not be exceeded outside of waters in which mixing is allowed pursuant to Section 302.102.

d)

Constituent	STORET Number	AS (ug/L)	CS (ug/L)
Arsenic (total)	01002	360	190
Cadmium (total)	01027	exp[A + Bln(H)], but not to exceed 50 ug/L, where A = -2.918 and B = 1.128	exp[A + Bln(H)], where A = -3.490 and B = 0.7852
Chromium (total hexavalent)	01032	16	11
Chromium (total trivalent)	01033	exp[A + Bln(H)], where A = 3.688 and B = 0.8190	exp[A + Bln(H)], where A = 1.561 and B = 0.8190
Copper (total)	01042	exp[A + Bln(H)], where A = -1.464 and B = 0.9422	exp[A + Bln(H)], where A = -1.465 and B = 0.8545
Cyanide	00718	22	5.2
Lead (total)	01051	exp[A + Bln(H)], but not to exceed 100 ug/L, where A = -1.460 and B = 1.273	Not Applied
Mercury	71900	0.5	Not Applied
TRC	50060	19	11

where: ug/L = microgram per liter,

exp[x] = base of natural logarithms raised to the x-power, and

ln(H) = natural logarithm of Hardness (STORET 00900).

c) Concentrations of the following chemical constituents shall not be exceeded except in waters for which mixing is allowed pursuant to Section 302.102.

Constituent	Units	STORET Number	Standard
Barium (total)	mg/L	01007	5.0
Boron (total)	mg/L	01022	1.0
Chloride (total)	mg/L	00940	500.
Fluoride	mg/L	00951	1.4
Iron (dissolved)	mg/L	01046	1.0
Manganese (total)	mg/L	01055	1.0
Nickel (total)	mg/L	01067	1.0
Phenols	mg/L	32730	0.1
Selenium (total)	mg/L	01147	1.0
Silver (total)	ug/L	01077	5.0
Sulfate	mg/L	00945	500.
Total Dissolved Solids	mg/L	70300	1000.
Zinc (total)	mg/L	01092	1.0

where: mg/L = milligram per liter and

ug/L = microgram per liter

(Source: Amended at 14 Ill. Reg. 11979, effective July 9, 1990)

Section 302.209 Fecal Coliform

a) During the months May through October, based on a minimum of five samples taken over not more than a 30 day period, fecal coliform (STORET number 31616) shall not exceed a geometric mean of 200 per 100 ml, nor shall more than 10% of the samples during any 30 day period exceed 400 per 100 ml in protected waters. Protected waters are defined as waters which, due to natural characteristics, aesthetic value or environmental significance are deserving of protection from pathogenic organisms. Protected waters will meet one or both of the following conditions:

1) presently support or have the physical characteristics to support primary contact;

2) flow through or adjacent to parks or residential areas.

b) Waters unsuited to support primary contact uses because of physical, hydrologic or geographic configuration and are located in areas unlikely to be frequented by the public on a routine basis as determined by the Agency at 35 Ill. Adm. Code 309, Subpart A, are exempt from this standard.

c) The Agency shall apply this rule pursuant to 35 Ill. Adm. Code 304.121.

(Source: Amended at 12 Ill. Reg. 12082, effective July 11, 1988)

Section 302.210 Other Toxic Substances

Waters of the State shall be free from any substances or combination of substances in concentrations toxic or harmful to human health, or to animal, plant or aquatic life. Individual chemical substances or parameters for which numeric standards are specified in this Subpart are not subject to this Section.

a) Any substance or combination of substances shall be deemed to be toxic or harmful to aquatic life if present in concentrations that exceed the following:

1) An Acute Aquatic Toxicity Criterion (AATC) validly derived and correctly applied pursuant to procedures set forth in Sections 302.612 through 302.618 or in Section 302.621; or

2) A Chronic Aquatic Toxicity Criterion (CATC) validly derived and correctly applied pursuant to procedures set forth in Sections 302.627 or 302.630.

b) Any substance or combination of substances shall be deemed to be toxic or harmful to wild or domestic animal life if present in concentrations that exceed any Wild and Domestic Animal Protection Criterion (WDAPC) validly derived and correctly applied pursuant to Section 302.633.

c) Any substance or combination of substances shall be deemed to be toxic or harmful to human health if present in concentrations that exceed criteria, validly derived and correctly applied, based on either of the following:

1) Disease or functional impairment due to a physiological mechanism for which there is a threshold dose below which no damage occurs calculated pursuant to Sections 302.642 through 302.648 (Human Threshold Criterion); or

2) Disease or functional impairment due to a physiological mechanism for which any dose may cause some risk of damage calculated pursuant to Sections 302.651 through 302.658 (Human Nonthreshold Criterion).

d) The most stringent criterion of subsections (a), (b), and (c) shall apply at all points outside of any waters within which mixing is allowed pursuant to Section 302.102. In addition, the AATC derived pursuant to subsection (a)(1) shall apply in all waters except that it shall not apply within a ZID that is prescribed in accordance with Section 302.102.

e) The procedures of Subpart F set forth minimum data requirements, appropriate test protocols and data assessment methods for establishing criteria pursuant to subsections(a), (b), and (c). No other procedures may be used to establish such criteria unless approved by the Board in a rulemaking or adjusted standards proceeding pursuant to Title VII of the Act. The validity and applicability of the Subpart F procedures may not be challenged in any proceeding brought pursuant to Titles VIII or X of the Act, although the validity and correctness of application of the numeric criteria derived pursuant to Subpart F may be challenged in such proceedings pursuant to subsection (f).

f) 1) A permittee may challenge the validity and correctness of application of a criterion derived by the Agency pursuant to this Section only at the time such criterion is first applied in an NPDES permit pursuant to 35 Ill. Adm. Code 309.152 or in an action pursuant to Title VIII of the Act for violation of the toxicity water quality standard. Failure of a person to challenge the validity of a criterion at the time of its first application shall constitute a waiver of such challenge in any subsequent proceeding involving application of the criterion to that person.

2) Consistent with subsection (f)(1), if a criterion is included as, or is used to derive, a condition of an NPDES discharge permit, a permittee may challenge the criterion in a permit appeal pursuant to Section 40 of the Act and 35 Ill. Adm. Code 309.181. In any such action, the Agency shall include in the record all information upon which it has relied in developing and applying the criterion, whether such information was developed by the Agency or submitted by the

Petitioner. THE BURDEN OF PROOF SHALL BE ON THE PETITIONER TO DEMONSTRATE THAT THE CRITERION-BASED CONDITION IS NOT NECESSARY TO ACCOMPLISH THE PURPOSES OF SUBSECTION (a) (Section 40(a)(1) of the Act), but there is no presumption in favor of the general validity and correctness of the application of the criterion as reflected in the challenged condition.

3) Consistent with subsection (f)(1), in an action where alleged violation of the toxicity water quality standard is based on alleged excursion of a criterion, the person bringing such action shall have the burdens of going forward with proof and of persuasion regarding the general validity and correctness of application of the criterion.

g) Subsections (a) through (e) do not apply to USEPA registered pesticides approved for aquatic application and applied pursuant to the following conditions:

1) Application shall be made in strict accordance with label directions;

2) Applicator shall be properly certified under the provisions of the Federal Insecticide, Fungicide, and Rodenticide Act (7 U.S.C. 135 et seq. (1972));

3) Applications of aquatic pesticides must be in accordance with the laws, regulations and guidelines of all State and federal agencies authorized by law to regulate, use or supervise pesticide applications, among which is included the Department of Energy and Natural Resources pursuant to Section 3 of "AN ACT in relation to natural resources, research, data collection and environmental studies", Ill. Rev. Stat. 1987 ch. 96 1/2, par. 7403.

4) No aquatic pesticide shall be applied to waters affecting public or food processing water supplies unless a permit to apply the pesticide has been obtained from the Agency. All permits shall be issued so as not to cause a violation of the Act or of any of the Board's rules or regulations. To aid applicators in determining their responsibilities under this subsection, a list of waters affecting public water supplies will be published and maintained by the Agency's Division of Public Water Supplies.

(Source: Amended at 14 Ill. Reg. 2899, effective February 13, 1990)

Section 302.211 Temperature

a) Temperature has STORET number (F°) 00011 and (C°) 00010.

b) There shall be no abnormal temperature changes that may adversely affect aquatic life unless caused by natural conditions.

c) The normal daily and seasonal temperature fluctuations which existed before the addition of heat due to other than natural causes shall be maintained.

d) The maximum temperature rise above natural temperatures shall not exceed 2.8°C (5°F).

e) In addition, the water temperature at representative locations in the main river shall not exceed the maximum limits in the following table during more than one percent of the hours in the 12-month period ending with any month. Moreover, at no time shall the water temperature at such locations exceed the maximum limits in the following table by more than 1.7°C (3°F).

	°C	°F		°C	°F
JAN.	16	60	JUL.	32	90
FEB.	16	60	AUG.	32	90
MAR.	16	60	SEPT.	32	90
APR.	32	90	OCT.	32	90
MAY	32	90	NOV.	32	90
JUNE	32	90	DEC.	16	60

f) The owner or operator of a source of heated effluent which discharges 150 megawatts (0.5 billion British thermal units per hour) or more shall demonstrate in a hearing before this Pollution Control Board (Board) not less than 5 nor more than 6 years after the effective date of these regulations or, in the case of new sources, after the commencement of operation, that discharges from that source have not caused and cannot be reasonably expected to cause significant ecological damage to the receiving waters. If such proof is not made to the satisfaction of the Board appropriate corrective measures shall be ordered to be taken within a reasonable time as determined by the Board.

g) Permits for heated effluent discharges, whether issued by the Board or the Illinois Environmental Protection Agency (Agency), shall be subject to revision in the event that reasonable future development creates a need for reallocation of the assimilative capacity of the receiving stream as defined in the regulation above.

h) The owner or operator of a source of heated effluent shall maintain such records and conduct such studies of the effluents from such sources and of their effects as may be required by the Agency or in any permit granted under the Illinois Environmental Protection Act (Act).

i) Appropriate corrective measures will be required if, upon complaint filed in accordance with Board rules, it is found at any time that any heated effluent causes significant ecological damage to the receiving stream.

j) All effluents to an artificial cooling lake must comply with the applicable provisions of the thermal water quality standards as set forth in this Section and 35 Ill. Adm. Code 303, except when all of the following requirements are met:

1) All discharges from the artificial cooling lake to other waters of the State comply with the applicable provisions of subsections (b) through (e).

2) The heated effluent discharged to the artificial cooling lake complies with all other applicable provisions of this Chapter, except subsections (b) through (e).

3) At an adjudicative hearing the discharger shall satisfactorily demonstrate to the Board that the artificial cooling lake receiving the heated effluent will be environmentally acceptable, and within the intent of the Act, including, but not limited to:

A) provision of conditions capable of supporting shellfish, fish and wildlife, and recreational uses consistent with good management practices, and

B) control of the thermal component of the discharger's effluent by a technologically feasible and economically reasonable method.

4) The required showing in subsection (j)(3) may take the form of an acceptable final environmental impact statement or pertinent provisions of environmental assessments used in the preparation of the final environmental impact statement, or may take the form of a showing pursuant to Section 316(a) of the Clean Water Act (CWA) (33 U.S.C. 1251 et seq.), which addresses the requirements of subsection (j)(3).

5) If an adequate showing as provided in subsection (j)(3) is found, the Board shall promulgate specific thermal standards to be applied to the discharge to that artificial cooling lake.

(Source: Amended 13 Ill. Reg. 5998, effective April 18, 1989)

Section 302.212 Ammonia Nitrogen and Un-ionized Ammonia

a) Ammonia nitrogen (as N: Storet Number 00610) shall in no case exceed 15 mg/l.

b) If ammonia nitrogen is less than 15 mg/l and greater than or equal to 1.5 mg/l, then un-ionized ammonia (as N) shall not exceed 0.04 mg/l.

c) Ammonia nitrogen concentrations of less than 1.5 mg/l are lawful regardless of un-ionized ammonia concentration.

d) For purposes of this section the concentration of un-ionized ammonia shall be computed according to the following equation:

$$U = \frac{N}{[0.94412(1 + 10^{X}) + 0.0559]} \quad \text{where:}$$

$$X = 0.09018 + \frac{2729.92}{(T + 273.16)} - pH$$

U = Concentration of un-ionized ammonia as N in mg/l
N = Concentration of ammonia nitrogen as N in mg/l
T = Temperature in degrees Celsius

e) The following table indicates the maximum ammonia nitrogen concentrations allowable for certain combinations of pH and temperature:

AMMONIA NITROGEN WATER QUALITY STANDARD (mg/l)

TEMP. °C (°F)	pH 6.0	6.5	7.0	7.5	8.0	8.5	9.0
5 (41)	15	15	15	9.6	3.1	1.5	1.5
10 (50)	15	15	15	6.5	2.1	1.5	1.5
15 (59)	15	15	13.9	4.4	1.5	1.5	1.5
20 (68)	15	15	9.6	3.1	1.5	1.5	1.5
25 (77)	15	15	6.7	2.1	1.5	1.5	1.5
30 (86)	15	14.9	4.7	1.5	1.5	1.5	1.5
35 (95)	15	10.7	3.4	1.5	1.5	1.5	1.5

(Source: 6 Ill. Reg. 11161, effective September 7, 1982)

SUBPART C: PUBLIC AND FOOD PROCESSING WATER SUPPLY STANDARDS

Section 302.301 Scope and Applicability

Subpart C contains the public and food processing water supply standards. These are cumulative with the general use standards of Subpart B and must be met in all waters designated in Part 303 at any point at which water is withdrawn for treatment and distribution as a potable supply or for food processing. Waters of the State are generally designated for public and food processing use (Section 303.202).

Section 302.302 Algicide Permits

The water quality standards of Subparts B and C may be exceeded if such occurrence results from the application of an algicide in accordance with the terms of an algicide permit issued by the Agency pursuant to Part 602.

(Note: Prior to codification, Rules 203 and 204(d) of Ch 6: Public Water Supplies.)

Section 302.303 Finished Water Standards

Water shall be of such quality that with treatment consisting of coagulation, sedimentation, filtration, storage and chlorination, or other equivalent treatment processes, the treated water shall meet in all respects the requirements of Part 604.

(Note: Prior to codification, Table I, Rule 304 of Ch 6: Public Water Supplies.)

Section 302.304 Chemical Constituents

The following levels of chemical constituents shall not be exceeded:

CONSTITUENT	STORET NUMBER	CONCENTRATION (mg/l)
Arsenic (total)	01002	0.05
Barium (total)	01007	1.0
Cadmium (total)	01027	0.010
Chloride	00940	250.
Chromium	01034	0.05
Iron (dissolved)	01046	0.3
Lead (total)	01051	0.05
Manganese (total)	01055	0.15
Nitrate-Nitrogen	00620	10.
Oil (hexane-solubles or equivalent)	00550, 00556 or 00560	0.1
Organics		
Pesticides		
Chlorinated Hydro-carbon Insecticides		
Aldrin	39330	0.001
Chlordane	39350	0.003
DDT	39370	0.05
Dieldrin	39380	0.001
Endrin	39390	0.0002
Heptachlor	39410	0.0001
Heptachlor Epoxide	39420	0.0001
Lindane	39782	0.004
Methoxychlor	39480	0.1
Toxaphene	39400	0.005
Organophosphate Insecticides		
Parathion	39540	0.1
Chlorophenoxy Herbicides		
2,4-Dichlorophenoxy-acetic acid (2,4-D)	39730	0.1
2-(2,4,5-Trichloro-phenoxy)- propionic acid (2,4,5-TP or Silvex)	39760	0.01
Phenols	32730	0.001
Selenium (total)	01147	0.01
Sulfates	00945	250.
Total Dissolved Solids	70300	500.

(Source: Amended 14 Ill. Reg. 11979, effective July 9, 1990)

Section 302.305 Other Contaminants

Other contaminants which will not be adequately reduced by the treatment processes noted in Section 302.303 shall not be present in concentrations hazardous to human health.

Section 302.306 Fecal Coliform

Notwithstanding the provisions of Section 302.209, at no time shall the geometric mean, based on a minimum of five samples taken over not more than a 30 day period, of fecal coliform (STORET number 31616) exceed 2000 per 100 ml.

(Source: Added at 12 Ill. Reg. 12082, effective July 11, 1988)

SUBPART D: SECONDARY CONTACT AND INDIGENOUS AQUATIC LIFE STANDARDS

Section 302.401 Scope and Applicability

Subpart D contains the secondary contact and indigenous aquatic life standards. These must be met only by certain waters specifically designated in Part 303. The general use and public water supply standards do not apply to waters designated for secondary contact and indigenous aquatic life (Section 303.204).

Section 302.402 Purpose

Secondary contact and indigenous aquatic life standards are intended for those waters not suited for general use activities but which will be appropriate for all secondary contact uses and which will be capable of supporting an indigenous aquatic life limited only by the physical configuration of the body of water, characteristics and origin of the water and the presence of contaminants in amounts that do not exceed the water quality standards listed in Subpart D.

(Source: Amended at 3 Ill. Reg. 95, effective May 17, 1979)

Section 302.403 Unnatural Sludge

Waters subject to this subpart shall be free from unnatural sludge or bottom deposits, floating debris, visible oil, odor, unnatural plant or algal growth, or unnatural color or turbidity.

Section 302.404 pH

pH (STORET number 00400) shall be within the range of 6.0 to 9.0 except for natural causes.

Section 302.405 Dissolved Oxygen

Dissolved oxygen (STORET number 00300) shall not be less than 4.0 mg/l at any time, except that the Calumet-Sag Channel shall not be less than 3.0 mg/l at any time.

(Source: Amended at 12 Ill. Reg. 9911, effective May 27, 1988).

Section 302.406 Fecal Coliform (Repealed)

Section 302.407 Chemical Constituents

Concentrations of other chemical constituents shall not exceed the following standards:

CONSTITUENT	STORET NUMBER	CONCENTRATION (mg/l)
Ammonia Un-ionized (as N)*	00619	0.1
Arsenic (total)	01002	1.0
Barium (total)	01007	5.0
Cadmium (total)	01027	0.15
Chromium (total hexavalent)	01032	0.3
Chromium (total trivalent)	01033	1.0
Copper (total)	01042	1.0
Cyanide (total)	00720	0.10
Fluoride (total)	00951	15.0
Iron (total)	01045	2.0
Iron (dissolved)	01046	0.5
Lead (total)	01051	0.1
Manganese (total)	01055	1.0
Mercury (total)	71900	0.0005
Nickel (total)	01067	1.0
Oil, fats and grease	00550, 00556 or 00560	15.0**
Phenols	32730	0.3
Selenium (total)	01147	1.0
Silver	01077	1.1
Zinc (total)	01092	1.0
Total Dissolved Solids	70300	1500

*For purposes of this section the concentration of un-ionized ammonia shall be computed according to the following equation:

$$U = \frac{N}{[0.94412(1 + 10^{X}) + 0.0559]} \quad \text{where:}$$

$$X = 0.09018 + \frac{2729.92}{(T + 273.16)} - pH$$

U = Concentration of un-ionized ammonia as N in mg/l
N = Concentration of ammonia nitrogen as N in mg/l
T = Temperature in degrees Celsius

**Oil shall be analytically separated into polar and non-polar components if the total concentration exceeds 15 mg/l. In no case shall either of the components exceed 15 mg/l (i.e., 15 mg/l polar materials and 15 mg/l non-polar materials).

(Source: Amended at 12 Ill. Reg. 9911, effective May 27, 1988)

Section 302.408 Temperature

Temperature (STORET number (°F) 00011 and (°C) 00010) shall not exceed 34°C (93°F) more than 5% of the time, or 37.8°C (100°F) at any time.

Section 302.409 Cyanide

Cyanide (total) shall not exceed 0.10 mg/l

(Source: Added at 2 Ill. Reg. no. 44, page 151, effective November 2, 1978)

Section 302.410 Substances Toxic to Aquatic Life

Any substance toxic to aquatic life not listed in Section 302.407 shall not exceed one half of the 96-hour median tolerance limit (96-hour TL_m) for native fish or essential fish food organisms.

(Source: Added at 3 Ill. Reg. 190, effective June 21, 1979.)

APPENDIX C

Lake Periodic Report Fish Data

TABLE 5 LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : LMB
SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
3	1.2	3	-	-	0	-	-	-
4	1.6	9	-	-	0	-	-	-
5	2	0	-	-	0	-	-	-
6	2.4	0	-	-	0	-	-	-
7	2.8	0	-	-	0	-	-	-
8	3.2	0	-	-	0	-	-	-
9	3.6	0	-	-	0	-	-	-
10	4	0	-	-	0	-	-	-
11	4.4	0	-	-	0	-	-	-
12	4.8	0	-	-	0	-	-	-
13	5.2	0	-	-	0	-	-	-
14	5.6	0	-	-	0	-	-	-
15	6	0	-	-	0	-	-	-
16	6.4	0	-	-	0	-	-	-
17	6.8	0	-	-	0	-	-	-
18	7.2	0	-	-	0	-	-	-
19	7.6	1	98	.21	1	95	1	1.25
20	8	0	-	-	0	-	-	-
21	8.4	0	-	-	0	-	-	-
22	8.8	0	-	-	0	-	-	-
23	9.2	2	184	.4	2	99	1.04	1.35
24	9.6	0	-	-	0	-	-	-
25	10	0	-	-	0	-	-	-
26	10.4	3	283	.62	3	107	1.12	1.5
27	10.8	1	310	.68	1	107	1.12	1.5
28	11.2	0	-	-	0	-	-	-
29	11.6	1	400	.88	1	109	1.14	1.54
30	12	0	-	-	0	-	-	-
31	12.4	0	-	-	0	-	-	-
32	12.8	1	480	1.1	1	100	1.04	1.45
33	13.2	2	592	1.3	2	110	1.14	1.6
34	13.6	0	-	-	0	-	-	-
35	14	1	700	1.5	1	103	1.06	1.52
36	14.4	4	743	1.6	4	102	1.06	1.51
37	14.8	1	780	1.7	1	103	1.06	1.52
38	15.2	0	-	-	0	-	-	-
39	15.6	0	-	-	0	-	-	-
40	16	3	1033	2.3	3	102	1.05	1.53
41	16.4	0	-	-	0	-	-	-
42	16.8	0	-	-	0	-	-	-
43	17.2	0	-	-	0	-	-	-
44	17.6	2	1400	3.1	2	106	1.1	1.63
45	18	0	-	-	0	-	-	-
46	18.4	0	-	-	0	-	-	-
47	18.8	1	1760	3.9	1	108	1.12	1.68
48	19.2	0	-	-	0	-	-	-
49	19.6	0	-	-	0	-	-	-
50	20	0	-	-	0	-	-	-
51	20.4	1	2630	5.8	1	120	1.25	1.91
TOTAL		36			24			

TABLE 6

LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : LMB
SAMPLES: 1-E1 1-E2

LENGTH GROUP CM	LENGTH GROUP INCHES	TOTAL L-FREQ	MEAN WEIGHT GRAMS	MEAN WEIGHT LBS	SAMPLE SIZE	MEAN CONDITION WR	MEAN CONDITION KN	MEAN CONDITION K
3 - 11.9	1.2 - 4.8	12	-	-	0	-	-	-
12 - 20.9	4.8 - 8.4	1	98	.21	1	95	1	1.25
21 - 25.9	8.4 - 10.4	2	184	.4	2	99	1.04	1.35
26 - 30.9	10.4 - 12.4	5	312	.68	5	108	1.12	1.51
31 - 34.9	12.4 - 14	3	555	1.2	3	106	1.1	1.55
35 - 39.9	14 - 16	6	742	1.6	6	102	1.06	1.51
40 - 44.9	16 - 18	5	1180	2.6	5	103	1.07	1.57
45 - 48.9	18 - 19.6	1	1760	3.9	1	108	1.12	1.68
49 - 51.9	19.6 - 20.8	1	2630	5.8	1	120	1.25	1.91
TOTAL		36			24			

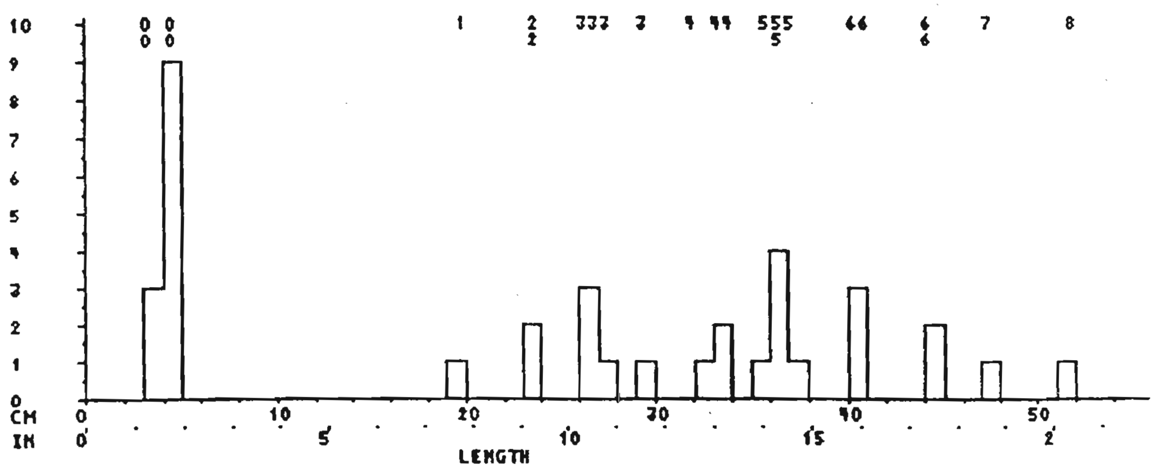

FIGURE 1. CHARLESTON SIDE CHANNEL LAKE LARGEMOUTH BASS COLLECTED JULY 6, 1989.
FREQUENCY VS. FISH LENGTH 36 INDIVIDUALS
AGE GROUP IN YEARS (AS DECIMAL, OR A=10, B=11 ETC.) IS SHOWN AT TOP.

TABLE 7 SIZE AT AGE TABLE
CHARLESTON SIDE CHANNEL LAKE
JULY 6, 1989

SPECIES: LARGEMOUTH BASS

AGE	MIN LENGTH mm (in)	MAX LENGTH mm (in)	MEAN LENGTH mm (in)	MEAN WEIGHT gm (lb)	NUMBER * OF FISH
0+	0 (.00)	119 (4.69)	42 (1.65)	1 (.00)	12
1+	120 (4.72)	209 (8.23)	195 (7.68)	107 (.24)	1
2+	210 (8.27)	259 (10.20)	235 (9.25)	192 (.42)	2
3+	260 (10.24)	309 (12.17)	273 (10.75)	307 (.68)	5
4+	310 (12.20)	349 (13.74)	331 (13.03)	559 (1.23)	3
5+	350 (13.78)	399 (15.71)	365 (14.37)	752 (1.66)	6
6+	400 (15.75)	449 (17.68)	421 (16.57)	1179 (2.60)	5
7+	450 (17.72)	489 (19.25)	475 (18.70)	1703 (3.75)	1
8+	490 (19.29)	519 (20.43)	515 (20.28)	2188 (4.82)	1

* Number of fish from length-frequency distribution.

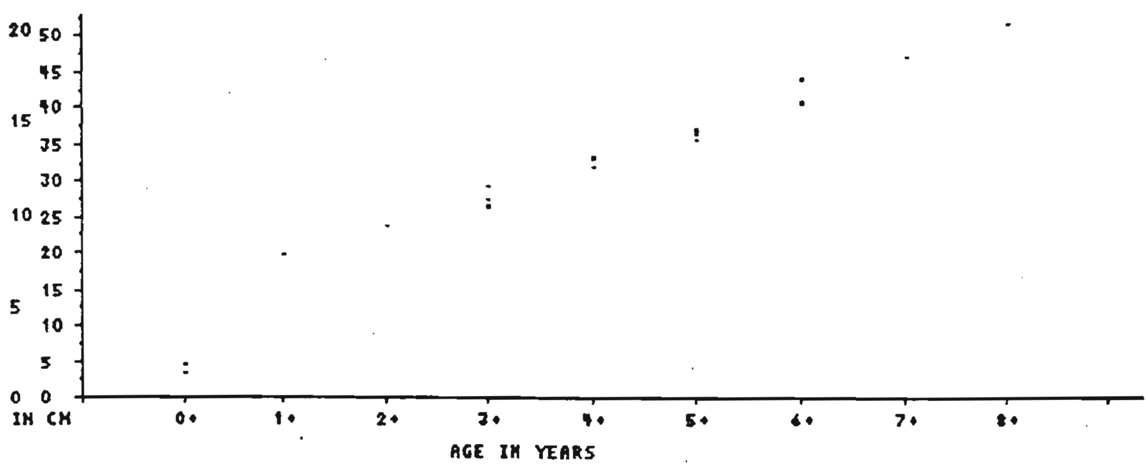

FIGURE 2. CHARLESTON SIDE CHANNEL LAKE LARGEMOUTH BASS COLLECTED JULY 6, 1989. AGE VS. LENGTH FOR INDIVIDUAL FISH

TABLE 8

LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : BLG
SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
2	.8	1	-	-	0	-	-	-
3	1.2	0	-	-	0	-	-	-
4	1.6	0	-	-	0	-	-	-
5	2	0	-	-	0	-	-	-
6	2.4	9	4.5	0	2	104	.94	1.63
7	2.8	20	10.8	.02	6	158	1.49	2.61
8	3.2	34	14.3	.03	6	134	1.3	2.3
9	3.6	51	18	.03	6	124	1.24	2.19
10	4	39	24.5	.05	6	115	1.18	2.11
11	4.4	14	27.2	.05	6	103	1.07	1.92
12	4.8	18	47.7	.1	6	128	1.37	2.46
13	5.2	37	58.3	.12	6	126	1.37	2.48
14	5.6	26	76.3	.16	6	127	1.41	2.57
15	6	28	89.3	.19	6	120	1.35	2.47
16	6.4	29	101	.22	6	109	1.26	2.3
17	6.8	9	116	.25	5	103	1.2	2.21
18	7.2	2	127	.27	2	99	1.16	2.15
TOTAL		317			69			

TABLE 9

LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : BLG
SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
2 - 5.9	.8 - 2.4	1	-	-	0	-	-	-
6 - 12.9	2.4 - 5.2	185	22.7	.05	38	126	1.26	2.23
13 - 14.9	5.2 - 6	63	67.3	.14	12	126	1.39	2.53
15 - 18.9	6 - 7.6	68	104	.22	19	110	1.26	2.31
TOTAL		317			69			

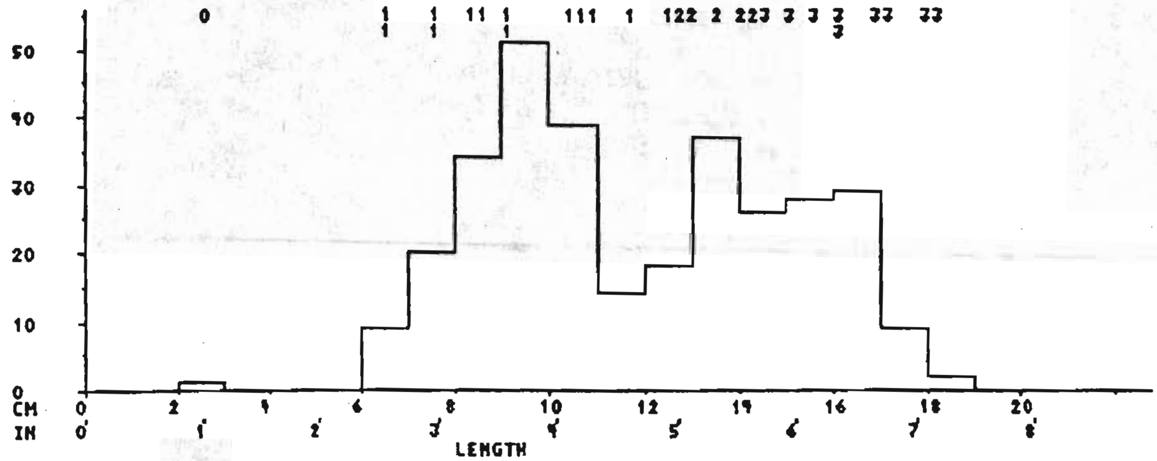

FIGURE 3. CHARLESTON SIDE CHANNEL LAKE BLUEGILL COLLECTED JULY 6, 1989.
FREQUENCY VS. FISH LENGTH 317 INDIVIDUALS
AGE GROUP IN YEARS (AS DECIMAL, OR A=10, B=11 ETC.) IS SHOWN AT TOP.

TABLE 10

SIZE AT AGE TABLE
CHARLESTON SIDE CHANNEL LAKE
JULY 6, 1989

SPECIES: BLUEGILL

AGE	MIN LENGTH mm (in)	MAX LENGTH mm (in)	MEAN LENGTH mm (in)	MEAN WEIGHT gm (lb)	NUMBER * OF FISH
0+	0 (.00)	59 (2.32)	25 (.98)	0 (.00)	1
1+	60 (2.36)	125 (4.92)	94 (3.70)	20 (.04)	178
2+	126 (4.96)	145 (5.71)	136 (5.35)	59 (.13)	60
3+	146 (5.75)	185 (7.28)	160 (6.30)	100 (.22)	78

* Number of fish from length-frequency distribution.

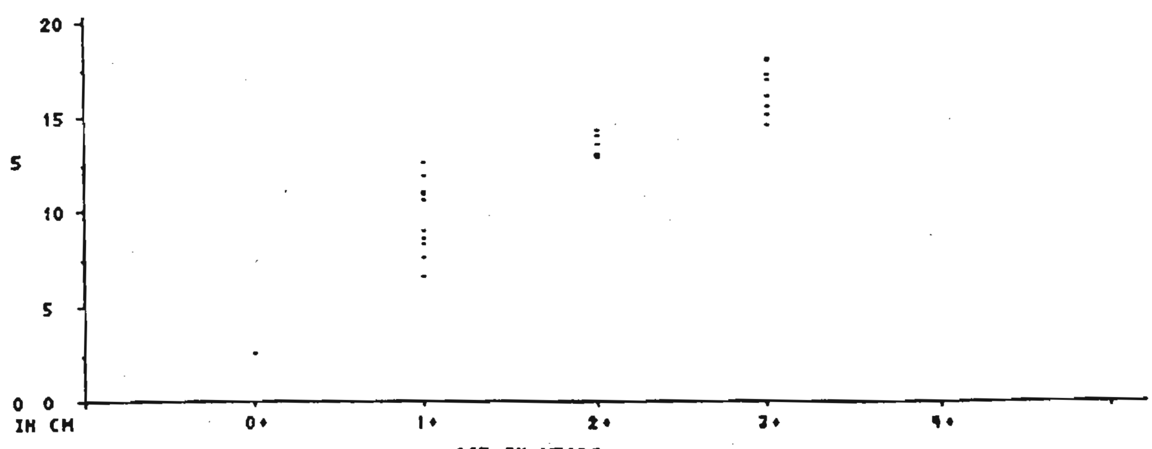

FIGURE 4. CHARLESTON SIDE CHANNEL LAKE BLUEGILL COLLECTED JULY 6, 1989.
AGE VS. LENGTH FOR INDIVIDUAL FISH

TABLE 11

LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : WHC
SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
2	.8	1	-	-	0	-	-	-
3	1.2	0	-	-	0	-	-	-
4	1.6	0	-	-	0	-	-	-
5	2	0	-	-	0	-	-	-
6	2.4	0	-	-	0	-	-	-
7	2.8	0	-	-	0	-	-	-
8	3.2	0	-	-	0	-	-	-
9	3.6	0	-	-	0	-	-	-
10	4	0	-	-	0	-	-	-
11	4.4	0	-	-	0	-	-	-
12	4.8	0	-	-	0	-	-	-
13	5.2	0	-	-	0	-	-	-
14	5.6	0	-	-	0	-	-	-
15	6	1	38	.08	1	69	.91	16
16	6.4	6	56.7	.12	3	90	1.18	5.85
17	6.8	48	64	.14	6	86	1.1	3.04
18	7.2	10	67.3	.14	3	75	.95	2.49
19	7.6	1	70	.15	1	65	.82	2.17
20	8	2	107	.23	2	90	1.11	1.27
21	8.4	0	-	-	0	-	-	-
22	8.8	0	-	-	0	-	-	-
23	9.2	1	176	.38	1	96	1.14	4.1
24	9.6	0	-	-	0	-	-	-
25	10	3	210	.46	3	87	1.01	1.27
26	10.4	0	-	-	0	-	-	-
27	10.8	1	240	.52	1	82	.94	2.7
TOTAL		74			21			

TABLE 12

LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : WHC
SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
2 - 6.9	.8 - 2.8	1	-	-	0	-	-	-
7 - 14.9	2.8 - 6	0	-	-	0	-	-	-
15 - 20.9	6 - 8.4	68	67.4	.14	16	83	1.06	3.99
21 - 24.9	8.4 - 10	1	176	.38	1	96	1.14	4.1
25 - 27.9	10 - 11.2	4	218	.47	4	86	.99	2.75
TOTAL		74			21			

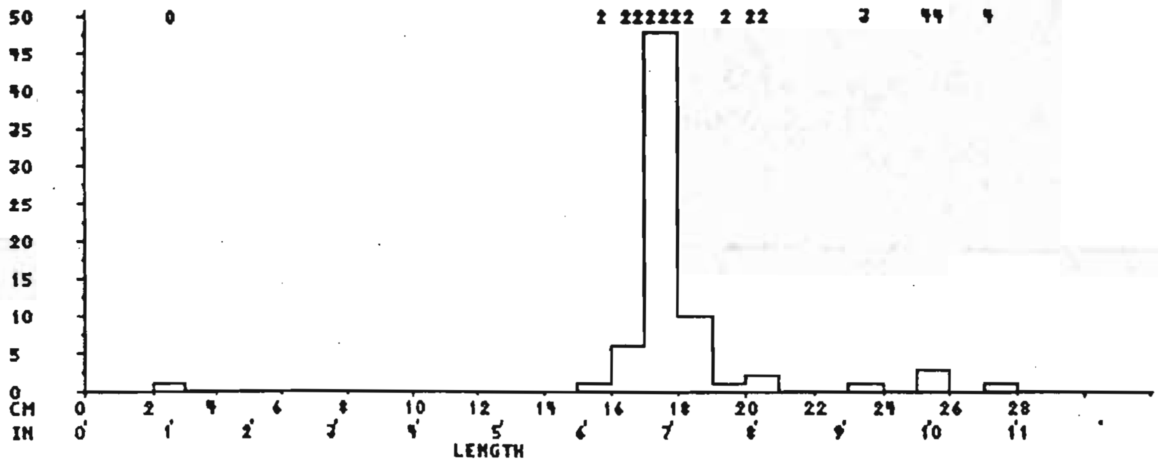

FIGURE 5. CHARLESTON SIDE CHANNEL LAKE WHITE CRAPPIE COLLECTED JULY 6, 1989.
FREQUENCY VS. FISH LENGTH 74 INDIVIDUALS
AGE GROUP IN YEARS (AS DECIMAL, OR A=10, B=11 ETC.) IS SHOWN AT TOP.

TABLE 13 SIZE AT AGE TABLE
CHARLESTON SIDE CHANNEL LAKE
JULY 6, 1989

SPECIES: WHITE CRAPPIE

AGE	MIN LENGTH mm (in)	MAX LENGTH mm (in)	MEAN LENGTH mm (in)	MEAN WEIGHT gm (lb)	NUMBER * OF FISH
0+	0 (.00)	69 (2.72)	25 (.98)	0 (.00)	1
1+	70 (2.76)	149 (5.87)	0 (.00)	0 (.00)	0
2+	150 (5.91)	209 (8.23)	176 (6.93)	65 (.14)	68
3+	210 (8.27)	249 (9.80)	235 (9.25)	153 (.34)	1
4+	250 (9.84)	279 (10.98)	260 (10.24)	209 (.46)	4

* Number of fish from length-frequency distribution.

FIGURE 6. CHARLESTON SIDE CHANNEL LAKE WHITE CRAPPIE COLLECTED JULY 6, 1989.
AGE VS. LENGTH FOR INDIVIDUAL FISH

TABLE 14

LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : CCF
SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
24	9.6	1	132	.29	1	101	1.22	.86
25	10	2	144	.31	2	101	1.21	2.76
26	10.4	3	155	.34	3	95	1.14	2.32
27	10.8	3	166	.36	3	93	1.11	1.71
28	11.2	3	191	.42	3	93	1.1	.82
29	11.6	1	230	.5	1	101	1.22	2.45
30	12	2	264	.58	2	105	1.25	.93
31	12.4	0	-	-	0	-	-	-
32	12.8	1	278	.61	1	93	1.12	2.29
33	13.2	2	345	.76	2	99	1.18	2.5
34	13.6	1	560	1.2	1	148	1.77	1.37
35	14	1	405	.89	1	97	1.16	2.41
36	14.4	6	543	1.2	4	118	1.4	2.62
37	14.8	4	489	1.1	4	97	1.16	1.29
38	15.2	1	450	.99	1	81	.95	.77
39	15.6	2	638	1.4	2	110	1.31	1.04
40	16	1	648	1.4	1	105	1.25	5.63
41	16.4	0	-	-	0	-	-	-
42	16.8	0	-	-	0	-	-	-
43	17.2	1	780	1.7	1	100	1.18	.97
44	17.6	1	1050	2.3	1	123	1.45	4.48
45	18	0	-	-	0	-	-	-
46	18.4	0	-	-	0	-	-	-
47	18.8	0	-	-	0	-	-	-
48	19.2	0	-	-	0	-	-	-
49	19.6	0	-	-	0	-	-	-
50	20	0	-	-	0	-	-	-
51	20.4	0	-	-	0	-	-	-
52	20.8	0	-	-	0	-	-	-
53	21.2	1	1740	3.8	1	113	1.33	1.16
54	21.6	0	-	-	0	-	-	-
55	22	0	-	-	0	-	-	-
56	22.4	0	-	-	0	-	-	-
57	22.8	1	2050	4.5	1	105	1.22	1.1
58	23.2	0	-	-	0	-	-	-
59	23.6	0	-	-	0	-	-	-
60	24	0	-	-	0	-	-	-
61	24.4	0	-	-	0	-	-	-
62	24.8	0	-	-	0	-	-	-
63	25.2	0	-	-	0	-	-	-
64	25.6	0	-	-	0	-	-	-
65	26	0	-	-	0	-	-	-
66	26.4	0	-	-	0	-	-	-
67	26.8	0	-	-	0	-	-	-
68	27.2	1	3380	7.5	1	97	1.14	1.06
TOTAL		39			37			

TABLE 15 LENGTH FREQUENCY/CONDITION INDEX

CHARLESTON SIDE CHANNEL LAKE

SUMMER 1989

SPECIES : CCF

SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
24 - 30.9	9.6 - 12.4	15	181	.39	15	97	1.16	1.68
31 - 34.9	12.4 - 14	4	382	.84	4	110	1.31	2.16
35 - 40.9	14 - 16.4	15	531	1.2	13	105	1.25	2.04
41 - 48.9	16.4 - 19.6	2	915	2	2	112	1.32	3.57
49 - 54.9	19.6 - 22	1	1740	3.8	1	113	1.33	3.07
55 - 61.9	22 - 24.8	1	2050	4.5	1	105	1.22	1.1
62 - 68.9	24.8 - 27.6	1	3380	7.5	1	97	1.14	1.06
TOTAL		39			37			

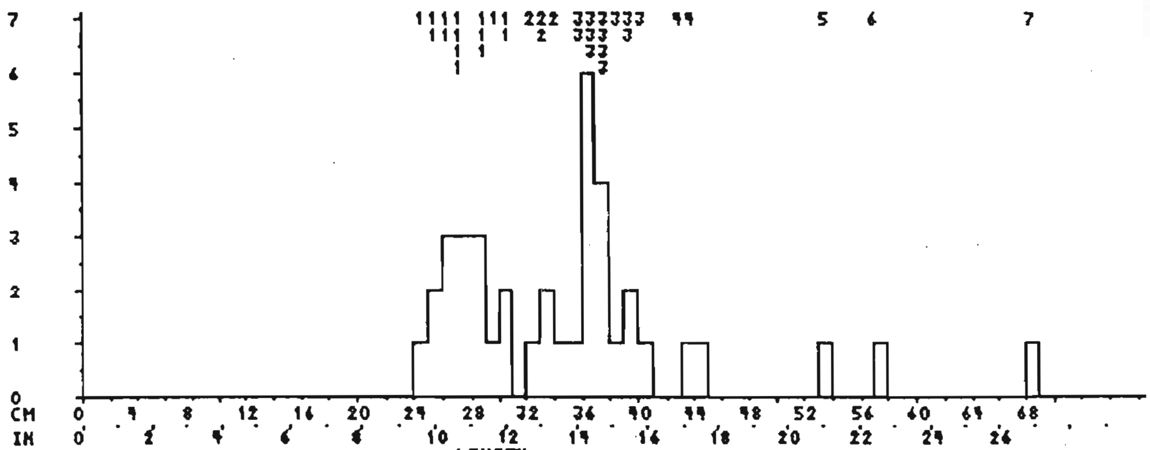

FIGURE 7. CHARLESTON SIDE CHANNEL LAKE CHANNEL CATFISH COLLECTED JULY 6, 1989.
FREQUENCY VS. FISH LENGTH 39 INDIVIDUALS
AGE GROUP IN YEARS (AS DECIMAL, OR A=10, B=11 ETC.) IS SHOWN AT TOP.

TABLE 16

SIZE AT AGE TABLE
CHARLESTON SIDE CHANNEL LAKE
JULY 6, 1989

SPECIES: CHANNEL CATFISH

AGE	MIN LENGTH mm (in)	MAX LENGTH mm (in)	MEAN LENGTH mm (in)	MEAN WEIGHT gm (lb)	NUMBER * OF FISH
0+	0 (.00)	239 (9.41)	0 (.00)	0 (.00)	0
1+	240 (9.45)	309 (12.17)	275 (10.83)	200 (.44)	15
2+	310 (12.20)	349 (13.74)	335 (13.19)	356 (.78)	4
3+	350 (13.78)	409 (16.10)	375 (14.76)	502 (1.11)	15
4+	410 (16.14)	489 (19.25)	440 (17.32)	810 (1.79)	2
5+	490 (19.29)	549 (21.61)	535 (21.06)	1460 (3.22)	1
6+	550 (21.65)	619 (24.37)	575 (22.64)	1815 (4.00)	1
7+	620 (24.41)	689 (27.13)	685 (26.97)	3078 (6.79)	1

* Number of fish from length-frequency distribution.

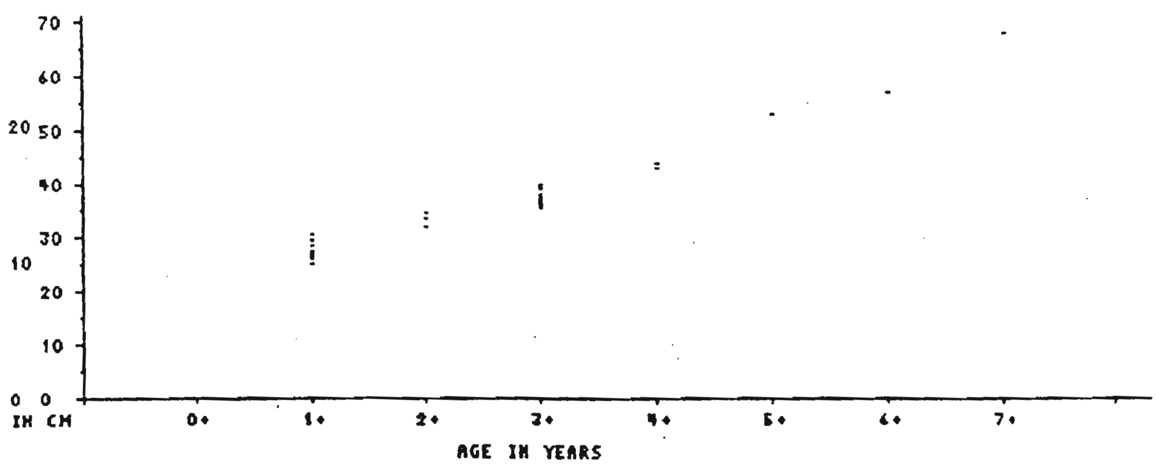

FIGURE 8. CHARLESTON SIDE CHANNEL LAKE CHANNEL CATFISH COLLECTED JULY 6, 1989.
AGE VS. LENGTH FOR INDIVIDUAL FISH

TABLE 17

LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : FCF
SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
72	28.8	1	5450	12	1	-	-	-
TOTAL		1			1			

TABLE 18

LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : GZS
SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
3	1.2	125	-	-	0	-	-	-
4	1.6	255	-	-	0	-	-	-
5	2	45	-	-	0	-	-	-
6	2.4	0	-	-	0	-	-	-
7	2.8	0	-	-	0	-	-	-
8	3.2	0	-	-	0	-	-	-
9	3.6	0	-	-	0	-	-	-
10	4	0	-	-	0	-	-	-
11	4.4	0	-	-	0	-	-	-
12	4.8	0	-	-	0	-	-	-
13	5.2	180	25.4	.05	5	116	1.01	3.98
14	5.6	545	28.7	.06	6	103	.9	3.47
15	6	240	32	.07	6	97	.87	3.48
16	6.4	170	34.5	.07	6	89	.8	3.71
17	6.8	105	40.3	.08	6	88	.8	3.82
18	7.2	35	53.6	.11	5	98	.89	2.37
19	7.6	0	-	-	0	-	-	-
20	8	0	-	-	0	-	-	-
21	8.4	0	-	-	0	-	-	-
22	8.8	0	-	-	0	-	-	-
23	9.2	0	-	-	0	-	-	-
24	9.6	10	146	.32	1	111	1.06	1.89
TOTAL		1710			35			

TABLE 19

LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : GSF
SAMPLES: 1-E1 1-E2

LENGTH GROUP CM	INCHES	TOTAL L-FREQ	MEAN WEIGHT GRAMS	LBS	SAMPLE SIZE	MEAN CONDITION WR	KN	K
6	2.4	1	-	-	0	-	-	-
7	2.8	0	-	-	0	-	-	-
8	3.2	3	9.7	.02	3	-	1.01	6.38
9	3.6	3	20	.04	3	-	1.23	6.63
10	4	3	23.3	.05	3	-	1.13	6.29
11	4.4	7	40	.08	5	-	1.47	5.04
12	4.8	4	32.3	.07	3	-	.93	6.69
13	5.2	1	52	.11	1	-	1.18	22
14	5.6	6	71.2	.15	5	-	1.2	6.5
15	6	4	89.3	.19	3	-	1.27	9.45
16	6.4	2	93	.2	2	-	1.1	13
TOTAL		34			28			

TABLE 20

LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : LOS
SAMPLES: 1-E1 1-E2

LENGTH GROUP CM	INCHES	TOTAL L-FREQ	MEAN WEIGHT GRAMS	LBS	SAMPLE SIZE	MEAN CONDITION WR	KN	K
7	2.8	2	7	.01	2	-	-	7.83
8	3.2	9	13	.02	4	-	-	4.78
9	3.6	6	19.4	.04	5	-	-	3.97
10	4	10	25.3	.05	3	-	-	6.29
11	4.4	9	43.5	.09	4	-	-	6.3
12	4.8	18	54	.11	4	-	-	5.02
13	5.2	27	71	.15	6	-	-	3.7
14	5.6	9	67.3	.14	3	-	-	11
15	6	2	85	.18	2	-	-	14
TOTAL		92			33			

TABLE 21

LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : WAM
SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
7	2.8	1	8	.01	1	-	-	16
8	3.2	0	-	-	0	-	-	-
9	3.6	2	17	.03	2	-	-	9.94
10	4	2	23	.05	2	-	-	9.44
11	4.4	8	34.7	.07	3	-	-	8.4
12	4.8	1	34	.07	1	-	-	20
13	5.2	4	58.7	.12	3	-	-	7.4
14	5.6	2	62	.13	2	-	-	16
15	6	3	84	.18	3	-	-	9.45
TOTAL		23			17			

TABLE 22

LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : LGH
SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
9	3.6	1	16	.03	1	-	-	20
10	4	0	-	-	0	-	-	-
11	4.4	0	-	-	0	-	-	-
12	4.8	0	-	-	0	-	-	-
13	5.2	0	-	-	0	-	-	-
14	5.6	0	-	-	0	-	-	-
15	6	0	-	-	0	-	-	-
16	6.4	1	96	.21	1	-	-	27
TOTAL		2			2			

TABLE 23: LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : WGH
SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
9	3.6	1	16	.03	1	-	-	20
TOTAL		1			1			

TABLE 24 LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : CAP
SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
36	14.4	1	700	1.5	1	-	2.04	12
37	14.8	0	-	-	0	-	-	-
38	15.2	1	700	1.5	1	-	1.83	2.04
39	15.6	1	750	1.7	1	-	1.81	3.36
40	16	2	860	1.9	2	-	1.89	4.12
41	16.4	3	1020	2.2	3	-	2.03	1.39
42	16.8	2	1115	2.5	2	-	2.11	1.45
43	17.2	3	1073	2.4	3	-	1.9	1.63
44	17.6	2	1205	2.7	2	-	1.97	3.58
45	18	0	-	-	0	-	-	-
46	18.4	1	1180	2.6	1	-	1.72	1.16
47	18.8	0	-	-	0	-	-	-
48	19.2	0	-	-	0	-	-	-
49	19.6	0	-	-	0	-	-	-
50	20	1	1830	4	1	-	2.09	1.41
51	20.4	1	1900	4.2	1	-	2.05	3.29
52	20.8	0	-	-	0	-	-	-
53	21.2	0	-	-	0	-	-	-
54	21.6	0	-	-	0	-	-	-
55	22	2	2410	5.3	2	-	2.16	1.44
56	22.4	1	2500	5.5	1	-	2.12	1.41
57	22.8	0	-	-	0	-	-	-
58	23.2	0	-	-	0	-	-	-
59	23.6	1	2720	6	1	-	1.91	1.27
TOTAL		22			22			

TABLE 25

LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : YLB
SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
14	5.6	1	60	.13	1	-	1.56	34
15	6	9	66	.14	3	-	1.47	11
16	6.4	21	68	.14	3	-	1.35	11
17	6.8	5	72.7	.16	3	-	1.2	9.11
18	7.2	2	85	.18	2	-	1.13	7.29
TOTAL		38			12			

TABLE 26

LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : ULL
SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
34	13.6	1	600	1.3	1	-	-	1.37
35	14	1	600	1.3	1	-	-	2.41
36	14.4	4	668	1.5	4	-	-	2.97
37	14.8	4	670	1.5	3	-	-	1.73
38	15.2	3	743	1.6	3	-	-	.67
39	15.6	1	850	1.9	1	-	-	3.36
40	16	1	840	1.9	1	-	-	8.25
41	16.4	1	950	2.1	1	-	-	4.19
TOTAL		16			15			

TABLE 27

LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : YEB
SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
14	5.6	2	30	.06	2	-	-	17
15	6	3	40	.08	3	-	-	11
16	6.4	2	52	.11	2	-	-	16
17	6.8	1	98	.21	1	-	-	27
18	7.2	1	102	.22	1	-	-	15
TOTAL		9			9			

TABLE 28

LENGTH FREQUENCY/CONDITION INDEX
CHARLESTON SIDE CHANNEL LAKE
SUMMER 1989

SPECIES : BRS
SAMPLES: 1-E1 1-E2

LENGTH GROUP		TOTAL	MEAN WEIGHT		SAMPLE	MEAN CONDITION		
CM	INCHES	L-FREQ	GRAMS	LBS	SIZE	WR	KN	K
3	1.2	10	-	-	0	-	-	-
4	1.6	0	-	-	0	-	-	-
5	2	0	-	-	0	-	-	-
6	2.4	0	-	-	0	-	-	-
7	2.8	0	-	-	0	-	-	-
8	3.2	4	1	0	4	-	-	4.78
9	3.6	1	1	0	1	-	-	20
TOTAL		15			5			

FISH STOCKING RECORD

COUNTY Coles

WATER (NAME) Charleston Side Channel Lake

DATE	SPECIES	NO.	Size Range or Avr. Wgt.	CONDITION	SOURCE	REMARKS
7-7-83	CCF	15,000	6-8"	good	Grassy	
9-3-85	CCF	8,650	8 inch	good	Grassy	
8-26-86	CCF	6,920	8 inch	good	Grassy	
7-23-87	CCF	5,882	8 inch	good	Grassy	5.79/ pound
6-23-88	CCF	5,190	7.6 inch	good	Grassy	
10-17-88	SBH	2,000	4-5 inch	good	Keo Fish Farm	Purchased by the City of Charleston
7-12-89	LMB	1,500	2 inch	good	Jake Wolf	Stocked by Bill McMorris, Black Widow Lake, Greenup
7-25-89	CCF	1,730	8 inch	good	Grassy	6.3 per pound
9-19-89	SBH	3,460	5 inch	good	Fountain Bluff Fish Farm	$2,595 FishAmerica Foundati[illegible] Grant Funds, Purchased by Cit[illegible]

F.M. 2.0 Distribution: State and Public—District, Area, Central Offices (8/70)

APPENDIX D

Sediment Load and Streamflow Data for Tributaries
to the Charleston Side-Channel Reservoir

Appendix D. Sediment Load and Streamflow Data for Tributaries to Charleston Side-Channel Reservoir.

sedload = suspended sediment (gm/l) Qcfs = streamflow (cu ft/se
precipitation (in) Qmgd = streamflow (mil gal/day

Row	date	site	time	sedload	Qcfs	Qmgd	precip
1	2/02/89						0.4
2	2/05/89						0.4
3	2/06/89						0.1
4	2/12/89						0.2
5	2/14/89						0.05
6	2/15/89						0.25
7	2/18/89	4		0.0204			
8	2/18/89	3		0.0193			
9	2/18/89	2		0.0458			
10	2/18/89	1		5.6E-3			
11	2/20/89	5		0.5741			
12	2/20/89	2		0.0167			
13	2/20/89	2		0.0303			
14	2/20/89	1		5.7E-3			
15	3/04/89						0.5
16	3/05/89						0.25
17	3/06/89						0.8
18	3/09/89	3		0.0114			
19	3/09/89	2		0.0304			
20	3/10/89	3		1.0208			
21	3/10/89	2		0.7377			
22	3/10/89	2		0.0373			
23	3/10/89	1		0.072			
24	3/11/89	4		0.0943			
25	3/11/89	3		1.3271			
26	3/11/89	2		0.0168			
27	3/11/89	1		0.0163			
28	3/18/89						0.15
29	3/20/89						1
30	3/26/89	3		0.1344			
31	3/26/89	1		0.0861			
32	3/27/89						0.15
33	3/28/89						0.05
34	3/29/89						0.2
35	3/30/89						0.25
36	4/02/89						0.7
37	4/02/89	4	1550	0.185			
38	4/02/89	3	1545	0.0745			
39	4/02/89	2	1515	0.0724			
40	4/02/89	1	1500	0.0378	0.16	0.105	
41	4/03/89						1.6
42	4/03/89	6	1340	0.1622			
43	4/03/89	4	1330	1.126			
44	4/03/89	3	1315	2.7139			
45	4/03/89	2	1300	4.8158			
46	4/03/89	2	1900	2.7894			
47	4/03/89	1	1830	1.6093			
48	4/04/89	4	1850	0.1906			
49	4/04/89	3	1830	0.0642			
50	4/04/89	2	1800	0.1057			

Row	date	site	time	sedload	Qcfs	Qmgd	precip
---	----	----	----	-------	----	----	------
51	4/04/89	1	1745	0.027	0.286	0.185	
52	4/05/89						0.05
53	4/07/89						0.05
54	4/07/89	1	840		0.078	0.05	
55	4/08/89						0.8
56	4/08/89	1			0.697	0.45	
57	4/14/89						0.1
58	4/18/89						0.25
59	4/18/89	2		1.2998			
60	4/23/89						1.4
61	4/23/89	4	1900	0.0288			
62	4/23/89	4	1855	0.028			
63	4/23/89	3	1845	0.0348			
64	4/23/89	3	1840	0.0396			
65	4/23/89	2	1820	0.0391			
66	4/23/89	2	1815	0.0397			
67	4/23/89	1	1805	0.0345	0.442	0.286	
68	4/23/89	1	1800	0.0331	0.442	0.286	
69	4/24/89	1	1230		0.216	0.139	
70	4/27/89						1.25
71	4/27/89	1			1.03	0.662	
72	4/28/89						0.5
73	4/28/89	4	1755	0.0211			
74	4/28/89	4	1750	0.0216			
75	4/28/89	3	1745	0.0218			
76	4/28/89	3	1740	0.0215			
77	4/28/89	2	1720	0.0339			
78	4/28/89	2	1715	0.0353			
79	4/28/89	1	930		0.303	0.196	
80	4/28/89	1	1705	0.0342	0.442	0.286	
81	4/28/89	1	1700	0.0283	0.442	0.286	
82	4/28/89	1	1030		0.668	0.432	
83	4/29/89						0.6
84	5/03/89	1	1230		0.113	0.073	
85	5/04/89						0.5
86	5/05/89	3	1400		0.063	0.041	
87	5/05/89	1	1350		0.113	0.073	
88	5/09/89						0.55
89	5/09/89	4	1330	0.0129			
90	5/09/89	2	1245	0.107			
91	5/09/89	1	1230	0.0953	0.134	0.087	
92	5/09/89	3	1320	0.0893	0.181	0.117	
93	5/15/89						0.05
94	5/17/89	4	1845	2.3E-3			
95	5/17/89	2	1741	2.3E-3			
96	5/17/89	3	1836	3.4E-3	0.013	9E-3	
97	5/17/89	1	1730	0.0108	0.032	0.02	
98	5/18/89	3	1050		0.022	0.014	
99	5/18/89	1	1050		0.039	0.025	
100	5/19/89	6	2015	0.0232			

Row	date	site	time	sedload	Qcfs	Qmgd	precip
101	5/19/89	6	2010	0.0238			
102	5/19/89	4	1915	0.0287			
103	5/19/89	4	1910	0.0286			
104	5/19/89	2	1820	0.105			
105	5/19/89	2	1815	0.1037			
106	5/19/89	3	1510		0.078	0.05	
107	5/19/89	1	1500		0.086	0.056	
108	5/19/89	1	1955	0.0143	0.099	0.063	
109	5/19/89	1	1950	0.0163	0.099	0.063	
110	5/19/89	1	1805	0.1167	0.151	0.098	
111	5/19/89	1	1755	0.1342	0.151	0.098	
112	5/19/89	3	1905	0.1092	0.359	0.232	
113	5/19/89	3	1900	0.1151	0.359	0.232	
114	5/20/89						0.7
115	5/23/89						0.7
116	5/24/89	3	1100		0.034	0.022	
117	5/24/89	1	1100		0.045	0.029	
118	5/25/89						0.25
119	5/25/89	3	1050		0.045	0.029	
120	5/25/89	1	1050		0.045	0.029	
121	5/26/89						0.15
122	6/01/89						0.3
123	6/01/89	4	1800	0.1653			
124	6/01/89	3	1800	0.6096			
125	6/01/89	3	800		0.01	6E-3	
126	6/01/89	1	800		0.026	0.017	
127	6/02/89	1	1150		0.026	0.017	
128	6/03/89						0.2
129	6/05/89						0.2
130	6/07/89	3	1130		7E-3	6E-3	
131	6/07/89	1	800		0.022	0.014	
132	6/12/89						0.15
133	6/14/89						0.05
134	6/14/89	3	1450	0	0	0	
135	6/14/89	1	1450		8E-3	5E-3	
136	6/15/89	3	1740	0	0	0	
137	6/15/89	4	1745	6E-3	8E-3	5E-3	
138	6/15/89	2	1620	8.3E-3	8E-3	5E-3	
139	6/15/89	1	1600	8.2E-3	8E-3	5E-3	
140	6/18/89						0.1
141	6/21/89	3	1110	0	0	0	
142	6/21/89	1	1110		5E-3	4E-3	
143	6/27/89	4	1215	0.042			
144	6/27/89	2	1125	0.0358			
145	6/27/89	3	1210	0.0167	0.034	0.022	
146	6/27/89	1	1110	0.0202	0.045	0.029	
147	6/30/89	1	930		5E-3	4E-3	
148	7/02/89						0.2
149	7/03/89						
150	7/03/89	1	1530		0.253	0.164	

Row	date	site	time	sedload	Qcfs	Qmgd	precip
151	7/03/89	3	1550		0.819	0.529	
152	7/04/89	1	1940		8E-3	5E-3	
153	7/05/89	3	1050		7E-3	6E-3	
154	7/05/89	1	1050		0.012	8E-3	
155	7/06/89	3	1355	0	0	0	
156	7/06/89	1	1350		7E-3	6E-3	
157	7/08/89						0.05
158	7/12/89						0.15
159	7/13/89	1		0	0	0	
160	7/13/89	3		0	0	0	
161	7/19/89	1	745	0	0	0	
162	7/19/89	3	1230		0.078	0.05	
163	7/19/89	1	1210		1	0.711	1
164	7/20/89						1.2
165	7/21/89	1	1300		0.022	0.014	0.3
166	7/23/89						0.4
167	7/24/89						0.11
168	7/25/89						0.5
169	7/29/89						0.25
170	8/02/89	3	1515		0	0	
171	8/02/89	1	1500		5E-3	2E-3	
172	8/03/89	1	1415		1E-3	5E-4	
173	8/05/89	1	1120	0	0	0	0.9
174	8/10/89	3	1120	0	0	0	
175	8/11/89						0.5
176	8/15/89						0.05
177	8/16/89	1	730	0	0	0	0.01
178	8/16/89	3	730	0	0	0	0.01
179	8/17/89	1	730	0	0	0	
180	8/17/89	3	730	0	0	0	
181	8/20/89						1.1
182	8/22/89						0.01
183	8/23/89						0.1
184	8/28/89	4	1720	0.6028			1.1
185	8/28/89	3	1715	0.5489	0.3	0.2	1.1
186	8/28/89	1	1700	1.7583	0.34	0.22	1.1
187	8/29/89	3	1110		8E-3	5E-3	0.1
188	8/29/89	1	1100		0.015	0.01	0.1
189	8/31/89						0.1
190	9/01/89						1
191	9/08/89						3.7
192	9/09/89	1	1400	0.0941	0.253	0.164	2.1
193	9/10/89	2	1815	0.0115			
194	9/10/89	4	1905	0.0255			
195	9/10/89	3	1900	7.3E-3	0.057	0.037	
196	9/10/89	1	1800	0.0126	0.123	0.079	
197	9/13/89						0.05
198	9/14/89						1.8
199	9/20/89	2	1800	2.4E-3			
200	9/20/89	1	1755	4E-3	0.22	0.014	

Row	date	site	time	sedload	Qcfs	Qmgd	precip
201	9/23/89						0.1
202	9/25/89	2	1645	0.0454			
203	9/25/89	1	1630	3.5E-3	7E-3	5E-3	
204	9/26/89	2	1350	3.3E-3			
205	9/26/89	4	1250	2.3E-3			
206	9/26/89	3	1245	0	0	0	
207	9/26/89	1	1330	7.7E-3	5E-3	3E-3	
208	10/06/89						0.2
209	10/06/89						0.2
210	10/17/89						0.25
211	10/17/89						0.25
212	10/19/89						0.6
213	10/19/89						0.6
214	10/20/89						0.05
215	10/20/89						0.05
216	10/31/89						0.1
217	11/07/89						0.15
218	11/09/89						0.05
219	11/14/89						0.2
220	11/15/89						0.85
221	11/16/89	2	1520	0			
222	11/16/89	4	1450	1.2E-3			
223	11/16/89	1	1510	0	8E-3	5E-3	
224	11/16/89	3	1440	2.5E-3	8E-3	5E-3	
225	12/06/89						0.1
226	12/11/89						0.05
227	12/13/89						0.05
228	12/14/89						0.3
229	12/19/89						0.1
230	12/27/89						0.15
231	12/29/89						0.3
232	12/30/89						0.3
233	12/31/89						0.05
234	1/03/90						0.15
235	1/04/90	2	1545				
236	1/04/90	4	1515	7.7E-3			
237	1/04/90	1	1530	5.1E-3	0.022	0.014	
238	1/04/90	3	1500	1.8E-3	0.045	0.029	
239	1/09/90						0.1
240	1/11/90	2	1530	3E-4			
241	1/11/90	4	1515	3.2E-3			
242	1/11/90	1	1520	5.6E-3	5E-3	2E-3	
243	1/11/90	3	1500	1.5E-3	8E-3	5E-3	
244	1/16/90						0.01
245	1/17/90	4	1310	2E-3			
246	1/17/90	3	1300	2.9E-3	0.022	0.014	0.25
247	1/18/90	2	1315	4.1E-3			
248	1/18/90	4	1315	2.2E-3			
249	1/18/90	1	1300	3.1E-3	5E-3	2E-3	0.05
250	1/18/90	3	1300	1.4E-3	8E-3	5E-3	

Row	date	site	time	sedload	Qcfs	Qmgd	precip
251	1/19/90						0.5
252	1/23/90						0.15
253	1/25/90	2	1330	4E-3			
254	1/25/90	4	1330	4.2E-3			
255	1/25/90	1	1310	1.4E-3	0.045	0.029	0.42
256	1/25/90	3	1310	6.6E-3	0.051	0.033	
257	2/01/90	2	1315	2.4E-3			
258	2/01/90	4	1315	2.9E-3			
259	2/01/90	1	1310	2.9E-3	0.022	0.014	0.9
260	2/01/90	3	1310	5E-4	0.026	0.017	
261	2/02/90	2	1315	5.6E-3			
262	2/02/90	4	1315	6.9E-3			
263	2/02/90	3	1310	4.2E-3	0.156	0.101	
264	2/02/90	1	1310	3.8E-3	0.181	0.117	0.1
265	2/03/90						0.8
266	2/06/90	2	1315	2.6E-3			
267	2/06/90	4	1315	3.7E-3			
268	2/06/90	3	1310	1E-4	0.071	0.047	
269	2/06/90	1	1310	1.1E-3	0.104	0.067	0.15
270	2/08/90	2	1400	1E-4			
271	2/08/90	4		3E-4			
272	2/08/90	3		1E-4	0.045	0.029	
273	2/08/90	1	1345	6E-4	0.086	0.056	0.05
274	2/14/90						0.35
275	2/15/90	2	1445	0.094			
276	2/15/90	4	1510	0.3846			
277	2/15/90	1	1430	0.1761	0.852	0.551	1.5
278	2/15/90	3	1500	0.0809	0.919	0.594	
279	2/16/90	2	1415	0.0229			
280	2/16/90	4	1345	0.0153			
281	2/16/90	3	1330	0.0113	0.181	0.117	
282	2/16/90	1	1400	0.04	0.253	0.164	
283	2/22/90						1
284	2/24/90						0.1
285	2/25/90	1	1650	2.3E-3	0.086	0.056	0.1
286	2/25/90	3	1611	2E-3	0.045	0.029	
287	2/25/90	4	1624	1.8E-3			
288	2/27/90						0.2
289	3/08/90	1	1600	1.1E-3	0.113	0.073	0.25
290	3/08/90	2	1615	1.2E-3			
291	3/08/90	3	1630	4.2E-3	0.095	0.061	
292	3/08/90	4	1645	1E-4			
293	3/10/90						0.35
294	3/15/90	1	1600	0.1054	0.045	0.029	0.1
295	3/15/90	2	1615	0.12			
296	3/15/90	3	1630	0.1029	0.113	0.073	
297	3/15/90	4	1645	0.1037			
298	3/22/90						0.1
299	3/24/90						0.24

Length	299	299	299	299	299	299	299
Type	D	N	N	N	N	N	N

APPENDIX E

Results of Grain-Size Analysis of Reservoir Bottom Sediments

Appendix E. Results of Grain-Size Analysis of Reservoir Bottom Sediments.

Sample Sites	Results Sand	Silt	Clay	Organics	Averages Sand	Silt	Clay	Organics
1	11.73%	56.67%	15.05%	16.54%	12.22%	58.22%	14.49%	15.08%
	12.71%	59.76%	13.92%	13.61%				
2	13.09%	58.23%	12.91%	15.76%	13.88%	57.22%	13.81%	15.09%
	14.67%	56.20%	14.70%	14.42%				
3	15.10%	59.19%	14.56%	11.15%	15.74%	61.91%	12.68%	9.69%
	16.38%	64.62%	10.79%	8.22%				
4	24.15%	48.79%	12.90%	14.16%	25.62%	49.96%	13.29%	11.15%
	27.08%	51.12%	13.67%	8.13%				
5	0.27%	51.45%	39.13%	9.15%	0.42%	48.33%	40.36%	10.90%
	0.56%	45.20%	41.58%	12.65%				
6	3.33%	65.16%	18.81%	12.69%	3.40%	64.98%	18.62%	13.01%
	3.46%	64.79%	18.43%	13.32%				
7	3.89%	58.00%	21.25%	16.86%	4.12%	57.11%	22.62%	16.16%
	4.35%	56.22%	23.98%	15.45%				
8	88.59%				88.70%	5.73%	3.73%	1.72%
	88.89%			1.51%				
	88.61%	5.73%	3.73%	1.93%				
9	90.42%				90.58%	5.59%	2.37%	0.87%
	90.45%			0.57%				
	90.87%	5.59%	2.37%	1.17%				
11	5.02%	64.68%	17.85%	12.45%	4.88%	61.27%	20.47%	13.39%
	4.74%	57.85%	23.08%	14.32%				
12	35.81%	49.26%	9.21%	5.72%	35.80%	45.36%	11.42%	7.43%
	35.78%	41.46%	13.63%	9.13%				
13	0.69%	54.39%	34.97%	9.95%	0.62%	52.46%	36.60%	10.32%
	0.55%	50.53%	38.23%	10.68%				
14	9.05%	62.47%	19.09%	9.39%	9.24%	64.09%	18.34%	8.34%
	9.43%	65.70%	17.59%	7.28%				
15	50.01%	35.93%	9.15%	4.92%	48.79%	36.15%	9.07%	6.00%
	47.57%	36.37%	8.99%	7.08%				

	Sand	Silt	Clay	Organics	Sand	Silt	Clay	Organics
16	1.55%	63.59%	25.74%	9.12%	1.37%	63.46%	24.77%	10.40%
	1.19%	63.33%	23.80%	11.68%				
17	95.68%	2.30%	1.72%	0.29%	95.57%	2.34%	1.84%	0.25%
	95.46%	2.38%	1.96%	0.21%				
18	30.32%	49.13%	12.53%	8.02%	30.20%	48.94%	12.76%	8.10%
	30.07%	48.75%	12.99%	8.18%				
19	41.27%	38.01%	12.82%	7.91%	39.48%	38.62%	13.08%	8.83%
	37.69%	39.23%	13.34%	9.74%				
20	8.07%	47.16%	26.11%	18.67%	7.81%	47.61%	24.41%	20.19%
	7.54%	48.06%	22.70%	21.71%				
21	32.12%	51.48%	9.23%	7.17%	33.49%	48.10%	10.02%	8.40%
	34.85%	44.72%	10.80%	9.62%				
22	0.62%			8.89%	0.67%	52.34%	34.18%	10.83%
	0.71%	52.34%	34.18%	12.77%				
23	18.34%			4.35%	19.72%	60.74%	11.75%	5.38%
	21.10%	60.74%	11.75%	6.41%				
24	70.64%			1.52%	71.27%	16.86%	7.91%	2.43%
	71.90%	16.86%	7.91%	3.33%				
25	82.01%			3.75%	83.22%	8.71%	3.98%	3.32%
	84.42%	8.71%	3.98%	2.89%				
26	0.52%			6.14%	0.71%	56.92%	33.57%	7.39%
	0.89%	56.92%	33.57%	8.63%				

APPENDIX F

Sediment Study of the Charleston
Side-Channel Reservoir
Summer 1989

SEDIMENT STUDY OF THE CHARLESTON
SIDE-CHANNEL RESERVOIR
Summer 1989

PART I - METAL and METALLOID ANALYSIS
PART II - BENTHIC SURVEY

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TABLE OF CONTENTS

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SUMMARY

The Charleston Side Channel Reservoir is a 1.1 billion gallon water supply for the City of Charleston in Coles County of east-central Illinois. It was created in 1981 by the construction of a dike when the former impoundment was shown to have reduced storage capacity due to siltation. In the past few years, the water quality, wildlife habitat, and recreational value have deteriorated. This is probably due to the static condition of the reservoir which has caused oxygen depletion and has increased the potential of contaminant accumulation in the bottom sediments, particularly heavy metals which readily precipitate under moderately basic conditions. The reservoir typically shows a pH of 8.0 to 8.5. Metals, metalloids, and other chemicals enter the reservoir by surface runoff, water pumped in from the Embarras River, copper sulfate treatment, duck hunting, and other activities.

The purpose of this study was to quantitate and compare the metal and metalloid concentrations and benthic organism types and populations in the sediments at various locations in the reservoir and the river. Sediment samples were taken during the summer of 1989 with a Ponar dredge at six sites used for reservoir monitoring (June and September) and at three sites in the river (August). Methods for sample preparation were according to Standard Methods prescribed by th APHA, AWWA, and WPCF. Digestion and extraction of metals were accomplished with nitric and perchloric acids. The samples were analyzed by direct aspiration atomic absorption spectroscopy (AAS) at Eastern Illinois University, and by inductively coupled plasma emission spectroscopy (ICP) at the University of Illinois.

The results indicate that for most of the 21 elements analyzed, there was no significant difference between the concentrations of most metals and metalloids found in the reservoir and those found in the river sediments with a few exceptions. Arsenic, calcium, magnesium, manganese, and sodium were more

abundant in the reservoir by factors ranging from 1.2 to 1.9. Elevated levels of each of these could have come from nearby human activities. Copper was significantly higher (2 1/2 times higher) in the reservoir due to periodic use of copper sulfate as an algicide. Sampling sites throughout the reservoir showed similar concentrations, i.e., there is no notable increase in metal and metalloid concentrations at sites where water runoff into the reservoir from surrounding high ground is greater. Interestingly, but unexplained, is the apparent trend for the metal and metalloid concentrations in the reservoir sediment to be somewhat higher in June than in September. The possibility that some release of these elements into the water has occurred by September should be considered for further investigation.

The June samples under 5X and 20X magnification produced no living examples of the "expected" annelids, mollusks, and arthropods that are usual residents of the benthos of lakes in this region. Dissolved oxygen data showed that the reservoir was essentially anoxic near the bottom suggesting that recovery from anoxic conditions associated with winter conditions (in lakes with little turn over) was minimal. The September samples showed a slight increase in dissolved oxygen at the bottom and some tubifex worms were now found along with a few living fresh water muscles. It appears that the reservoir bottom remains largely anoxic throughout the year as a result of the lack of water flow or turn over.

Future studies may use the data acquired from this study to provide an extensive baseline from which to verify the stability of the Charleston Reservoir. Since the reservoir has a slower turn over and a controlled environment, this study should prove to be useful in determining the extent and causes of reservoir pollution and possible solutions for control and management. Daily Lab, in October 1988, extracted three samples that were analyzed for six elements (we studied 21 elements). Their analysis indicated that each of their samples contained substantially lower amounts of metals and metalloids than recorded by either our results or by the April 1989 Illinois Environmental Protection Agency study. The two samples, analyzed by IEPA for 13 elements, resulted in one sample giving much higher concentrations than ours and the other about equal to ours. In 1973, IEPA reported on 63 Illinois lakes which did not include Lake Charleston. However, if we base their criteria for levels of metals and metlloids found throughout Illinois, the Charleston Reservoir rates favorably "normal" to "low" in the concentrations of the 10 elements studied by IEPA. Further sampling and analysis should be performed with particular attention paid to the six metals (Arsenic, Calcium, Copper, Magnesium, Manganese, and Sodium) that appeared to be more abundant in the reservoir than in the river. We feel that anoxic conditions and subsequent low population of benthos is of greater concern than the metal and nonmetal concentrations and indicates an undesirable ecosystem.

INTRODUCTION

The Embarras River, located on the east side of Charleston, has served as the main water supply for the city since the late 1870's since sufficient well water does not seem to be available. At first, water was pumped directly from the river and used. In the 1895 a dam was built to increase the capacity for the growing population. In 1947, Riverview Dam was built to further increase the capacity, and the impoundment became known as Lake Charleston. Wildlife flourished in the area and it became a popular source of recreation. Fishing, hiking, boating, and seasonal duck hunting were permitted.

In time, siltation began to drastically decrease the storage capacity of the lake which had developed a shallow, mucky bottom. In 1981, a dike was constructed to create an enclosed, Side-Channel Reservoir, separate from the river flow (Fig. 1). Figure 1 also shows six reservoir sediment sampling sites (1-6) and three river sampling sites (L1-L3) used in this study. Sites 1-5 and L1-L3 are traditionally used sampling sites for water analysis and the same as used in the Charleston Watershed Project. Note, that the "L" designation for sampling sites located in the Embarras River are termed as "Lake Charleston Sites" (upstream of the dam) by the Charleston Watershed Project. Site 6 was added for this study to compare sediment from areas that were originally islands before construction of the side-channel dike in 1981 raised the water level by about seven feet. A pump station was built on the south end of the dike to pump water into the reservoir from the river as needed. As a result, the storage capacity was increased to 1.1 billion gallons and siltation decreased significantly.

However, in the past few years several problems have developed in the closed-system reservoir:

1. Deterioration of water quality, particularly in odor and taste (possible due to algal blooms and/or fish kills).
2. Populations of some fish species in poor condition

(possibly due to oxygen depletion, sublethal concentrations of toxic metals, low transparency, and minimal vegetation cover).

3. Ultimately, rapid eutrophication and depletion of desirable habitat and recreational value.

In addition, the IEPA has ranked the reservoir 6th most serious in the state as "Needs Assessment for Protection, Restoration, and Management" [1]. Most of the data supporting this classification result from studies for the Volunteer Lake Monitoring Program. Furthermore, only a few sediment samples have been collected and analyzed [2] (for metals and metalloids) in the past with which sediment contamination could be monitored. Furthermore, to our knowledge no benthic survey has been performed in the past. This study is designed to alleviate these omissions. It is possible that nutrient loading and accumulation of metals and metalloids in the sediments of the enclosed reservoir could be a cause of the problems mentioned.

The following conditions have increased the potential for accumulation of metals and metalloids in the bottom sediments:

I. Approximately 2/3 of the reservoir water is pumped in from the Embarras River and 1/3 enters as runoff.

II. Copper sulfate has been applied to the reservoir six times in the past three years to control noxious algal blooms. It is generally applied between April and October, and each application includes 2000 pounds of copper sulfate plus 1000 pounds of citric acid as a chelator [2].

III. Duck hunting has been permitted in the area since 1947 and fishing well before that. Both may contribute to the accumulation of lead.

IV. The runoff includes drainage and erosion from the surrounding agricultural, commercial, industrial, municipal, residential, and forest lands.

A. Particular concerns:

1. Increased erosion from the area north of the reservoir due to clearing of timber. (Fig. 1, Site 5)
2. Leaching of metals from soil by acid rain which then precipitate in the alkaline reservoir water (pH=8-8.5).
3. Contaminants entering the west side of the reservoir (drowned valley) from industrial runoff and leaching of metals from a buried junkyard also in that area. (Fig. 1 Site 4)
4. Contaminants entering via the Embarras River and concentrating at the point of intake.
5. Accumulation of aluminum at Site 4 from unintentional, occasional runoff of lime-alum sludge from the treatment facility.

V. The enclosed nature of the reservoir has eliminated water circulation through the reservoir. Water leaves primarily by pumping to the Treatment Plant or by evaporation.

The purpose of this study was to determine the concentrations of certain metals and metalloids in the sediments at selected sites to see if significant accumulation has occurred which could be due to particular activities or runoff from specific areas. It was also to determine the benthos populations within the reservoir and attempt to correlate differences in populations to element concentrations within the sediment. This study provides baseline data that may be used for comparison with future monitoring. Figure 2 shows the current depth profile of the reservoir.

PART I - METAL and METALLOID ANALYSIS

Project Design

Sediment samples were taken from 6 reservoir sites (Site 1 - Site 6 in Fig. 1 and Fig. 3). Samples were also taken from 3 river sites (L1 - L3 in Fig. 1 and Site 3 in Fig. 3). Figure 3 also shows detailed locations for replicate (Rep) samples taken at each site.

The samples were treated to extract metals and metalloids and analyzed for concentrations of lead and copper by a Perkin Elmer Model 2380 Atomic Absorption Spectrophotometer (AAS) with a deuterium lamp background correction. This analysis involved the use of lab space, equipment, and materials from the Chemistry Departments of Eastern Illinois University and the University of Illinois. Forty milliliters of each digested sample were submitted to the University of Illinois (Urbana-Champaign) Microanalytical Lab (Thomas P. McCarthy) for quantitative analysis of 21 elements by atomic emission on a Perkin Elmer Plasma 2, Inductively Coupled Plasma Spectrophotometer (ICP).

Comparison of data was made regarding element concentration versus sample site. Comparisons were also made with previously reported results obtained by the IEPA and Daily Analytical Laboratories (Peoria, IL) on a few sediment samples from the Charleston Reservoir [2], and an extensive study of sediment conducted by the IEPA on 63 Illinois lakes in 1979 [3].

Methods and Materials

Samples were taken with a Ponar dredge from each site (Fig. 3 and Table 1) and stored in polyethylene bottles at approximately 20 degrees Celsius until treatment. Treatment began by drainage of a portion of each sample of excess water and weighing them while still wet. Then they were dried at 110 degrees Celsius, cooled, and reweighed (Table 1). The dried samples were ground to a powder with a mortar and pestle. A measured amount of each sample (Table 1) was digested with nitric and perchloric acids according to <u>Standard Methods for the Treatment of Water and Wastewater</u> [4], section 302F. The resulting sample solutions containing the extracted metals and metalloids were each diluted to a total volume of 250 milliliters in a volumetric flask with millipore water (treated with a Milli-Q water system). We estimate that the diluted extract contained 4.0-4.5%w perchloric acid, 1.5-3.0%w nitric acid, and 93-95%w water in addition to the extracted ions.

Atomic Absorption Analysis

Quantitative analysis of copper and lead in the samples was achieved by atomic absorption spectroscopy, AAS. Approximately 20 milliliters of each sample were directly aspirated into an air/acetylene flame for lead analysis. The sample solutions for copper analysis were further diluted 1:1 with millipore water. Millipore water was used for blanks. Wavelength selected for copper was 327.5nm and for lead was 283.4nm. A deuterium background corrector was used for each element. Stock solutions were prepared by dissolving elemental copper or lead nitrate as prescribed by the Perkin-Elmer operating manual [5]. Standard solutions were prepared by serial dilution of 1,000 mg/L stock solutions. Absorption readings were averaged for 50 replicate runs. Three of these mean readings were recorded for each sample. Standard deviations ranged from .0004-.0006 for each average. Concentrations for each sample were estimated from the calibration curves. Results are shown in Table 2. Calibration curves for each element were established by linear least squares fit of data (Table 2 and Figs. 4 and 5). The working curves showed good linearity for Beer's Law with regression coefficients of .9998 for lead and .9985 for copper.

ICP Analysis

Finally, 40 milliliters of each sample were submitted for analysis by atomic emission ICP at the University of Illinois. This type of instrumentation is capable of simultaneously analyzing up to 72 elements in about 1 minute with minimal spectral interference (high sensitivity) [6]. Where as Millipore water was used alone for blanks and in preparation of standards of AAS, Millipore water and estimated amounts of nitric and perchloric acids present in the samples were used in the blanks and standards for ICP to minimize matrix effects during analysis. As discussed later the ICP results are probably the more accurate especially for elements such as lead that show chemical interferences by AAS. For this study, 21 elements were quantitated for each sample by this method. Results are shown in Table 3.

Results and Discussion

Concentrations of all elements analyzed for the sediments of the reservoir are summarized in Table 4 which also includes results from preliminary studies conducted by the IEPA and Daily Analytical Laboratories [2] on a few sites in the reservoir and data obtained by the IEPA in 1979 for 63 Illinois lakes [3] for comparison. Site 3 was excluded from the data shown in Table 4 because the significantly low concentrations at this site are probably due to the scouring action of pumped water which left a sandy texture of the sample instead of sediment.

Comparison of the AAS and ICP analysis of copper and lead gave predictable results. Copper concentrations agreed within about 10% with the AAS results usually higher. Lead concentrations were consistently higher by about 25% as determined by AAS. The Perkin-Elmer AAS manual [4] states "Large excesses of other elements may interfere with the lead signal (e.g., 10,000 mg/L iron enhances the lead signal)". Our extracts contained very high concentrations of iron, aluminum, and calcium. ICP emission analysis operates at about 10,000K where as an AAS air-acetylene flame produces only about 2500K. The higher temperatures for ICP eliminate most chemical interferences. The ICP data should be relied on over the AAS data. The latter is presented here for information only.

Sediment concentrations at each site and replicate for the 21 elements analyzed are presented in Figs. 6 - 27 to illustrate any significant trends in accumulation. It is known that cadmium, copper, iron, lead, and zinc are toxic at certain concentrations. These 5 metals will be elaborated upon later. The degree of toxicity for each depends upon water conditions such as pH, temperature, hardness, etc. At the reservoir pH, approximately 8-8.5, these metals are insoluble and probably settle in the bottom sediments. Furthermore, it is possible that "heavy metals... in sediments can be passed along successive trophic levels (e.g., from heterotrophic bacteria to tubificids to fish)" (Ref. [3], p.44). Both copper and zinc cause death in fish when they precipitate at pH=8-9 and accumulate in the gills. Sublethal effects of zinc have also shown retardation of growth in bluegills and fathead minnows [7]. Thus, it is important that such potentially hazardous metals be monitored, especially in regard to the static condition of the reservoir.

The results indicate that for most of the 21 elements analyzed, there was no significant difference between the concentrations of most metals and metalloids found in the reservoir and those found in the river sediments with a few exceptions (Table 4 and Fig. 6-27). Arsenic, calcium, magnesium, manganese, and sodium were more abundant in the reservoir by factors ranging from 1.2 to 1.9. Elevated levels of each of these could have come from nearby human activities. Copper which was significantly higher in the reservoir due to periodic use of copper sulfate as an algicide. Sampling sites throughout the reservoir showed similar concentrations, therefore, there is no notable increase in metal and metalloid concentrations at sites where water runoff into the reservoir from surrounding high ground is greater. Interestingly, but unexplained, is the apparent trend for the metal and metalloid concentrations in the reservoir sediment to be somewhat higher in June than in September. The possibility that some release of these elements into the water has occurred by September should be considered for further investigation.

Finally, the data obtained for this study should prove to be useful in determining the extent and causes of reservoir pollution and possible solutions for control and management. They should also serve as valuable baseline data from which to ascertain future changes in concentrations. Earlier analysis of metals and metalloids in the sediment are sparce and inconsistent. In October 1988 three samples were analyzed by Daily Lab for only six elements. Comparison with our current analysis would suggest that concentrations have increased substantially since then. However, in April 1989 the Illinois Environmental Protection Agency analyzed two samples for 13 elements with one sample giving much higher concentrations than ours and the other about equal to ours. As compared with the 1973 IEPA report on 63 Illinois lakes the Charleston Reservoir rates favorably "normal" to "low" in the concentrations of the 10 elements studied by IEPA (we studied 21 elements). Anoxic conditions such as encountered at the bottom of the reservoir can result in certain elements (such as iron) going to a reduced state (ferrous) which aids its solution into the water (Ref. [3], p. 50). We recommend that further sampling and analysis be performed with particular attention paid to the six metals (arsenic, calcium, copper, magnesium, manganese, and sodium) that appeared to be more abundant in the reservoir than in the river.

Specific comments on aluminum, cadmium, copper, iron, and zinc follow:

__Aluminum__. Excessive accumulation of aluminum was expected to be occurring at Site 4 due to occasional unintentional lime-alum sludge runoff from the water treatment plant. From these data, Site 4 had the second lowest aluminum concentrations of all sites. Thus, no significant elevation of aluminum appears to have occurred at this site. It also appears that aluminum in the river sediment was slightly higher than the reservoir at this time. Aluminum in the river sediment averaged 5426 mg/kg, while the reservoir (excluding Site 3) averaged 3770 mg/kg.

__Cadmium__. Cadmium is a potentially toxic metal, and has an additive interaction in fish when combined with zinc [8]. The sediment concentrations for the river and the reservoir appear to be about the same. The average for each is 1.1 mg/kg indicating no significant accumulation.

__Copper__. The application of copper sulfate to control algae is suspected to be the primary source of copper into the reservoir.

It has been applied six times in the past three years, twice in 1987, three times in 1988, and once in 1989. Each application includes 2000 pounds of copper sulfate and 1000 pounds of citric acid as a chelator. It is probable that most of the copper precipitates in the alkaline water and settles in the sediment. It appears that copper concentrations were significantly higher in the reservoir sediment than in the river with the exception of Site 3 (Fig. 3). Reservoir sediment concentrations averaged 19.5 (excluding Site 3), and the river sediments averaged 7.7 mg/kg. This significant difference reflects accumulation in the reservoir sediments.

__Iron__. Overall, iron concentrations were considerably higher than other metals except for calcium. Elevated concentrations in the reservoir sediments were possibly due to anoxic hypolimnion conditions under which oxidation and precipitation of primarily ferrous sulfide occurs (Ref. [3], p. 50). Note that the replicates showing the highest iron levels were taken from greater depths than the other replicates taken at those sites.

However, the mean sediments concentrations of the reservoir (excluding Site 3) and the river were about the same. The river averaged 8710 mg/kg and reservoir averaged 8774 mg/kg suggesting no significant accumulation at this time.

__Lead__. Lead levels in the reservoir sediment do not appear to be significantly different than the river sediments in this study. The reservoir averaged 8.1 mg/kg (excluding Site 3), and the river averaged 7.9 mg/kg. The alarmingly high lead concentration reported by Daily Lab in 1988 at Site 3 (120 mg/kg) was not evident from this study. Their sample may have contained some lead shot or a lead sinker which would give higher concentrations.

__Zinc__. Zinc concentrations in the sediment of the reservoir were slightly higher than copper, however, the river had a slightly higher average concentration of zinc than the reservoir. The river sediment averaged 30.9 mg/kg while the reservoir sediment averaged

27.7 mg/kg (excluding Site 3). Therefore, accumulation of zinc is not apparent in the reservoir at this time.

PART II - BENTHIC SURVEY

Project Design

The following conclusions were drawn about the body of water known as the Charleston Side-Channel Reservoir from benthic samples taken from this area on June 28, 1989 and on September 21, 1989.

The survey was taken in response to concern expressed about water quality and safety from the staff of the Water Treatement Plant of the City of Charleston who use this as their source of potable water.

The reservoir is a "man made" lake that was constructed expressly to function as a stable source of potable water for the city. The creation of this "artificial" environment produced the unexpected but not unexplainable benthic conditions that were illustrated by the examination of the samples taken on the two dates mentioned above.

Methods and Materials

The samples that were collected with a "Ponar" sampling device, kept refrigerated, and were observed within 24 hours under 5X and 20X magnification for the "expected" annelids, mollusks, and arthropods that are usual residents of the benthos of lakes in this region.

Results and Discussion

The June samples were taken from the same sites that yielded the samples for the chemical analysis in Part I of this report. They produced no living examples of the three expected classes. In fact, only a few arthropod "artifacts" that were mostly leg segments from crayfish and a few mollusks shells were identified after several hours of examining the samples.

During collection and subsequent observations, a strong odor was noted that is characteristic of anaerobic bacterial activity. These factors led to the conclusion that the sediments of the reservoir contained few or no living macro-organisms simply because the oxygen content of that region was not at a level high enough for them to carry on adequate metabolism. Later comparison of dissolved oxygen data provided by the Charleston Water Treatment Plant and the Environmental Biology program at Eastern Illinois University substantiated this theory, Table 5 [2].

The September samples indicated that recovery had been minimal even with the nominal rise in dissolved oxygen. The elevation in oxygen furthermore, was most notable near the surface with rapidly decreasing concentrations as depths increased. It is most likely due to algal activity and is definitely cyclic. Although living organisms were observed in the samples that were collected from approximately the same sites as the June samples, their relative numbers seemed to be far below what would be expected in a normal environment at that time of year. It was also noted that the sediments were less anaerobic smelling than the June samples. The tubifex worm population was the most notable with 46 being identified from ~13g of sample material. Three living fresh water muscles and numerous broken and half shells were identified along with a few crayfish exoskeleton parts and assorted surface insect fragments. The numbers of organisms seemed to correspond directly to the type of bottom. The greater the percentage of organic material in the sediments, the greater the concentration of annelids. This is most probably a food influenced situation and not related to external factors.

Based upon the above mentioned observations several conclusions can be drawn. Most important being the environment of the original area has been altered significantly enough from its naturally occurring state to limit or exclude habitation by expected fauna. The greatest alteration is the conversion of a flowing lake situation, which prior to the 1930's was a river, into a lake with minimal inflow and outflow. There is now minimal input of dissolved oxygen from the Embarras River. Also missing is the normal "cleansing" effect provided by the movement of water. This cleansing usually prevents the accelerated accumulation of undesirable heavy metals (although the results mentioned earlier in this paper did not, in all except for copper, indicate a build up), pesticides, salts, and organic sediments that inhibit the life functions of most benthic dwellers. Although the Embarras is not the most desirable source of water for a balanced temperate lake ecosystem, due in large part to the high amount of runoff from tilled land, it is not an unusual situation for this area in which surface water is the only available source.

Another notable condition is the result of algae control techniques. Situations exist in this reservoir that make abnormally high algal blooms a common occurrence. The factors that affect this situation are the lack of water movement, elevated concentrations of undesirable chemicals such as phosphates and nitrates, high water temperatures, and minimal shading of the water by surrounding vegetation. As these algae often impart undesirable odors and tastes to the water, they must be controlled. This is done with copper sulfate and is a widely accepted practice. The adverse effect being the death of many benthic organisms that are sensitive to copper sulfate. The abnormally high level of copper would substantiate this theory.

It was noted that fish were present in the reservoir. They are, in all probability, able to exist in some numbers, as opposed to benthic organisms, in that they can move closer to the surface and utilize oxygen that has penetrated from the atmosphere and also utilize the algae produced oxygen which is also closer to the surface and is mostly not available to the bottom dwellers.

Continued sampling at the same dates and sites will assure that this was not a unique situation caused by an unknown artificial or natural occurrence or even an error in collecting or identifying methods. Dissolved oxygen tests should continue to be conducted in the future on the sediments. This should clear up some of the questions concerning true oxygen levels and their effects on the target populations. This study was in our estimation a pilot, carried out to establish a baseline for comparison to the results of future studies.

The Charleston Reservoir has suffered a marked degeneration from the biological standpoint. This is illustrated by the lack of organisms in the populations that had been targeted for study and even the appearance of the shore line which it has only small stands of aquatic macrophytes. No single factor may be responsible for this, but it is most probably the result of a combination of events revolving around the major alteration of an existing ecosystem and the failure of the floral and faunal residents to adapt to this change.

Although the sediment samples which were collected from the Embarras River showed a more normal faunal population, in all probability, they have little bearing on the faunal make up of the reservoir. The reason being the extreme difference in the two environments. One being inhabited by organisms that evolved over a long period of time in a moving water environment and the other a sedate environment that has not had time to evolve an appropriate fauna. For this reason, no comparisons have been made.

The low numbers of target organisms identified in this study are probably an indicator of a larger problem. That problem being the failure of natural (and necessary) populations to establish and flourish in a highly altered environment. The maintenance of a desirable situation in the reservoir depends greatly on it's ability to achieve a homeostatic condition. Although our data on the reservoir is only now being developed and needs to be supported by continued sampling, the prognosis is not good from the biological standpoint. Further degeneration of the current fauna is likely to occur before a new ecosystem evolves that is more adapted to the existing environment. This process in all probability will take many years.

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APPENDIX G

The Birds of Charleston Side-Channel Reservoir

The Birds Of Charleston Side-Channel Reservoir
Coles County, Illinois

submitted by:

Ron Bradley
30 March 1990

Introduction

The following represents a list of the avifauna of the Charleston Side-Channel Reservoir area. The information contained herein is based on personal observations and experiences for the period from 1 November 1983 thru 15 March 1990. Review of this document, as well as a wealth of information, has been provided by L. Barry Hunt (LBH). For his time and effort, I am extremely grateful. The format for reporting the status and abundance of birds is patterned after that of H. David Bohlen in his book, An Annotated Check-list of The Birds Of Illinois, Illinois State Museum Popular Science Series, Volume IX, 1978.

The status of birds contained herein is described by the following terms:

Resident--birds that are present all year

Migrant--birds that pass thru the area enroute to wintering or breeding areas

Winter resident--birds present during winter and usually proceed north with the coming of spring

Summer resident--birds that nest in the area

The abundance of a species is separated arbitrarily into four catagories:

Common--occurs in considerable numbers at the right season

Fairly common--occurs in numbers but to a lesser degree than common; if looked for at right season a few can be seen

Uncommon--occurs in small numbers; even if looked for at right season, might be missed in a day

Rare--may occur once or twice a year, some years not at all

*--represents Illinois Endangered Species

**--represents Illinois Threatened Species

***--represents Federally Endangered Species

The Birds Of Charleston Side-Channel Reservoir

Common Loon--common migrant

Late March--Early May (one June record, LBH)
Late October--Late December (one January record)
High count: 125, 15 November 1985

Horned Grebe--fairly common migrant

Early February--Early April
Late September--Late December
High count: 25, 12 November 1986

Pied-billed Grebe*--common migrant

Early March--Early May (rare in June)
Late August--Early December
High count: 130, 20 October 1987

Double-crested Cormorant*--fairly common migrant

Late March--Late May
Late August--Early December
High count: 65, 6 November 1988

Great Blue Heron--common migrant and summer resident, uncommon winter resident

Mid-February--Late December (three January records)
High count: 15, 3 August 1986

Green-backed Heron--uncommon migrant and summer resident

Mid-April--Late September (LBH)

Little Blue Heron*--rare migrant

Two records: 1, 10 May 1988 (LBH); 2, 14-17 July 1988 (LBH)

Great Egret*--uncommon migrant

Late March--Early November
High counts: 3, 4 November 1986 ; 3, 30 March 1988

Black-crowned Night Heron*--uncommon migrant (LBH)

Tundra Swan

One record: 1, 9 December 1988

Canada Goose--common migrant, uncommon winter resident

Early September--Late April
High counts: 150, 6 January 1985; 150, 3 December 1985;
150, 18 December 1986

Greater White-fronted Goose

One record: 1, 25 October 1985

Snow Goose--rare migrant

Late January--Mid-March
Mid-October--Mid-November
High count: 45, 19 October 1986

Mallard--common migrant, fairly common winter resident

Early September--Mid-April
High count: 100, 17 January 1987

American Black Duck--fairly common migrant and winter resident

Early October--Early April
High count: 25, 11 January 1987

Gadwall--fairly common migrant

Late February--Late April
Late September--Late November
High count: 25, 21 October 1986

Northern Pintail--fairly common migrant

Mid-January--Late March
Late September--Late December
High count: 6, 14 March 1987

Green-winged Teal--fairly common migrant

Mid-March--Late April
Early September--Late October
High count: 10, 23 March 1988

Blue-winged Teal--fairly common migrant

Late March--Early May
Late August--Late October
High count: 200, 21 October 1984

American Wigeon--common migrant

Late February--Late April
Mid-September--Late November (one January record)
High count: 25, 7 March 1988

Northern Shoveler--common migrant

Early March--Late April (one February record)
Late August--Late November
High count: 30, 20-22 March 1987

Wood Duck--common migrant and summer resident

Mid-March--Late October (LBH)
High count: 12, 14 September 1988 (past record; 296, 19 October 1969, M. Colin)

Redhead--fairly common migrant

Early February--Early April
Mid-October--Late December
High counts: 50, 3 March 1987; 50, 19 November 1988

Ring-necked Duck--fairly common migrant

Early February--Late April (one January record)
Early October--Early December
High count: 200, 29 October 1988

Canvasback--uncommon migrant, occasional winter resident

Late October--Mid-March
High count: 12, 3 March 1987

Lesser Scaup--common migrant

Early February--Early May (three January records)
Early October--Late December
High count: 1000, 29 March 1988

Common Goldeneye--common migrant, occasional winter resident

Early November--Mid-March
High count: 40, 23 February 1986

Bufflehead--fairly common migrant

Early February--Late April
Late October--Early December
High count: 70, 11 November 1985

Oldsquaw--rare migrant

Three records: 1, 11 March 1989; 2, 17 March 1989; 1, 5 January 1990

White-winged Scoter--rare migrant

Three records: 1, 1-9 January 1985; 2, 22-24 February 1986 (LBH); 1, 21 October 1989 (LBH)

Surf Scoter--rare migrant

One record: 1 female, 30 January--5 February 1989 (Past records: 1, 5 November 1969, M. Colin; 1, 26 November 1977, L. Bates)

Black Scoter--rare migrant

EIU specimen collected by John Kline, 5 December 1970 (LBH)

Ruddy Duck--common migrant

Early March--Late April (two January records)
Late September--Early December
High count: 100, 12 November 1986

Hooded Merganser--fairly common migrant, occasional winter resident

Late October--Late March
High count: 25, 12 November 1989

Common Merganser--fairly common migrant, occasional winter resident

Mid-November--Mid-March
High count: 45, 26 February 1988

Red-breasted Merganser--common migrant

Mid-February--Late April
Late October--Mid-December
High count: 400, 23 March 1986

Turkey Vulture--common migrant, summer resident, rare in winter

Late February--Late October
High count: 9, 19 September 1987

Sharp-shinned Hawk*--rare migrant, winter resident

Three records: 1, 28 December 1986 (LBH); 1, 17 January 1987; 1, 4 November 1989

Cooper's Hawk*--rare migrant, winter resident

Two records: 1, 27 August 1987 (LBH); 1, 29 November 1989

Red-tailed Hawk--fairly common resident (1989 nest in Lakeview Park, LBH)

Red-shouldered Hawk*--rare migrant

One record: 28 December 1986 (LBH)

Rough-legged Hawk--rare migrant, winter resident

Three records: 1, 9 April 1986; 1, 28 December 1986 (LBH); 1, 24-28 February 1989

Bald Eagle***--uncommon migrant, winter resident

Late August--Early April (total of 55 sightings of 1-6 individuals)
High count: 6, 24-25 February 1988

Northern Harrier*--uncommon migrant

Early February--Late March (LBH)
Mid-September--Mid-October

Osprey*--common migrant, rare summer visitor

Late March--Early May
Late August--Late October
High counts: 4, 2 October 1986; 4, 18 September 1987

American Kestrel--uncommon migrant (LBH)

Northern Bobwhite--fairly common resident (nest located summer 1988, LBH)

Ring-necked Pheasant--fairly common resident (LBH)

King Rail--rare migrant

One record: 1, 27 April 1989 (LBH)

Sora--uncommon migrant

Mid-April--Early May (LBH)
Late August--October (LBH)

American Coot--common migrant

Early February--Mid-May
Late September--Late November
High count: 400, 2 November 1986

American Avocet--rare migrant

One record: 2, 29 April 1986 (S.R.Steele, LBH)

Lesser Golden Plover--rare migrant

Three records: 95, 6 October 1984 (LBH); 23, 12 October 1984 (LBH); 1, 9 April 1986 (LBH)

Black-bellied Plover--rare migrant

Two records: 1, 20 September 1984 (LBH); 1, 12 October 1984 (LBH)

Semipalmated Plover--uncommon migrant

Late April--Late May (LBH)
Early August--Late September
High count: 3, 20 September 1986

Killdeer--common migrant, summer resident

Late February--Late October (one December record)
High count: 15, 13 September 1986

Common Snipe--uncommon migrant

Early--Late April (LBH)
Late October--Mid-November
High count: 9, 4 November 1989

Short-billed Dowitcher--rare migrant

Two records: 3 April-14 May 1986 (LBH); 17-22 August 1989 (LBH)

Stilt Sandpiper--rare migrant

Two records: 3 April-14 May 1986 (LBH); 20 September 1986 (LBH)

Greater Yellowlegs--uncommon migrant

One spring record: 26 April 1986 (LBH)
Early August--Early November
High counts: 2, 10-20 September 1986; 2, 4 November 1989

Semipalmated Sandpiper--fairly common migrant

Two spring records: 20 April 1986 (LBH); 1 June 1986 (LBH)
Early August--Late September
High count: 8, 10 September 1986

Western Sandpiper--rare fall migrant

No spring records
Two records: 1-5, 10-20 September 1986 (RBr, LBH);
1, 8 November 1988

Herring Gull--fairly common migrant, winter resident

Late September--Late March
High count: 25, 3 December 1985

Ring-billed Gull--common migrant, winter resident

Late August--Early May
High count: 500, 4-12 March 1986

Franklin's Gull--rare fall migrant

Two records: 1, 16 November 1985; 1, 12-18 November 1988

Bonaparte's Gull--fairly common migrant

Early March--Late April
Late September--Late December
High count: 25, 29 October 1988

Forster's Tern*--uncommon migrant

Mid-April--Early May
Late August--Late October
High count: 8-10, 5 May 1985 (LBH)

Common Tern*--uncommon migrant

Early April--Early May
Early-Late September
High count: 16, 9 May 1989

Caspian Tern--uncommon migrant

One spring record: 23 April 1989 (LBH)
Early August--Early October
High count: 5, 15 September 1989

Black Tern*--uncommon migrant

One summer record: 2, 7 June 1988
Early-Late September
High counts: 2, 10 September 1986; 2, 7 June 1988

Mourning Dove--common resident

Yellow-billed Cuckoo--uncommon migrant, summer resident

Early May--Mid-October

Great Horned Owl--rare resident

Two records: 2, 7 September 1986; 1, 14 March 1990

Barred Owl--uncommon resident

Three records: 1, 7 September 1986; 1, 20 September 1986;
1, 28 September 1986

Short-eared Owl*--rare migrant

One record: 8-13 November 1988

Whip-poor-will--rare migrant, summer resident

One record: 1, 17 April 1985

Common Nighthawk--uncommon migrant, summer resident

High count: 20, 21 September 1989

Chimney Swift--fairly common migrant, summer resident

Mid-April--Mid-October
High count: 100, 20 September 1989

Ruby-throated Hummingbird--uncommon migrant, summer resident

Belted Kingfisher--common resident

Northern Flicker--common summer resident, rare winter resident

Pileated Woodpecker--rare resident (nested in Lakeview Park 1977-1984, LBH)

Three records: 1, 28 September 1986; 1, 17 January 1987; 1, 14 March 1987

Red-bellied Woodpecker--common resident

Red-headed Woodpecker--common resident

High count: 12, 28 September 1986

Yellow-bellied Sapsucker--fairly common migrant (LBH)

Hairy Woodpecker--uncommon resident (LBH)

Downy Woodpecker--common resident

Eastern Kingbird--fairly common migrant, summer resident

Late April--Early September (LBH)

Great-crested Flycatcher--fairly common migrant, summer resident

Late April--Early September (LBH)

Eastern Phoebe--uncommon migrant, summer resident

Late March--Mid-October

Acadian Flycatcher--fairly common migrant, summer resident

Early May--Mid-August (LBH)

Least Flycatcher--uncommon migrant

Early May--Late May (LBH)
Late August--Late September (LBH)

Eastern Wood Pewee--fairly common migrant, summer resident

Olive-sided Flycatcher--rare migrant

One record: 1, 29 August 1989 (LBH)

Tree Swallow--common migrant, summer resident

Mid-March--Late October
High count: 5000, 8 October 1985

Bank Swallow--fairly common migrant, summer resident

Late April--Late August (LBH)

Rough-winged Swallow--fairly common resident

Late March--Late September
High count: 12, 27 September 1986

Barn Swallow--common migrant, summer resident

Early April--Mid-October
High count: 40, 30 September 1985

Cliff Swallow--uncommon migrant

Early May--Mid-May (one March record; 1, 29 March 1987)
Early August--Mid-October
High count: 30, 13 September 1986

Purple Martin--uncommon migrant, summer resident

Early April--Late August (LBH)
High count: 7, 6 April 1987

Blue Jay--common resident

High count: 10, 1 October 1985

American Crow--common resident

High counts: 8, 21 October 1984; 8, 4 March 1987

Carolina Chickadee--common resident

Tufted Titmouse--common resident

White-breasted Nuthatch--common resident

Red-breasted Nuthatch--uncommon migrant, winter resident

Mid-September--Early May (LBH)

Brown Creeper**--uncommon migrant, winter resident, rare summer resident (nest at Lakeview Park, 1980, LBH)

Early October--Late April

House Wren--common migrant, summer resident

Mid-April--Mid-October (LBH)

Winter Wren--rare migrant

One record: 1, 29 September 1984

Bewick's Wren*--rare migrant

One record: 6-20 April 1986 (LBH)

Carolina Wren--(increasingly) common resident

Northern Mockingbird--fairly common summer resident, rare winter resident

Gray Catbird--common migrant, summer resident

Brown Thrasher--common migrant, summer resident

American Robin--common migrant, summer resident

Early March--Early November

Wood Thrush--common migrant, summer resident

Late April--Late September (LBH)

Hermit Thrush--uncommon migrant

Early April--Early May (LBH)
Early October--Late October (LBH)

Swainson's Thrush--common migrant

Early May--Late May (LBH)
Early September--Late September (LBH)

Gray-cheeked Thrush--fairly common migrant

Early May--Late May (LBH)
Mid-September--Late September (LBH)

Veery**--fairly common migrant

Early May--Late May (LBH)
Early-Mid September (LBH)

Eastern Bluebird--uncommon migrant and summer resident, rare winter resident

Early April--Early November
One winter record: 2, 20 January 1988

Blue-gray Gnatcatcher--fairly common migrant, summer resident

Mid-April--Early September (LBH)
High count: 6, 12 April 1985

Golden-crowned Kinglet--migrant, rare winter resident

Late March--Mid-April (LBH)
Early October--Mid-November (LBH)

Ruby-crowned Kinglet--fairly common migrant

Early April--Mid-May (LBH)
Late September--Early November

Water Pipit--rare migrant (LBH)

Cedar Waxwing--uncommon, erratic migrant and resident

High count: 35, 16 September 1985

European Starling--common resident

White-eyed Vireo--fairly common migrant, summer resident

Late April--Mid-September (LBH)

Yellow-throated Vireo--fairly common migrant, summer resident

Late April--Mid-September (LBH)

Solitary Vireo--uncommon migrant

Late April--Mid-May (LBH)
Late September--Mid-October (LBH)

Red-eyed Vireo--common migrant, summer resident

Late April--Early October (LBH)

Philadelphia Vireo--uncommon migrant

Early May--Late May (LBH)
Mid-September--Early October (LBH)

Warbling Vireo--fairly common migrant, summer resident

Late April--Mid-September (LBH)

Black-and-White Warbler--fairly common migrant

Late April--Mid-May (LBH)
Late August--Early October (LBH)

Prothonotary Warbler--fairly common migrant, summer resident

Late April--Mid-August

Worm-eating Warbler--rare migrant, summer resident (nested at Lakeview Park 1972, LBH)

Late April--Mid-August (LBH)

Golden-winged Warbler--fairly common migrant

Early May--Mid-May (LBH)
Late August--Mid-September (LBH)

Blue-winged Warbler--uncommon spring migrant, rare fall migrant

Late April--Late May (LBH)
One fall record: 3 September 1989 (LBH)

Tennessee Warbler--common migrant

Late April--Late May (LBH)
Late August--Mid-October (LBH)

Orange-crowned Warbler--rare spring migrant, uncommon fall migrant

Late April--Early May (LBH)
Late September--Late October (LBH)

Nashville Warbler--fairly common migrant

Late April--Mid-May (LBH)
Early September--Mid-October (LBH)

Northern Parula--uncommon migrant, summer resident

Mid-April--Late September (LBH)

Yellow Warbler--fairly common migrant, summer resident

Late April--Late August (LBH)

Magnolia Warbler--fairly common migrant

Early May--Late May (LBH)
Late August--Early October (LBH)

Cape May Warbler--uncommon migrant

Early May--Mid-May (LBH)
Early September--Late September (LBH)

Black-throated Blue Warbler--rare spring migrant, uncommon fall migrant

One spring record: 10 May 1989 (LBH)
Early September--Late September (LBH)

Yellow-rumped Warbler--common migrant

Early April--Mid-May (LBH)
Mid-September--Early November

Black-throated Green Warbler--fairly common migrant

Late April--Mid-May (LBH)
Early September--Mid-October
High count: 8, 30 September 1984

Cerulean Warbler--uncommon migrant, summer resident

Late April--Late August (LBH)

Blackburnian Warbler--fairly common migrant

Early--Mid-May (LBH)
Late August--Late September (LBH)

Yellow-throated Warbler--uncommon migrant, summer resident

Mid-April--Mid-September (LBH)

Chestnut-sided Warbler--fairly common migrant

Early May--Mid-May (LBH)
Late August--Late September (LBH)

Bay-breasted Warbler--uncommon spring migrant, common fall migrant

Mid-May--Late May (LBH)
Early September--Early October (LBH)

Blackpoll Warbler--fairly common spring migrant, uncommon fall migrant

Early May--Late May (LBH)
Early September--Late September (LBH)

Palm Warbler--fairly common migrant

Late April--Mid-May (LBH)
Late September--Mid-October (LBH)

Ovenbird--fairly common migrant, uncommon summer resident

Late April--Early October (LBH)

Northern Waterthrush--fairly common migrant

Late April--Mid-May (LBH)
Late August--Late September (LBH)

Louisiana Waterthrush--uncommon migrant, summer resident

Mid-April--Late July (LBH)

Kentucky Warbler--uncommon migrant, summer resident

Early May--Mid-August (LBH)

Mourning Warbler--uncommon spring migrant, rare fall migrant

Mid-May--Late May (LBH)
Late August--Early September (LBH)

Common Yellowthroat--fairly common migrant and summer resident

Late April--Early October (LBH)

Yellow-breasted Chat--uncommon migrant and summer resident

Early May--Mid-July (LBH)

Hooded Warbler--rare migrant

One recent record: 27 April 1989 (LBH)
Several April--May records at Lakeview Park during 1970's (LBH)

Wilson's Warbler--fairly common migrant

Early May--Late May (LBH)
Late August--Late September (LBH)

Canada Warbler--fairly common migrant

Mid-May--Late May (LBH)
Late August--Mid-September (LBH)

American Redstart--common migrant, uncommon summer resident

Early May--Late May (LBH)
Late August--Early October (LBH)

House Sparrow--common resident

Eastern Meadowlark--fairly common migrant and summer resident, rare winter resident

Mid-February--Early December (LBH)

Red-winged Blackbird--common migrant and summer resident, rare winter resident

Late February--Late November
One winter record: 6, 4 February 1986
High count: 75, 10 September 1986

Orchard Oriole--fairly common migrant and summer resident

Late April--Late July (LBH)

Northern Oriole--fairly common migrant and summer resident

Late April--Early September (LBH)

Common Grackle--common migrant and summer resident, rare winter resident

Late February--Early December (LBH)
One winter record: 40, 4 February 1986
High count: 1000, 8 October 1985

Brown-headed Cowbird--fairly common migrant and summer resident

Early March--Late October (LBH)

Scarlet Tanager--fairly common migrant and summer resident

Late April--Late September (LBH)

Summer Tanager--uncommon migrant and summer resident

Early May--Early September (LBH)

Northern Cardinal--common resident

Rose-breasted Grosbeak--common migrant, fairly common summer resident

Blue Grosbeak--(recent) rare migrant and summer resident

Mid-May--Mid-August, 1988 and 1989 (LBH)

Indigo Bunting--common migrant and summer resident

Late April--Early October (LBH)

Dickcissel--uncommon migrant and summer resident

Early May--Late August (LBH)

Evening Grosbeak--rare winter migrant

One record: 3, 16 December 1985

Purple Finch--fairly common migrant and irregular winter resident

Mid-October--Early May (LBH)

House Finch--(increasingly) common resident since 1984

Pine Siskin--irregular migrant and winter resident

Late October--Early May (LBH)

American Goldfinch--fairly common summer resident, uncommon winter resident

High count: 10, 13 September 1986

Rufous-sided Towhee--fairly common migrant and summer resident

Mid-March--Late October (LBH)

Savannah Sparrow--uncommon migrant

Early April--Mid-May (LBH)
Early September--Mid-October (LBH)

Dark-eyed Junco--common migrant and winter resident

Early October--Late April (LBH)
High count: 8, 16 November 1985

American Tree Sparrow--fairly common migrant and winter resident

Early November--Late March
High counts: 10, 8 November 1988; 10, 4 January 1989; 10, 9 March 1989

Chipping Sparrow--fairly common migrant and summer resident

Early April--Late October
High count: 10, 30 September 1985

Field Sparrow--fairly common migrant and summer resident

Mid-March--Late October

White-crowned Sparrow--fairly common migrant, uncommon winter resident

Early May--Mid-May (LBH)
Mid-October--Late November (LBH)

White-throated Sparrow--fairly common migrant, uncommon winter resident

Early April--Mid-May (LBH)
Late September--Mid-November (LBH)

Fox Sparrow--uncommon migrant

Early March--Early April (LBH)
Early October--Early November (LBH)

Lincoln's Sparrow--uncommon migrant

Early May--Mid-May (LBH)
Early October--Late October (LBH)

Swamp Sparrow--fairly common migrant, rare winter resident

Late March--Mid-May (LBH)
Early October--Mid-November (LBH)

Song Sparrow--fairly common resident

High count: 4, 4 November 1989

APPENDIX H

Charleston Side-Channel Reservoir
Proposed Watershed Zoning Additions
and Amendments to Existing Rules and Regulations

CITY OF CHARLESTON, ILLINOIS

WATER TREATMENT PLANT

CHARLESTON SIDE CHANNEL RESERVOIR

PROPOSED WATERSHED ZONING ADDITIONS

AND AMENDMENTS TO EXISTING RULES AND REGULATIONS

MARCH 19, 1990

INTRODUCTION

The need for additional zoning laws and regulations to the current City of Charleston Zoning rules is very apparent. With the Clean Water Act 314 Grant that was received by the City of Charleston for watershed study, items became apparent that need attention. Finding information and zoning rules and regulations that accumate to our reservoir has been a trying task. The following information came from combinations of ordinances and sample ordinances from the Section 208 of the Water Quality Amendments of 1972 (PL92-500). The ordinances provide a means by which the City can assure that the site planning and development takes potential erosion, sedimentation, logging, and chemical problems into account and includes effective measures for their control. While the principal intent of the ordinance is preventive, they also include provisions for enforcement action where this becomes necessary. The ordinances are similar to many others from planning aids of the Northeastern Illinois Planning Commission and the Southwestern Illinois Metropolitan and Regional Planning Commission and were adopted from models set up by those agencies. I submit these zoning ordinances, rules and regulations, and zoning amendments for comment and consideration to: The Charleston City Council

City of Charleston Administrative Officers:

Building and Zoning Officer Jeff Finley
City Engineer Mark Dwiggins
City Clerk Patsy Loew
Assistant to the Mayor Clement Assarre
Charleston Building and Zoning Committee

Sincerely,

Dick Sherman
Charleston Water Superintendent

AN ORDINANCE PROVIDING FOR THE CONTROL OF SOIL EROSION AND SEDIMENTATION, PESTICIDE AND HERBICIDE CONTROL, AND LOGGING FROM EXISTING AREAS AND AREAS UNDERGOING DEVELOPMENT

ORDINANCE

ARTICLE I
FINDINGS AND PURPOSE

A. Findings

The City Council of the City of Charleston hereby finds that:

1. Excessive quantities of soil may erode from areas undergoing development for certain non-agricultural uses including but not limited to the construction of dwelling units, commercial buildings and industrial plants, the building of roads and highways, and the creation of recreational facilities;

2. The washing, blowing, and falling of eroded soil across and upon roadways endangers the health and safety of users thereof by decreasing vision and reducing traction of road vehicles;

3. Soil erosion necessitates the costly repairing of gullies, washed-outs fills, and embankments;

4. Sediment from soil erosion tends to clog sewers and ditches and to pollute and silt rivers, streams, lakes, and reservoirs;

5. Sediment limits the use of water and waterways for most beneficial purposes, promotes the growth of undesirable aquatic weeds, destroys fish and other desirable aquatic life, and is costly and difficult to remove;

6. Sediment reduces the channel capacity of waterways, resulting in increased chances of flooding at risk to public health and safety;

7. Pesticides may wash from private lands and accumulate in the streams and waterways of the reservoir watershed. Some of these are very hazardous, costly and difficult to remove from the potable drinking water supply;

8. Herbicides may kill wanted ground cover used to control erosion and wash from private lands to pollute the streams and waterways of the reservoir watershed. Many of these herbicides are very hazardous, costly and difficult to remove from the potable drinking water supply;

9. The commercial logging of timber in forested land of the watershed could cause sediment and soil erosion at a much accelerated rate causing sedimentation of the Charleston Side Channel Reservoir to increase and the supply of water in the reservoir to decrease.

B. Purpose

The City Council therefore declares that the purpose of this ordinance is to safeguard persons, protect property, prevent damage to the environment, and promote the public welfare by guiding, regulating and controlling the use of pesticides and herbicides, the design, construction, use and maintenance of any development or other activity which disturbs or breaks the topsoil or otherwise results in the movement of earth on land situated in the Charleston Side Channel Reservoir Watershed.

ARTICLE II
DEFINITIONS

For the purposes of this Ordinance certain terms used herein are defined as set forth below:

BUILDING PERMIT means a permit issued by the City of Charleston for the construction, erection or alteration of a structure or building.

BZAP means Charleston Board of Zoning Appeals and Planning.

CERTIFY OR CERTIFICATION means formally attesting that the specific inspections and tests where required have been performed, and that such tests comply with the applicable requirements of this Ordinance.

CITY means the City of Charleston, Coles County, Illinois

CUBIC YARDS means the amount of material in excavation and/or fill measured by the method of "average and areas."

EXCAVATION means any act by which organic matter, earth, sand, gravel, rock or any other similar material is cut into, dug, quarried, uncovered, removed, displaced, relocated or bulldozed and shall include the conditions resulting therefrom.

EXISTING GRADE means the vertical location of the existing ground surface prior to excavation or filling.

FILL means any act by which earth, sand, gravel, rock, or any other material is deposited, placed, replaced, pushed, dumped, pulled, transported or moved by man and/or equipment to a new location and shall include the conditions resulting therefrom.

FINAL GRADE means the vertical location of the ground or pavement surface after the grading work is completed in accordance with the site development plan.

GRADING means excavation or fill or any combination thereof and shall include the conditions resulting from any excavation or fill.

HERBICIDE means any chemical or chemical compound used for the control or removal of vegetation.

ILLINOIS DEPT. OF CONSERVATION (DIV. OF FORESTRY) PERMIT means any permit issued by the Illinois Dept of Conservation (Div. of Forestry) for pre-restoration of the forest, soil, and topography of any specific area.

NATURAL DRAINAGE means channels formed in the existing surface topography of the earth prior to changes made by unnatural causes.

LOGGING means the cutting and removal of trees for commercial sale.

PARCEL means all contiguous land in one ownership.

PERMITTEE means any person to whom a site development permit is issued.

PERSON means any individual, firm or corporation, public or private, the State of Illinois and its agencies or political subdivisions, and the United States of America, its agencies and instrumentalities, and any agent, servant, officer or employee of any of the foregoing.

PESTICIDES mean any chemical or chemical compound used for the extermination or control of insects, vermin, etc..

REMOVAL means cutting vegetation to the ground or stumps, complete extraction, or killing by spraying.

SITE means a lot or parcel of land, or a contiguous combination thereof, where grading work is performed as a single unified operation.

SITE DEVELOPMENT means altering terrain and/or vegetation and constructing improvements.

SITE DEVELOPMENT PERMIT means a permit issued by the City of Charleston for the construction or alteration of ground improvements and structures for the control of erosion, run-off and grading.

STRIPPING means land on which there are no structures or only structures which are secondary to the use or maintenance of the land itself.

ARTICLE III
GENERAL PRINCIPLES

It is the objective of this ordinance to control soil erosion, sedimentation, and chemical pollutants caused by development/restoration activities in the Charleston Side Channel Reservoir Watershed. Measures taken to control erosion and sedimentation should be adequate to assure that sediment is not transported from the site by a storm event of ten-year frequency or less. The following principles shall apply to all development activities within the Charleston Side Channel Reservoir Watershed and to the preparation of the submissions required under Article IV of this ordinance:

1. Development shall be related to the topography and soils of the site so as to create the least potential for erosion. Areas of steep slopes where high cuts and fills may be required shall be avoided wherever possible, and natural contours shall be followed as closely as possible.

2. Natural vegetation shall be retained and protected wherever possible. Areas immediately adjacent to natural watercourses shall be left undisturbed wherever possible.

3. Logging of trees shall be with the approval and recommendation of the Illinois Conservation Department Division of Forestry. A written site-restoration plan shall be completed and accepted by the Illinois Conservation Department Division of Forestry and the City of Charleston Building and Zoning officer. All trees for logging shall be marked by the Illinois Department of Conservation Division of Forestry.

4. The smallest practical area of land shall be exposed for the shortest practical time during development.

5. Sediment basins, debris basins, desilting basins, or silt traps or filters shall be installed and maintained to remove sediment from run-off waters from land undergoing development.

6. The selection of erosion and sedimentation control measures shall be based on assessment of the probable frequency of climatic and other events likely to contribute to erosion, and on evaluation of the risks, costs, and benefits involved.

7. In the design of erosion control facilities and practices, aesthetics and the requirements of continuing maintenance shall be considered.

8. Provision shall be made to accommodate the increased run-off caused by changed soil and surface conditions during and after development. Drainageways shall be designed so that their final gradients and the resultant velocities of discharges shall not create additional erosion.

9. Permanent vegetation and structures shall be installed as soon as practical during development.

10. Chemicals used for pesticide protection and herbicide control shall meet all applicable permits of the Illinois Environmental Protection Agency (for watersheds), the Illinois Department of Conservation, the City of Charleston, and all other applicable agencies. (<u>This includes all areas regardless of type of zoning</u>)

11. Rates of application for chemicals used for pesticide protection and herbicide control shall be approved by the Illinois Department of Conservation.

12. Each site using chemicals shall prepare a site plan and apply to the City of Charleston Department of Zoning and Building office for permit prior to use of chemicals.

13. Permits shall be required for logging in the watershed area. Permits shall be picked up and returned to the office of the City of Charleston Building and Zoning officer.

14. The property owner shall have approved a site-restoration plan approved by the Illinois Department of Conservation and the City of Charleston Building and Zoning Office prior to commercial timber logging.

15. Trees to be removed for commercial use shall be marked for removal by the Illinois Department of Conservation (Division of Forestry).

16. Logging contractors shall be properly registered and approved by the Illinois Department of Conservation (Division of Forestry)

17. The property owner (and/or) logging contractor shall be bonded to cover potential restoration costs. (With permit)

18. Inspections shall be made of the logging site by Illinois Department of Conservation and City of Charleston personnel before, during, and after logging operations.

19. Sub-division logging-tree removal shall require same as above.
(13-19)

20. No commercial logging shall be permitted in Residential zoned areas.

21. All deviations from these requirements shall be approved by the City Building and Zoning Officer prior to the issuance of the permit.

ARTICLE IV
SITE DEVELOPMENT PERMIT

A. Permit Required

Except as otherwise provided in this ordinance, no person shall commence or perform any grading, stripping, excavating, or filling of land, cut trees (logging), use any type of pesticide or herbicide, and replace, install, or renovate any existing septic system, without having first obtained a site development permit from the Building and Zoning Department of the City of Charleston.

B. Exceptions

A permit shall not be required for any of the following:

1. Development of a site of less than 5 acres for one single family home; provided that the person responsible for any such development shall implement necessary erosion, sedimentation, logging, and chemical protection measures to satisfy the principles set forth in Article III of this ordinance;

2. Excavation below final grade for the basement and footings of one single-family residence and appurtenant structures on a site in excess of five acres for which a building permit has been issued by the City of Charleston.

3. Agricultural use of land, including the implementation of conservation measures included in a farm conservation plan approved by the Soil And Water Conservation District, and including the construction of agricultural structures.

C. Application for Permit

Application for a site development permit shall be made by the owner of the property or his authorized agent to the City of Charleston Building and Zoning Officer on a form furnished for that purpose. Each application shall have the name(s) and address(es) of the owner or developer of the site and of any consulting firm retained by the applicant together with the name of the applicant's principal contact at such firm. Each application shall be signed by a licensed professional engineer and shall be accompanied by a filing fee of $______________. Each application shall include certification that any chemical application, land clearing, construction, or development involving the movement of earth shall be in accordance with the plans approved upon issuance of the permit.

D. Submissions

Each application for a site development permit shall be accompanied by the following information:

1. A vicinity map in sufficient detail to enable easy location in the field of the site for which the permit is sought, and including the boundary line and approximate acreage of the site, existing zoning, and a legend and scale.

2. A development plan of the site showing:

a. Existing topography of the site and adjacent land within approximately 100 feet of the boundaries, drawn at no greater than two-foot contour intervals and clearly portraying the conformation and drainage pattern of the area, at a scale of not less than one inch equals fifty feet (1"=50'), except in the case of sites larger than fifty (50) acres in which case the plan shall be to a scale of not less than one inch equals one hundred feet (1"=100')

b. The location of existing buildings, structures, utilities, water bodies, flood plains, drainage facilities, vegetative cover, paved areas and other significant natural or man-made features on the site and adjacent land within approximately 100 feet of the boundary.

c. A general description of the predominant soil types on the site, their location, and their limitations for the proposed use.

d. Proposed use of the site, including present development and planned utilization; areas of excavation, grading, and filling; proposed contours, finished grades, and street profiles; provisions for storm drainage, including the control of accelerated run-off, with a drainage area map and computations; kinds and locations of utilities; and areas and acreages proposed to be chemically treated, logged, paved, covered, sodded or seeded, vegetatively stabilized, or left undisturbed.

3. An erosion and sedimentation control plan showing:

a. All erosion and sedimentation control measures necessary to meet the objectives of this ordinance throughout all phases of construction and permanently after completion of development of the site.

b. Seeding mixtures and rates, types of sod, method of seedbed preparation, expected seeding dates, type and rate of lime and fertilizer application, and kind and quantity of mulching for both temporary and permanent vegetative control measures.

c. Provisions for maintenance of control facilities, including easements and estimates of the cost of maintenance.

Lesser Yellowlegs--fairly common migrant

One spring record: 3 April-23 May 1986 (LBH)
Early August--Early November
High count: 12, 30 September 1985

Solitary Sandpiper--uncommon migrant

One spring record: 9 April-14 May 1986 (LBH)
Early August--Mid-October
High count: 2, 10 October 1985

Spotted Sandpiper--fairly common migrant and summer resident

Mid-April--Late October
High count: 15, 7 September 1986

Dunlin--uncommon migrant

One spring record: 8 May-14 May 1986 (LBH)
Early October--Early December
High count: 11, 6-12 November 1988

Sanderling--rare migrant

Three records: 4-15 August 1984 (LBH); 20 September 1986 (LBH); 2, 30 August 1989

Pectoral Sandpiper--fairly common migrant

Two spring records: 14 May 1986 (LBH); 4 April 1989 (LBH)
Early August--Early November
High count: 12, 10 September 1986

White-rumped Sandpiper--rare migrant

Two records: 7, 23 May 1986 (LBH); 1, 29 May 1986 (LBH)

Baird's Sandpiper--rare migrant

One record: 2-5, 9-20 September 1986 (RBr, LBH)

Least Sandpiper--fairly common migrant

Two spring records: 11 April 1986 (LBH); 5, 23 May 1986 (LBH)
Early August--Early November
High count: 4, 30 September-10 October 1985

d. Identification of the person(s) or entity which shall have legal responsibility for maintenance of erosion control structures and measures after development is completed.

4. The proposed phasing of development of the site, including stripping and clearing, rough grading and construction, and final grading of landscaping. Phasing shall identify the expected date on which clearing, chemical treatment, logging shall begin, the estimated duration of exposure of cleared areas, and the sequence of clearing, chemical treatment, and/or logging, and the installation of temporary sediment control measures, installation of storm drainage, paving streets and parking areas, and establishment of permanent vegetative cover.

These submissions shall be prepared in accordance with the standards and requirements contained in"Procedures and Standards for Urban Soil Erosion and Sedimentation Control in Illinois" prepared by the Northeastern Illinois Soil Erosion and Sedimentation Control Steering Committee and adopted by the Coles County Soil and Water Conservation District, which standards and requirements are hereby incorporated into this ordinance by reference.

The City of Charleston may waive specific requirements for the content of submissions upon finding that the information submitted is sufficient to show that the work shall comply with the objectives and principles of this ordinance.

E. Bonds

The applicant shall be required to file with the City of Charleston a faithful performance bond or bonds, letter of credit, or other improvement security satisfactory to the City of Charleston Attorney in an amount deemed sufficient by the City of Charleston to cover all costs of improvements, landscaping, maintenance of improvements and landscaping, and chemical clean-ups for such period as specified by the City of Charleston, and engineering and inspection costs to cover the cost of failure or repair of improvements installed on the site. This provision may be waived by the City Engineer in the case of minimal property distrurbance.

F. Review and Approval

Each application for a site development permit shall be reviewed and acted upon according to the following procedures:

1. The City of Charleston shall review each application for a site development permit to determine its conformance with the provisions of this ordinance. The City of Charleston may also refer any application to the Coles County Soil and Water Conservation District, Illinois Department of Conservation (Division of Forestry), and\or any other local government or public agency within whose jurisdiction the site is located for review and com-

ment. Within a reasonable time after receiving an application, the City of Charleston shall in writing, (a) approve the permit application if it is found to be in conformance with the provisions of this ordinance, and issue the permit; (b) approve the permit application subject to such reasonable conditions as may be necessary to secure substantially the objectives of this ordinance, and issue the permit subject to these conditions; or (c) disapprove the permit application, indicating the deficiencies and the procedure for submitting a revised application and/or submission.

2. No site development permit shall be issued for a proposed development site unless:

a. The development, including but not limited to subdivisions and planned unit development, has been approved by the City of Charleston where applicable, or

b. Such permit is accompanied by or combined with a valid building permit issued by the City of Charleston, or

c. The proposed earth moving, logging, chemical use is coordinated with any overall development program previously approved by the City of Charleston for the area in which the site is situated. Provided all of the new rules and regulations are met in the previously approved program.

G. Appeals

The applicant, or any person or agency which received notice of the filing of the application, may appeal the decision of the City of Charleston as provided in paragraph F(3) of this Article IV, to BZAP. Upon receipt of an appeal, BZAP shall schedule and hold a public hearing. Notice of not more than thirty days and not less than 15 days shall be given. Said notice shall be published on the legal notice section of the local newspaper. The Charleston Zoning Board shall render a decision within thirty (30) days after the concussion of the hearing. Factors to be considered on review shall include, but need not be limited to, the effects of the proposed development on the surface water flow to tributary and downstream lands, any comprehensive watershed management plans, or the use of any retention facilities; possible saturation of fill and unsupported cuts by water, both natural and domestic; run-off surface waters that produce erosion and silting of drainageways; nature and type of soil or rock which when disturbed by the proposed development activities may create earth movement and produce slopes that cannot be landscaped;; excessive and unnecessary scarring of the natural landscape through grading or removal of vegetation; logging which would contribute to the erosion of soil; and chemical use which may leach into the waterways and reservoir of the City of Charleston whereby adversely effecting the potable drinking water of the City.

H. Retention of Plans

Plans, specifications, and reports for all site developments shall be retained in original form or on microfilm by the City of Charleston.

ARTICLE V
OPERATION STANDARDS AND REQUIREMENTS

A. Applicability

All grading, stripping, excavating, and filling which is subject to the permit requirements of this ordinance, and any grading, stripping, excavating and filling which is exempted from the permit requirement by paragraph B(1) of Article IV, shall be subject to the applicable standards and requirements set forth in this Article V.

B. Responsibility

The permittee shall not be relieved of responsibility for damage to persons or property otherwise imposed by law, and the City of Charleston or its officers or agents shall not be made liable for such damage, by (1) the issuance of a permit under this ordinance, (2) compliance with the provisions of that permit or with conditions attached to it by the City of Charleston, (3) failure of the City of Charleston officials to observe or recognize hazardous or unsightly conditions, (4) failure of City of Charleston officials to recommend denial of or to deny a permit, or (5) exemptions from the permit requirements of this ordinance, or (6) as prescribed by the Local Government and governmental Employees Tort Immunity Act.

C. Handbook Adopted by Reference

The standards and specifications contained in "Procedures and Standards for Urban Soil Erosion and Sedimentation Control in Illinois," cited in paragraph D of Article IV, are hereby incorporated into this Article V and made a part hereof by reference for the purpose of delineating procedures and methods of operation under site development and erosion and sedimentation control plans approved under Article IV. In the event of conflict between provisions of said manual and of this ordinance, the ordinance shall govern.

D. Inspection

The City of Charleston shall make inspections as hereinafter required and shall either approve that portion of work completed or shall notify the permittee wherein the work fails to comply with the site development or erosion, sedimentation, logging, or chemical use control plan as approved. Plans for grading, stripping, excavating, filling work, logging, and/or chemical treatment bearing the stamp of approval of the City of Charleston shall be maintained at the site during progress of the work. In order to obtain inspections, the permittee shall notify the City of Charleston at least two (2) working days before the completion of:

1. Start of work

2. Stripping and clearing
3. Rough grading
4. Final grading
5. Final landscaping
6. Final chemical application

If stripping, clearing, grading, logging, or chemical applications are to be done in phases or areas, the permittee shall give notice and request inspection at the completion of each of the above work stages in each phase or area. Results of inspections shall be given within a reasonable time. Permitee may continue work at the permitee's own risk with the permission of the City Engineer prior to written results of the inspection being available.

E. Special Precautions

1. If at any stage of the grading of any development site the City of Charleston determines by inspection that the nature of the site is such that further work authorized by an existing permit is likely to imperil any property, public way, watercourse or drainage structure, the City of Charleston may require, as a condition of allowing the work to be done, that such reasonable special precautions to be taken as is considered advisable to avoid the likelihood of such peril. "Special precautions" may include, but shall not be limited to, a more level exposed slope, construction of additional drainage facilities, berms, terracing, compaction, or cribbing, installation of plant materials for erosion control, and recommendations of a registered soils engineer and/or engineering geologist which may be made requirements for further work. (Costs to be incurred on developer)

2. Where it appears that storm damage may result because the grading on any development site is not complete, work may be stopped and the permittee required to install temporary structures or take such other measures as may be required to protect adjoining property or the public safety. On large developments or where unusual site conditions prevail, the City of Charleston Building and Zoning Officer may specify the time of starting grading and time of completion or may require that the operations be conducted in specified stages so as to insure completion of protective measures or devices prior to the advent of seasonal rains.

F. Amendment of Plans

Major amendments of the site development or erosion, sedimentation, logging, or chemical control plans shall be submitted to the City of Charleston and shall be processed and approved or disapproved in the same manner as the original plans. Field modifications of a minor nature may be authorized by the City of Charleston Building and Zoning Officer by written authorization to the permittee.

G. Expiration of Permit

Every site development permit shall expire and become null and void if the work authorized by such permit has not been commenced within one hundred and eighty (180) days, or is not completed by a date which shall be specified in the permit; except that the City of Charleston may, if the permittee presents satisfactory evidence that unusual difficulties have prevented work being commence or completed within the specified time limits, grant a reasonable extension of time if written application is made before the expiration date of the permit.

ARTICLE VI
ENFORCEMENT

A. Exceptions

BZAP may, in accordance with the following procedures, authorize exceptions to any of the requirements and regulations set forth in this ordinance:

1. Application for any exception shall be made by a verified petition of the applicant for a site development permit, stating fully the grounds of the petition and the facts relied upon by the applicant. Said petition shall be filed with the site development permit application. In order for the petition to be granted, it shall be necessary that the Charleston Zoning Board find all of the following facts with respect to the land referred to in the petition:

a. That the land is of such shape or size or is affected by such physical conditions or is subject to such title limitations of record that it is impossible or impractical for the applicant to comply with all of the requirements of this ordinance;

b. That the exception is necessary for the preservation and enjoyment of a substantial property right of the applicant; and

c. That the granting of the exception shall not be detrimental to the public welfare or injurious to other property in the vicinity of the subject property.

2. Each application for an exception shall be referred to the staff of the City of Charleston for review. The City of Charleston shall transmit its recommendations to the Zoning Board, which shall review such recommendations prior to granting or denying the exception.

3. The Zoning Board shall hold a public hearing on each application for exception, within 45 days after receiving application, in the manner provided with respect to appeals. After public hearing, BZAP may approve the site development permit application with the exceptions and conditions it deems necessary or it may disapprove such site development permit application and exception or it may take such other action as appropriate.

B. Stop-Work Order; Revocation of Permit

In the event any person holding a site development permit pursuant to this ordinance violates the terms of the permit, or carries on site development in such a manner as to materially adversely affect the health, welfare, or safety of persons residing or working in the neighborhood of the development site or so as to be materially detrimental to the public welfare or injurious to property or improvements in the neighborhood, the City of Charleston may suspend or revoke the site development permit.

1. Suspension of a permit shall be by a written stop-work order issued by the City of Charleston Building and Zoning Officer and delivered to the permittee or his agent or the person performing the work. The stop-work order shall be effective immediately, shall state the specific violations cited, and shall state the conditions under which work may be resumed. A stop-work order shall remain in effect until the next regularly scheduled meeting of the Charleston Zoning Board at which the conditions of sub-paragraph 2 can be met.

2. No site development permit shall be permanently suspended or revoked until a hearing is held by the Charleston Zoning Board. Written notice of such hearing shall be served on the permittee, either personally or by registered mail, and shall state:

a. the grounds for complaint or reasons for suspension of revocation, in clear and concise language;

b. the time when and place where such hearing shall be held.

Such notice shall be served on the permittee at least five (5) days prior to the date set for the hearing. At such hearing, the permittee shall be given an opportunity to be heard and may call witnesses and present evidence on his behalf. At the conclusion of the hearing the Charleston Zoning Board shall determine whether the permit shall be suspended or revoked.

C. Violations and Penalties

No person shall construct, enlarge, alter, repair, or maintain any grading, excavation or fill, or cause the same to be done, contrary to or in violation of any terms of this ordinance. Any person violating any of the provisions of this ordinance shall be deemed guilty or a misdemeanor, and each day during which any violation of any of the provisions of this ordinance is committed, continued, or permitted shall constitute a separate offense. Upon conviction of any such violation, such person, partnership or corporation shall be punished by a fine of not more that ($500) for each offense. In addition to any other penalty authorized by this section, any person, partnership, or corporation convicted of violating any of the provisions of this ordinance shall be required to restore the site to the condition existing prior to commission of the violation, or to bear the expense of such restoration.

D. Separability

The provisions and sections of this ordinance shall be deemed to be separable, and the invalidity of any portion of this ordinance shall not affect the validity of the remainder.

APPENDIX I

Charleston Side-Channel Reservoir
Diagnostic/Feasibility Study
Public Informational Meeting

Charleston Side-Channel Reservoir Diagnostic/Feasibility Study

Public Informational Meeting

March 7, 1992 - 1:00 p.m. - Charleston City Hall Council Chambers

Project Status Summary

PROJECT BACKGROUND

1) The study was conducted under a grant from the U.S. Environmental Protection Agency's (USEPA) Clean Lakes Program with the City of Charleston. Project costs were split equally between USEPA and the City of Charleston (City).

2) The USEPA portion was funded under the provisions of Section 314 of the Federal Clean Water Act.

3) The Clean Lakes Program grant is administered and overseen by the Illinois Environmental Protection Agency (IEPA).

4) The technical study was conducted by the City and Eastern Illinois University (EIU). Primary laboratory analyses were performed by the City, EIU, IEPA and the Illinois State Water Survey (ISWS). Additional laboratory analyses were performed by the University of Illinois at Urbana, IL, and Daily Analytical Laboratories of Peoria, IL.

5) Assistance for this study was provided by the USDA Soil Conservation Service (SCS) and Illinois Department of Conservation (IDOC).

6) Study period was May 1988 to October 1991.

7) Purpose of the study was to:
   - diagnose existing reservoir problems,
   - identify causes and sources for these problems,
   - evaluate alternatives for reservoir restoration and/or protection, and
   - assemble an implementation plan that safeguards the reservoir's future environmental and recreational qualities.

LAKE CHARLESTON (LC) AND CHARLESTON SIDE-CHANNEL RESERVOIR (CSCR) HISTORY

1) 1895, eight foot high channel dam constructed on Embarras River, near present day CSCR boat ramp.

2) 1947, completion of the Riverview Dam to form Lake Charleston. Lake Charleston was a 404 acre, 744 million gallon lake.

3) 1953, 1960, 1974, ISWS issued reports on the sedimentation problems of Lake Charleston.

4) 1974, close of Charleston beach due to high bacterial counts.

5) 1979 to 1982, construction and filling of CSCR. Reservoir was 346 acres and 1.199 billion gallons.

6) 1985 to present, sporadic taste and odor problems with potable water supply.

7) 1985, collapse of the spillway at Riverview Dam and emergency construction to protect the CSCR dike.

Diagnostic Study Overview

1) <u>Water Quality</u>

Table A
Surface Water Quality Data
Average of 1988 - 1990
(Units in mg/L)

	CSCR	4B+	5B++	LC
Transparency (inches)	15	-	-	10
Turbidity (NTU)	15.4	7.0	13	27
Total Suspended Solids	28.1	12.8	34.6	56.1
Volatile Suspended Solids	9.2	2.9	20.3	11.1
Nitrate/Nitrite-N	.11	.50	.52	6.86
Ammonia-N	.16	.14	.13	.20
Kjeldahl-N	1.54	-	-	-
Total Phosphorus	.144	.021	.126	.092
Dissolved Phosphorus	.026	.032	.054	.043
Total Alkalinity	134	325	339	202
pH (pH)	8.5	8.1	8.0	8.1
Chlorophyll A (ug/L)	72.45	-	-	-

\+ = 4B Ravine west shoreline deadwood of CSCR
++ = 5B Ravine north shoreline deadwood of CSCR

2) <u>Phytoplankton (algae)</u>

- Phytoplankton analysis suggests that the algae population was in a perpetual state of bloom. Frequently in warm weather months nuisance blue-green algae are the dominate species.

- These nuisance species and the decomposition products of other species emit odors and were responsible for the taste and odor problems of Charleston's drinking water.

3) <u>Macrophytes (rooted plants)</u>

- The combination of algae blooms and suspended inorganic matter have reduced the transparency of CSCR water. This shut out the needed light for submerged aquatic plants.

- Shoreline erosion defoliated large areas of CSCR shoreline.

- The two items above limited the amount of habitat available to fish and other aquatic animals.

4) <u>Bacteria</u>

- Testing started in June 1988 and ended in October 1989.

- Heterotrophs showed nothing unusual, and testing was discontinued after first year. (Range 200 to 10000/ml)

- Total Coliforms ranged from 100 to 3000/100ml, and testing was discontinued after first year.

- Fecal Coliforms (FC) were undetected in 30% of the tests. The single highest count was >400/100ml.

- Fecal Streptococci (FS) were undetected in 11% of the tests. Seven tests showed counts that exceeded 100/100ml.

- Highest FC & FS counts were found at site 5 (mouth of ravine northwest corner of CSCR). The source was probably agricultural rather than human contaminate.

- Testing of sample sites along the shore of the Lake Island tract was inconclusive.

- Results suggest that the bacteriological quality of the CSCR conforms to the 1987 IDPH criteria for bathing beaches.

5) <u>Fisheries</u>

- The IDOC conducts a biennial fish survey of the CSCR. Recent surveys have shown that white crappie are in poor condition and that the white crappie and gizzard shad are overpopulated.

- Each year the IDOC funds the stocking of channel catfish.

- Predator fish (hybrid striped and largemouth bass) were stocked to reduce the population of gizzard shad and to provide improved sport fishing. Funding came from the City, FishAmerica and the IDOC.

- IEPA performed fish tissue analysis on a carp sample from the CSCR. All monitored compounds were below the USDA action levels.

6) <u>Heavy Metals & Pesticides</u>

- The only metal to exceed the Public and Food Processing (PFP) water standard was Iron. CSCR samples have ranged from 150 to 900 ug/L with the PFP limit being 300 ug/L.

- No metals in CSCR samples exceeded the limits of the General Use water standards.

- Water samples analyzed for the presence of pesticides were within the State's water quality standards.

- Sediment samples analyzed for the presence of pesticides were all in concentrations below the laboratory equipment's detection limits.

- Sediments analyzed for metals compared favorably with other Illinois lakes.

- CSCR sediments compared to Lake Charleston sediments showed significantly higher copper concentrations. This was most likely due to the copper sulfate treatments used to control algae blooms.

7) <u>Water/Sediment Depths</u>

- The CSCR was mapped in 1988 to determine the water depth. See the attachment #1 for a copy of this map.
- The maximum water depth in 1982 was 20 feet. The maximum water depth in 1988 was 16 feet, and in 1991 it was closer to 15 feet.

- The CSCR was built to increase the water storage capacity and prevent sedimentation from the Embarras River.

- Most of the sedimentation now comes from shoreline erosion and tributary storm event loading.

8) Watershed

- Watershed tributaries were monitored at two stations for water quality. Table A shows water quality results for the tributaries.

- The CSCR watershed is made up of 1132 acres including both land and water surfaces.

- The three largest components of the watershed are forest acres (43.8%), water (29%), and residential (10.4%). See attachment #2 for Land-Use map.

9) Hydrologic Budget

- Inflows of water to the CSCR, including pumping, rain, and baseflow from tributaries, were monitored. Discharge from the treatment plant was estimated.

- Outflows of water from the CSCR, including pumping, overflow, and evaporation, were monitored.

- A breakdown of the hydrologic budget can be found in Table B.

10) Nutrient Budget

- Monitoring data and research data from other water quality investigations were used to create a nutrient/solids "budget" for the Charleston Side-Channel Reservoir (See Table C).

- Sources of nutrients/solids that were included in the CSCR budget were pumping from Lake Charleston, baseflow from tributaries, precipitation, shoreline erosion and internal regeneration.

- Losses of nutrients/solids, that were included, were from water pumped to the treatment plant and water exiting the CSCR via the overflows.

- Other potential sources and losses were investigated but were not included due to their minimal influence or technical difficulties with investigative techniques.

Table B. Hydraulic Budget

For the Charleston Side-Channel Reservoir

Water exiting the CSCR per year.

	Million Gal.	% of total
PUMPING TO PL	597.3	66.7
OVERFLOW	18.8	2.1
EVAPORATION	278.8	31.2
TOTAL OUT	894.9	100.0

Water going into the CSCR per year.

	Million Gal.	% of total
PUMPING FROM	424.0	51.3
BASEFLOW	52.1	6.3
BACKWASH	9.7	1.2
PRECIP.	340.5	41.2
TOTAL IN	826.3	100.0

Table C. Nutrient Budget

For the Charleston Side-Channel Reservoir

PARAMETER					Phosphorus			
LOCATION in Kg	NITRATE Kg/year	%	AMMONIA Kg/year	%	TOTAL DISS. Kg/year	%	TOTAL Kg/year	%
TO PLANT	942.87	97.77	396.53	97.60	73.646	97.72	302.932	97.68
OVERFLOW	21.51	2.23	9.73	2.40	1.715	2.28	7.2	2.32
TOTAL OUT	964.38		406.26		75.361		310.132	
FROM LAKE	8606.39	94.51	251.08	45.04	74.192	88.78	141.764	9.75
BASEFLOW	100.78	1.11	27.59	4.95	4.163	4.98	6.063	0.42
BACKWASH	17.7	0.19	6.2	1.11	0.690	0.83	1.39	0.10
PRECIP.	381.71	4.19	272.65	48.90	4.522	5.41	4.522	0.31
SHORELINE							636.62	43.78
INTERNAL *							663.7	45.64
TOTAL IN	9106.58		557.52		83.567		1454.059	
N - OUT	8142.2		151.26		8.205		1143.927	

LOCATION in Kg	SUSPEND SOLIDS Kg/year	%	TOTAL SOLIDS Kg/year	%	VOLATILE SOLIDS Kg/year	%	VOLSUS SOLIDS Kg/year	%
TO PLANT	94039.2	98.56	672160	96.34	213450	95.62	23031.7	97.48
OVERFLOW	1370.9	1.44	25551	3.66	9782	4.38	594.8	2.52
TOTAL OUT	95410.1		697711		223232		23626.5	
FROM LAKE	46479.6	50.67	769435	35.15	260590	88.29	9127	71.08
BASEFLOW	951.3	1.04	97980	4.48	25819	8.75	315.6	2.46
BACKWASH	44299	48.29	48528	2.22	8735	2.96	3397	26.46
SHORELINE			1273242	58.16				
TOTAL IN	91729.9		2189185		295144		12839.6	
IN - OUT	-3680.2		1491474		71912		-10786.9	

* Phosphorus is based on low aerobic value from USEPA 1980 "Clean Lakes Program Guidance Manual"

Existing Lake Uses and Problems

The Charleston Side-Channel Reservoir is a multipurpose water impoundment. The primary reason for constructing the CSCR was to maintain an adequate water supply. However it has played an important role in providing water related recreational opportunities for the citizens of Charleston and surrounding communities.

The CSCR supports a variety of uses. These uses can be adversely affected by water quality factors. Below is a partial list of reservoir uses followed in parenthesis by some of the factors that impair that use.

1 <u>Fishing</u> (water clarity, predator-prey balance, habitat, water depth)

2 <u>Boating</u> (water depth)

3 <u>Wildlife habitat and observation</u> (lack of habitat diversity "defoliated shoreline and lack of submersed aquatic macrophytes"

4 <u>General aesthetics</u> (water clarity, defoliated shoreline, algae blooms)

5 <u>Water supply</u> (Taste and odors "algae and their decomposition", THM's "chlorination by products", reduced total alkalinity)

6 <u>Research and education</u>

7 <u>Picnicking, hiking and sunbathing</u> (deterioration and vandalism of support facilities and general aesthetics)

Lake Management Plan

Restoration and protection strategies can be separated into two main groups; in-lake and watershed management approaches. Some approaches have little if any cost associated with them while other would represent a major capital expenditure. Many restoration strategies are available although not all are suitable for the conditions ate the CSCR.

Below you will find a list of management strategies that are potentially applicable to the conditions at the CSCR.

1) "In-Lake" management approaches

- dredging
- nutrient inactivation
- chemical algae control
- aeration
- fish management and stocking
- shoreline erosion control
- operational guidelines for maintaining reservoir water level

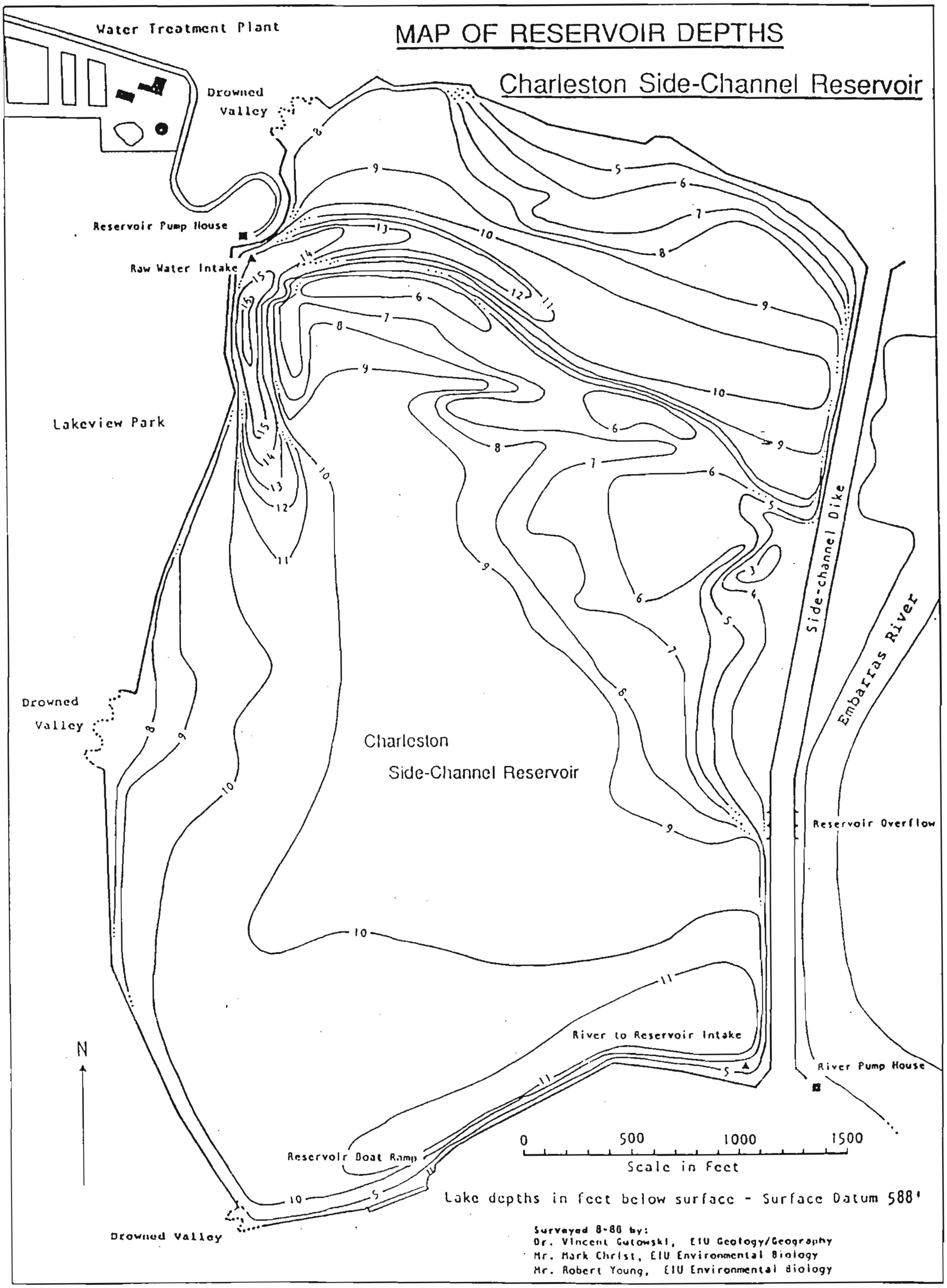
2) Watershed management approaches

- pre-treatment of pumping water
- presedimentation basins
- urban erosion/sediment control from construction sites and cleared areas
- septic system maintenance/replacement
- adoption of purposed watershed zoning ordinance
- purchase of lands that are highly susceptible to erosion

In addition to the above management approaches a number of options for the improvement of recreational support facilities will be discussed at the March 7, 1992 meeting. The final outcome of this Diagnostic/Feasibility Study will be a Reservoir management plan with specific recommendation. These recommendation will achieve restoration/protection of most lake uses with in the budgetary constraints of the City of Charleston.

For Further Information ?

More information about the study can be obtained by contacting Alan Alford at the Charleston Water Treatment Plant 2600 East Mc Kinley Av. Mr. Alford can be reached by phone (345-2977) or by mail (520 Jackson Ave. Charleston, Il. 61920).



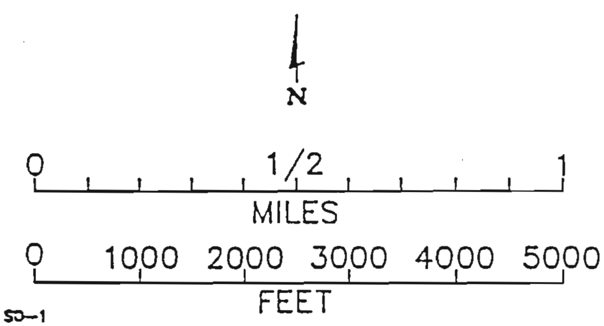
Attachment 1 Map of Reservoir Depths, Charleston Side-Channel Reservoir.

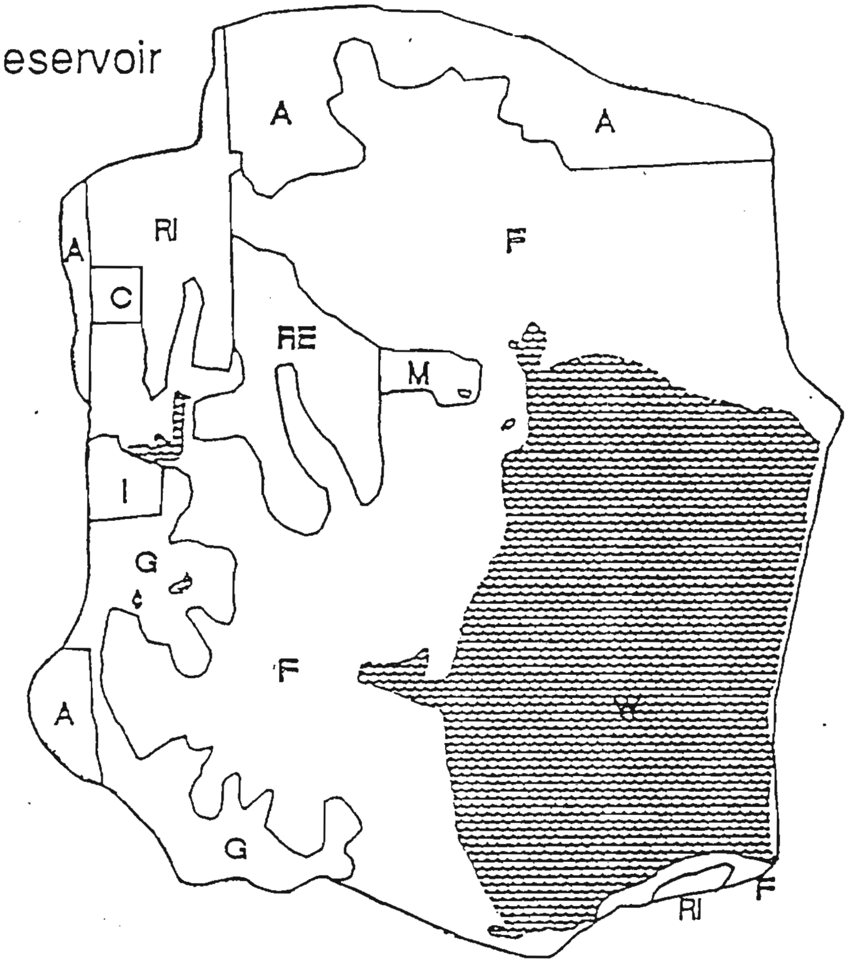
LAND USE MAP

Charleston Side-Channel Reservoir

LEGEND	MI^2	ACRES	% OF TOTAL
A=AGRICULTURAL	.1450	92.8	8.2
C=COMMERCIAL	.0225	14.4	1.3
G=GRASSLAND	.1050	67.2	5.9
I=INDUSTRIAL	.0100	6.4	.6
F=FOREST	.7775	497.6	43.8
M=MUNICIPAL	.0150	9.6	.8
RE=RESIDENTIAL ESTATE	.0925	59.2	5.3
RI=RESIDENTIAL	.0900	57.6	5.1
W=WATER	.5125	328.0	29.0
TOTAL	1.770	1132.8	100.0

ALL BOUNDARIES DRAWN FROM USGS TOPOGRAPHIC MAPS AND AIR PHOTOS. V.P.G 4/3/88





SD-1

Attachment 2 Land Use Map, Charleston Side-Channel Reservoir Watershed.